1 **Dogs (*Canis familiaris*) adjust their social behaviour to the differential role of inanimate**

2 **interactive agents**

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4 Eszter Petró[1], Judit Abdai[1], Anna Gergely[1,2], József Topál[2] and Ádám Miklósi[1,3]

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6 Affiliations

7 [1]*Department of Ethology, Eötvös Loránd University, Budapest, Hungary*

8 [2]*Institute of Cognitive Neuroscience and Psychology, Hungarian Academy of Sciences,*

9 *Budapest, Hungary*

10 [3]*MTA-ELTE Comparative Ethology Research Group, Budapest, Hungary*

11 *Corresponding author: petroeszti1989@gmail.com

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14

15 **Abstract**

16

17 Dogs are able to flexibly adjust their social behaviour to situation-specific characteristics of

18 their human partner's behaviour in problem situations. However, dogs do not necessarily

19 detect the specific role played by the human in a particular situation: they can form

20 expectations about their partners' behaviour based on previous experiences with them.

21 Utilizing inanimate objects (UMO – Unidentified Moving Object) as interacting agents offer

22 new possibilities for investigating social behaviour, because in this way we can remove or

23 control the influence of previous experience with the partner. The aim of the present study

24 was to investigate whether dogs are able to recognize the different roles of two UMOs and are

25 able to adjust their communicative behaviour toward them. In the *learning phase* of the

26 experiment dogs were presented with a two-way food-retrieval problem in which two UMOs,

27 which differed in their physical appearance and abilities, helped the dog obtain a piece of food

28 in their own particular manner. After a short experience with both UMOs, dogs in the *test*

29 *phase* faced with one of the problems in the presence of both inanimate partners. Overall,

30 dogs displayed similar levels of gazing behaviour toward the UMOs but in the first test they

31 looked, approached and touched the relevant partner first. This rapid adjustment of social

behaviour toward UMOs suggests that dogs may generalize their experiences with humans to other unfamiliar agents, and are able to select the appropriate partner when facing a problem situation.

Introduction

An intriguing problem in animal communication is whether and how individuals communicate their needs or goals to their companions. In the case of cooperative activities an individual may be facing an unsolvable problem, and it is necessary to solicit the partner's assistance in order to achieve its goal. For example, Melis et al. (2006) reported that chimpanzees are skilful in recognizing the situations in which collaboration is necessary and in determining who is the best collaborative partner.

Efficient solicitation of potential collaborators can be beneficial to both partners, and may also strengthen the inter-individual relationship. In some species such soliciting behaviour consists of a directional component which is related to the external target/problem and an attentional-getting component that directs the attention of the partner to the solicitor (e.g. Miklósi et al. 2000). For example, dogs indicate the location of a hidden target (e.g. food) to humans by gaze alternations between the hidden target and the human in a way that is functionally similar to infant behaviour in comparable situations (Miklósi et al. 2000; Gaunet 2008, 2010).

Virányi et al. (2006) run a nonverbal problem solving test in which dogs and 2.5 years old infants solicited help from a human helper by indicating the location of an out-of-reach desired toy and the tool needed to obtain it. In the four experimental conditions the helper was either present or absent during hiding of the toy and the tool and thus she knew only the location of the toy, the location of the tool, both or neither of them. Both dogs and children signalled the place of the toy more frequently when the helper was absent during the hiding compared to the condition when the helper was present. Kaminski et al. (2011) noted that dogs become more excited when the helper left them alone in the room and this could have led to a higher level of soliciting behaviours toward the returning helper. Although this cannot explain why dogs exhibited more frequent signalling only to the object that the helper had not witnessed being hidden, more recently it has been argued that dogs' differential communicative behaviour toward the helpers might be the result of experience with them during the training phase of the experiment (Gaunet and Massioui 2014).

65   Gaunet and Massioui (2014) tested dogs and 1-year-old infants in a similar problem solving

66   test to see whether they increase communicative signalling toward a human helper (owner or

67   caregiver) if she was absent during the hiding of the target. The experimenter placed an out of

68   reach toy either above or under one of two containers in the presence of the dog/infant and

69   either in the presence or absence of the helper. Both dogs and infants tended to solicit help in

70   both conditions and no differential communicative behaviour was reported in any of the test

71   situations. Importantly however subjects were called upon by the helper to locate the toy, thus

72   both dogs and infants may have simply responded to the imperative order.

73   The above mentioned studies indicate that dogs behave in ways which are at least *functionally*

74   similar to that of 1-to 2-year-old infants, and these communicative interactions between

75   humans and dogs show a close behavioural correspondence to mother-infant interactions.

76   Note however, that there are doubts as to whether the cognitive mechanisms underlying the

77   behavioural similarities in these species are the same (e.g. Lakatos et al. 2009).

78   A recent study (Horn et al. 2012) suggested that dogs may be able to flexibly adjust their

79   social behaviour to situation-specific characteristics of their human partner's behaviour in a

80   problem solving situation. Dogs could learn that each of the two human partners (filler and

81   helper) can solve one of two different problems. In the training phase dogs learned to use

82   efficiently a rotatable disc food-container to obtain 6 pieces of food. This apparatus was

83   equipped with a blocking mechanism that when activated, blocked the rotation of the disc,

84   thus only 3 pieces of food were accessible to the dogs. The filler re-baited the apparatus with

85   food if the dogs emptied it by eating all food pieces and the helper unblocked the apparatus if

86   it got blocked during the dogs' manipulation. In the test phase dogs approached the helper

87   first independently whether the apparatus was blocked or empty, but spent more time near the

88   filler when the apparatus was empty. The authors argued that dogs recognized the specific

89   role of the filler but not the helper. However, it is unclear whether the dogs' behaviour

90   indicated a communicative intent (for the behavioural criteria see Gaunet and Deputte 2011)

91   or the dogs had an expectation toward the filler to bring food without recognising the filler's

92   role in refilling the apparatus.

93   Other observations also show that dogs may have limited capability to solve physical

94   problems, for example, dogs failed to recognize the function of intermediate steps in a more

95   complex sequences of action that are only indirectly linked to getting the reward (Virányi et

96   al. 2006).

97   The Horn et al. (2012) study has further limitations. (1) Dogs have expectations about the

98   humans' actions due to their previous experiences with them. Thus they more or less prepared

99   to recognize the role of the filler, because getting the food from humans is a daily event. In

100 contrast, the unblocking by the helper was an unusual action for the dog. (2) Dogs may have

101 had difficulties recognising the nature of the physical problem they were exposed to (i.e. the

102 blocking mechanism) therefore they were not able to distinguish between the partners based

103 on their specific roles. (3) Dogs had unbalanced exposure to the partners, because only the

104 helper was interactive with the dog (the helper encouraged the dog to manipulate the

105 apparatus) in the training phase, but the dogs had more trials with the filler (who always

106 refilled the apparatus) in the test phase.

107 Whether or not dogs are able to choose their potential collaborators based on the partner's

108 problem solving competence and/or its willingness to cooperate still waits further

109 clarification. It is increasingly assumed that the use of interactive robots offers new

110 possibilities for studying inter-specific social behaviours (e.g. Kubinyi et al. 2004; Krause et

111 al. 2011, Ladu et al. 2015, Spinello et al. 2013) because the uncontrolled effects of previous

112 experiences can be eliminated, a robot's abilities and behaviour can be manipulated

113 independently of its embodiment and the experimenter can have more control over the robot's

114 behaviour compared to a living partner. In an earlier research (Gergely et al. 2013), we found

115 that in a problem situation dogs show similar behaviours toward an inanimate moving object

116 (UMO – Unidentified Moving Object) as they display toward a human whose behaviour

117 matched that of the UMO. However, the interactive behaviour of the dog emerged faster and

118 became more elaborated when the UMO was endowed with features typically linked to

119 animacy (eyespots, self-propelled motion and contingent reactivity).

120 The aim of the present study is to investigate dogs' ability to show differential soliciting

121 behaviour toward two physically dissimilar UMOs which assisted them in getting food by

122 solving different problems. We used a modified version of the experimental protocol

123 published by Horn et al. (2012) replacing the human helpers with UMOs. We aimed to find

124 out whether dogs interact with the respective agent which was observed to be able to solve the

125 problem. We predicted that in the test trials dogs should gaze, alternate their gaze, approach

126 and touch the UMO which assisted them in respective context during previous encounters.

127 Such discrimination would rapidly emerge in dogs, because they have also been shown to

128 learn about rules rapidly in cooperative social contexts even when interacting with unfamiliar

129 human partner (Topál et al. 2005) and also with conspecifics (Brauer et al. 2012).

130

131 **Materials and Methods**

132

Subjects

Fifty-eight adult pet dogs were recruited from the Family Dog database of the Department of Ethology, Eötvös Loránd University. We excluded 10 dogs because during the familiarisation phase or the first 3 trials of the learning phase they wanted to leave to room, did not took the reward from the UMOs or showed avoidance toward one of the UMOs. The remaining 48 dogs (mean age±SD: 3.7±2 years, 33 females, 25 males from different breeds) were randomly assigned to one of four experimental conditions (see Table 1). Subjects were allowed to participate only if they could be motivated with food. All subjects participated only in one of the four conditions:

Our experiment is based on non-invasive procedures for assessing dogs' behaviour. Non-invasive studies on dogs are allowed to be done without any special permission in Hungary by the University Institutional Animal Care and Use Committee (UIACUC, Eötvös Loránd University, Hungary). The currently operating Hungarian law ''1998. évi XXVIII. Törvény'' (The Animal Protection Act) defines experiments on animals in the 9th point of its 3rd paragraph (3. 1/9.). According to this definition our non-invasive observational study does not fall in the category of animal experiments. Our experimental procedure was consistent with the ASAB/ABS guidelines on the use of animals as described in "*Guidelines for the treatment of animals in behavioural research and teaching*".

The owners responding to our advertisement at the department's home page (http://kutyaetologia.elte.hu) volunteered to participate and provided written consent.

Apparatus

Dogs were tested at the Department of Ethology, Eötvös Loránd University in a 4.5 m×3.5 m testing room. In this experiment we used a remote-controlled (RC) car (#32710 RTR SWITCH, 28 cm x 16 cm x 13 cm) and a remote-controlled crane (Hobby Engine Premium Label RC Crane Truck 2.4 GHz, 65 cm x 17 cm x15cm) as UMOs (see Figure 1a). The car was controlled by Experimenter 2 who was standing in the corner of the lab and the crane was controlled by Experimenter 3 who was standing in the other corner of the lab. The UMOs were parking outside of the room and they could enter the room through two guillotine doors. Experimenter 2 opened the guillotine door for Experimenter 3 while she was driving the UMO and Experimenter 3 opened the door for Experimenter 2 (Figure 2). Throughout the experiment Experimenter 2 and Experimenter 3 did not interact with the dog.

165   An opaque wooden box (80 cm x 48 cm x 38cm) was used as a hiding location. There were

166   two holes (20 X 20 cm (front) and 12 X 12 cm (top) openings with closable lids) on the box;

167   one on the top and one on the front side. The food was placed in plastic bowl (7 cm x 7cm)

168   which could be taken out by the UMOs from the box by the means of magnets. The UMOs

169   differed in their physical abilities: the car obtained the food through the front hole and the

170   crane got the food from above through the hole on the top the crane had a magnet mounted on

171   its arm that could connect to a screw that was attached to the bowl, while the car had magnets

172   on its front and the bowl belonging to it had magnets on its side (see Figure 1.).

173

174   *Procedure*

175   *Familiarisation phase*: (1) The owner and the dog entered the room, the owner released the

176   dog and the dog could explore the room. The wooden box had been placed already in the

177   centre of the room but the UMOs were not present. Experimenter 2 and 3 had already been

178   stood in the room in their predetermined location (the opposite side as the UMO that was

179   controlled by them, i.e. same side as the guillotine door they operated). Next the owner sat

180   down at a predetermined location (O) and held the dog in front of him/her at a distance of 2 m

181   from the box (Fig. 3).

182   (2) Experimenter 1 entered the room and put a piece of food into a bowl in front of the dog

183   which the dog could eat. Then Experimenter 1 put a piece of food into the bowl and placed

184   the bowl either next to the front hole or next to the top hole depending on which UMO

185   entered the room first (car – front hole, crane – top hole). The proper UMO entered the room

186   and took the bowl to the dog that was allowed to eat the food. Then the UMO went out from

187   the room at the same door.

188   (3) Experimenter 1 placed the baited bowl at the other location (next to the front or top hole

189   respectively) and the other UMO entered the room and took the bowl to the dog (see also

190   Figure 2). The order of the UMOs was counterbalanced between subjects.

191

192   *Learning phase*:

193   In the problem situation two UMOs (car and crane) helped the dog to obtain a piece of food

194   which was placed at an inaccessible location inside the box.

195   (1) Experimenter1 entered the room with the bowl and one piece of sausage in her hands. She

196   showed the food to the dog then took it into the bowl.

197   (2) Experimenter 1 placed the bowl through one of the two holes into the box, closed the lid

198   on the other hole on the box and left the room. The owner took off the leash and encouraged

199 the dog to get the inaccessible food from the box. After 30 seconds the owner called the dog
200 back.
201 (3) The UMO which was capable for taking out the bowl through the currently open hole on
202 the box entered the room. The guillotine door was opened for this UMO by the Experimenter
203 (2 or 3) who controlled the other UMO by the means of hidden strings. The UMO took out the
204 bowl from the box and carried it to the dog who was allowed to eat the food (see Figure 2).
205 Both UMOs helped the dogs to get the food for 5-5 times. Two different orders for these
206 interactions were used (car=1, crane =2): 1-2-1-2-2-1-2-1-1-2 or 2-1-2-1-1-2-1-2-2-1.
207
208 *Test phase*: After the learning phase the owner and the dog left the room for 2-3 minutes with
209 Experimenter 1, while Experimenter 2 and 3 placed the UMOs to the front of one of the
210 guillotine doors (see Figures 2 and 3). Then the owner and the dog (on leash) entered the
211 room, the owner sat down at his/her predetermined location and held the dog in front of
212 him/her.
213 Then Experimenter 1 entered the room with the bowl and one piece of sausage in her hands.
214 She showed the food to the dog, put it into the bowl and hid the bowl into the box through one
215 of the holes (front hole or top hole). She closed the lid of the other hole and left the room. The
216 owner and the dog (on leash) went to the box and the dog was allowed to sniff into the box
217 through the open hole. Next they went back to their predetermined location and the owner sat
218 down. Then the owner took the dog off leash and encouraged it to move freely in the test
219 room for 30 seconds.
220 We observed the dogs' behaviour when they faced one of the two problems in the presence of
221 both passive UMOs. Subjects participated in two test trials in which either the top hole or the
222 front hole was baited. The UMOs were placed next to the same or the opposite door which
223 they used to enter the room during the Learning Phase. Thus the order of trials across the
224 subjects was counterbalanced for the hole that was opened and the location of the UMO as
225 well (see Table 1).
226 After the 30 second the appropriate UMO started to move and took the bowl with the food to
227 the dog.
228
229 *Behavioural variables and data analysis*
230 All trials were videotaped and dogs' behaviour during the 30 s of free movement was
231 analysed later with Solomon Coder 12.06.06 (András Péter http://solomoncoder.com).
232

Below is the list of behavioural units coded during the test trials. Except 'Looking at the UMO' and 'Gaze duration' all other variables were measuring occurrence/non-occurrence. The Cronbach alpha was 0.934.

First look (0/1): The dog looks first at one of the UMOs (car or crane) after the owner released the dog.

First approach (0/1): The dog approaches one of the UMOs within 1 m with his nose.

First touch (0/1): The dog touches one of the UMOs with its muzzle and paw.

Score 1 was given if the dog interacted (looked, approached, touched at) the appropriate partner (i.e. the car when the front hole was open; the crane when the top hole was open), and score 0 was given if the dog interacted with the inappropriate partner (i.e. the car when the front hole was open; the crane when the top hole was open).

Looking at the UMO (duration, s): looking duration at one of the UMOs.

Gaze alternation: number of gaze shifts between one of the UMOs and the box (place of food) directly (The criteria for gaze alternation was one second delay between the two gazes and looking at the UMO or the box was maximum 2 second long).

For statistical analysis we used IBM SPSS 21. First, we examined whether dogs chose the appropriate partner in the test phases (first look, first touch, first approach) using one-sample Binomial test (0.5 chance level) and one-sample Wilcoxon test was used to analyse whether dogs looked more at the appropriate partner in the test phase (proportion of the looking duration at the appropriate UMO: looking duration at the appropriate partner/sum of the looking duration).

Next we analysed the number of gaze alternations with GLMM for Binomial distribution in order to examine the effect of condition (same door or changed door), test partner (car vs. crane) and the repetition of test trials. We calculated the ratio of looking at the car and crane from the Looking at the UMO (duration) variable and we analysed it with GLMM for Normal distribution.

Results

First, we examined whether dogs choose the appropriate UMO in the test phase when they faced one of the problems in the presence of both passive UMOs. One-sample Binomial test

266   showed that dogs looked first (P=0.0001), approached first (P=0.009) and touched first

267   (P=0.003) the appropriate UMO according to the problem situation in the first test trial but

268   not in the second trial (first touch P=0.770; first approach P=0.626; first touch P=1.00).

269   Next we tested whether other factors may have influenced the dogs' choice. Binomial GLMM

270   showed no effect in the case of the *First approach* (N=78; Condition: $F_{1,74}$=3.859 P=0.053;

271   Partner: $F_{1,74}$=0.036 P=0.849; Trial: $F_{1,74}$=3.566 P=0.063) and *First touch* (N=67; Condition:

272    $F_{1,63}$=1.083 P= 0.302; Partner: $F_{1,63}$=0.366 P=0.548; Trial: $F_{1,63}$ =3.582 P=0.054). However in

273   the case of the *First look* at the appropriate partner Condition (same or changed door)

274   (Condition: $F_{1,94}$=4.371 P=0.039) and repeated testing trials (Trial: $F_{1,94}$=6.695 P=0.011)

275   reduced the looking at the appropriate partner, but there is not effect of the partner (N=94

276   Partner $F_{1,94}$=0.161; P=0.689). Note that the number of individuals is different for each

277   measure because some did not touch or approached either of the UMOs during the test.

278   We also examined whether dogs looked longer at the appropriate UMO in the test phases.

279   One–sample Wilcoxon signed rank test showed that dogs looked longer at the appropriate

280   UMO (N=48; T(+)=872 P=0.004) in the first trial, but not in the second trial (N=48 T(+)=411

281   P=0.69).

282   The analysis of Looking time proportion toward the partner with GLMM (Normal

283   distribution) and the Number of gaze alternations (Binomial distribution) did not show

284   significant effects indicating also that in general dogs had no preference to look at the car or

285   the crane (Looking time proportion: $F_{5,90}$= 0.39, P=0.85; Number of gaze alternations: $F_{5,70}$=

286   0.604, P=0.697).

287

288   **Discussion**

289

290   We found that dogs chose the appropriate UMO for obtaining the food, as they approached,

291   touched and looked first at the interacting agent which was able to retrieve the reward in the

292   respective context. However, dogs looked longer at the appropriate partner only in the first

293   test trial. This effect emerged because in the test the UMO did not react to the dogs'

294   behaviour, and it only started to move after 30 s passed. So on the second trial dogs may have

295   not been so confident in their choices because they oriented at the UMO during the first trial

296   in vain, as it did not react to their behaviour but started to move independently from it after 30

297   seconds at a random time. We know from our previous study that dogs initiate interactions

298   with an UMO that behaves interactively with them (if the partner starts to move when the dog

299   looks at it) (Gergely et al. 2013)

300 These results support previous findings by Horn et al. (2012), although importantly dogs in
301 the present study discriminated the role of both partners equally well. We assume that this
302 stronger effect was due to the improved methodology used in this study. The use of robots
303 enables researchers to control more attributes of the interaction and to better identify which
304 aspects of the agent's behaviour does the subject recognize. In addition to this, it makes
305 differentiating between the various characteristics and skills.(Ladu et al. 2015)

306 Dogs rapidly (after 5-5 trials) learned to discriminate between the two UMOs and solicited the
307 appropriate UMO in the specific situation. This rapid learning is quite interesting given earlier
308 reports of how many trials the dogs needed to reach a similar performance in other contexts.
309 For example, in non-interactive contexts involving traditional methods of discrimination
310 learning dogs may need 20 to 300 trials for achieving reliable performance (Milgram et al.
311 1994). Milgram et al. (1994) reported that laboratory beagles learned to associate the location
312 of food on the basis of an object placed nearby. However, on average these dogs needed about
313 400 trials to learn the discrimination task. Dogs also displayed difficulties in finding a hidden
314 food indicated solely by the presence of a physical marker (object) in a two-way choice task
315 (e.g. Agnetta et al. 2000; Riedel et al. 2006). For example, dogs did not associate the place of
316 the marker and the location of the hidden food after more than 70 trials (Agnetta et al. 2000).
317 In contrast, such discrimination develops faster if dogs learn in a social context. Dogs learned
318 to rely on a novel beacon for finding hidden food even after 20 trials when the indicating
319 object was manipulated by a human experimenter (Agnetta et al. 2000).

320 The possibility for interacting with inanimate objects could also facilitate dogs' interpretation
321 of the situation as being social. This can be seen in the emergence of social behaviours if the
322 situation resembles interaction with humans. Jenkins et al. (1978) trained dogs to approach a
323 flashing lamp which indicated the presence of a reward. After repeated interactions the dogs
324 started to show social behaviours toward the lamp (e.g. barking, play bow, tail wagging).
325 Thus, for the dogs the light did not only signal the arrival of food but the dogs also reacted to
326 it as if it were a social partner. This observation was extended by Gergely et al. (2013) who
327 showed that social interaction with an UMO elicit social behaviours in dogs that are also
328 displayed toward humans in similar situations (feeding context).

329 Dogs in the present experiment could have also recognised the parallels between their
330 everyday interactions with humans (helping to obtain inaccessible food) and the current
331 interaction with the UMOs. This interactive aspect could facilitate the discrimination between
332 two agents and allowed the family dogs to rapidly identify the appropriate UMO.

333   Dogs may have been able to recognise the specific abilities of the UMOs (the car is able to
334   bring out the food moving on the floor, and the crane is able raise the bowl). However, the
335   procedures applied both by Horn et al. (2012) and in the present study do not make it possible
336   to come to a definite conclusion. The more parsimonious interpretation is that dogs associated
337   the action of either UMOs with the specific location where the food was hidden.

338   There is so far no evidence on dogs' ability to attribute specific physical skills to other agents.
339   All findings to date rather suggest their limitation to specific physical regularities, such as
340   "connectedness" or "solidity". For example, Range et al. (2012) reported that dogs did not
341   spontaneously show any preference to a string which was connected to reward over an
342   unconnected one. Dogs did not seem to be able to solve problems in which objects could not
343   pass through a barrier (Müller et al 2014). Although not conclusive, at present this makes also
344   unlikely that dogs have the mental ability to relate different physical skills to other agents.

345   Despite the limitation of the present study, the utilisation of UMOs has many advantages in
346   studies exploring social problem solving (e.g. Abdai et al. 2015; Gergely et al. 2015). Dogs
347   have no experience with UMOs, thus they are not influenced by previous experience what is
348   the case if human are used as social partners in such experiments. Different sets of UMOs can
349   be used to test dogs' ability to generalise from one interactive agent to another one and how
350   this performance may depend on dogs' previous experience and physical similarity between
351   UMOs. The different abilities of the UMOs were determined by physical constraints, i.e. the
352   car was unable to use the top hole in the absence of a telescopic boom while the size of the
353   crane limited its access to the hidden food through the front hole. The utilisation of such
354   differences could be used in future studies to examine whether dogs are able to recognize the
355   abilities of the robotic agents. Finally, it is generally difficult in the case of a human partner,
356   as the differentiation of ability, willingness and the specific characteristics pose a big
357   challenge but the deployment of UMOs offers possibilities for the differentiation of these
358   concepts.

359   We conclude that even after a short experience dogs are able to choose the appropriate
360   helping partner when facing a certain problem. The rapid adjustment to the social situation
361   can be explained by dogs' generalisation ability which rested on the similarities experienced
362   with regard to food in human-dog and UMO-dog interactions.

363

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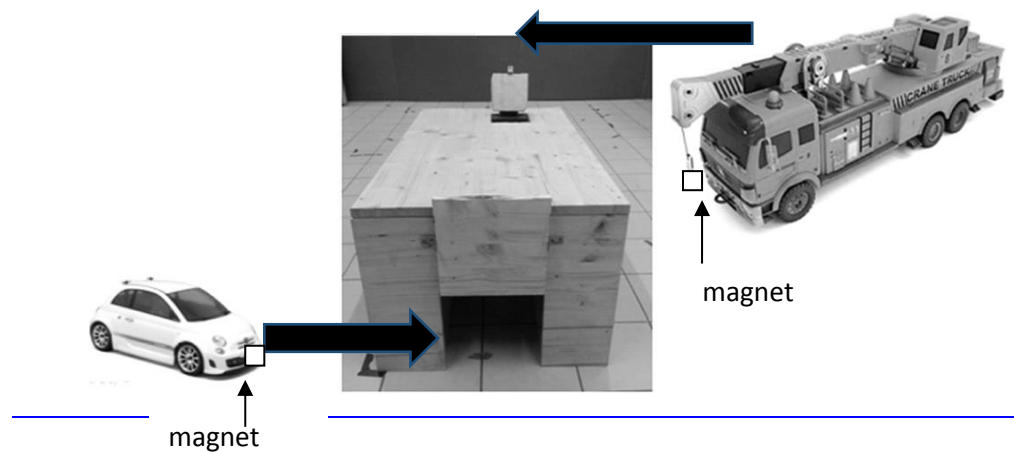
464

465 Tables

466

467 Table 1: The use of doors by the car and the crane during the learning phase, and the doors in

468 front of which the car and the crane was standing in the test phase (FH: the car could access

469 the food through the front hole; TH: the crane could access the food through the top hole) The

470 number of dogs and their ages is provided for each testing condition separately.

	Same door condition				Changed door condition			
Learning phase	Car: door A Crane: door B		Car: door B Crane: door A		Car: door A Crane: door B		Car: door B Crane: door A	
Test Phase (baited hole)	1st FH 2nd TH	1st TH 2nd FH	1st FH 2nd TH	1st TH 2nd FH	1st FH 2nd TH	1st TH 2nd FH	1st FH 2nd TH	1st TH 2nd FH
N of dogs (males &females) Mean age±SD (years)	N=12 7 & 5 4±2.2		N=12 3 & 9 3.6±2.3		N=12 3 & 9 4.2±2		N=12 7 & 5 3.2±2.2	

471

472   Figure legends

473

474   Figure 1 (a) The wooden box with two holes and the test partners (UMOs) and the bowl.

475   Arrows indicate the hole used by the car or the crane during the training and testing for

476   retrieving the food; (b) Two magnets were attached to the bowl by the means of which the

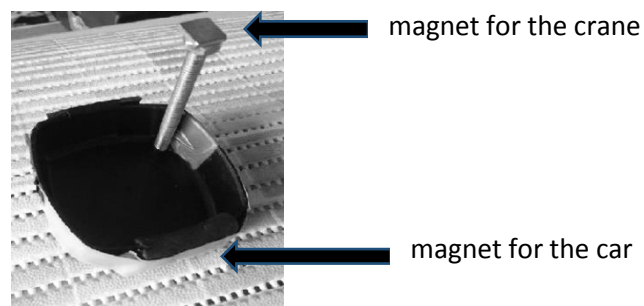477   UMOs could it get out from the wooden box.

478

479   **Figure 1a**

magnet

magnet

480

481   **Figure 1b**

482

magnet for the crane

magnet for the car

483

484

485

486

487   Figure 2 Experimental lay out indicating the paths of movement for the UMOs. Dashed lines

488   show the paths of the car from Door A or B to the front hole and then to the dog. Dotted lines

489   show the paths of the crane from Door A or B to the top hole and then to the dog.

490   O= owner's location; D= dogs' location, E2/3= experimenters' 2 and 3 location; B= location

491   of the wooden box; FH=front hole, TH=top hole, P1&P2= parking places of the UMOs

492   outside of the experimental room, T with triangle=positions of the UMOs during test trials;
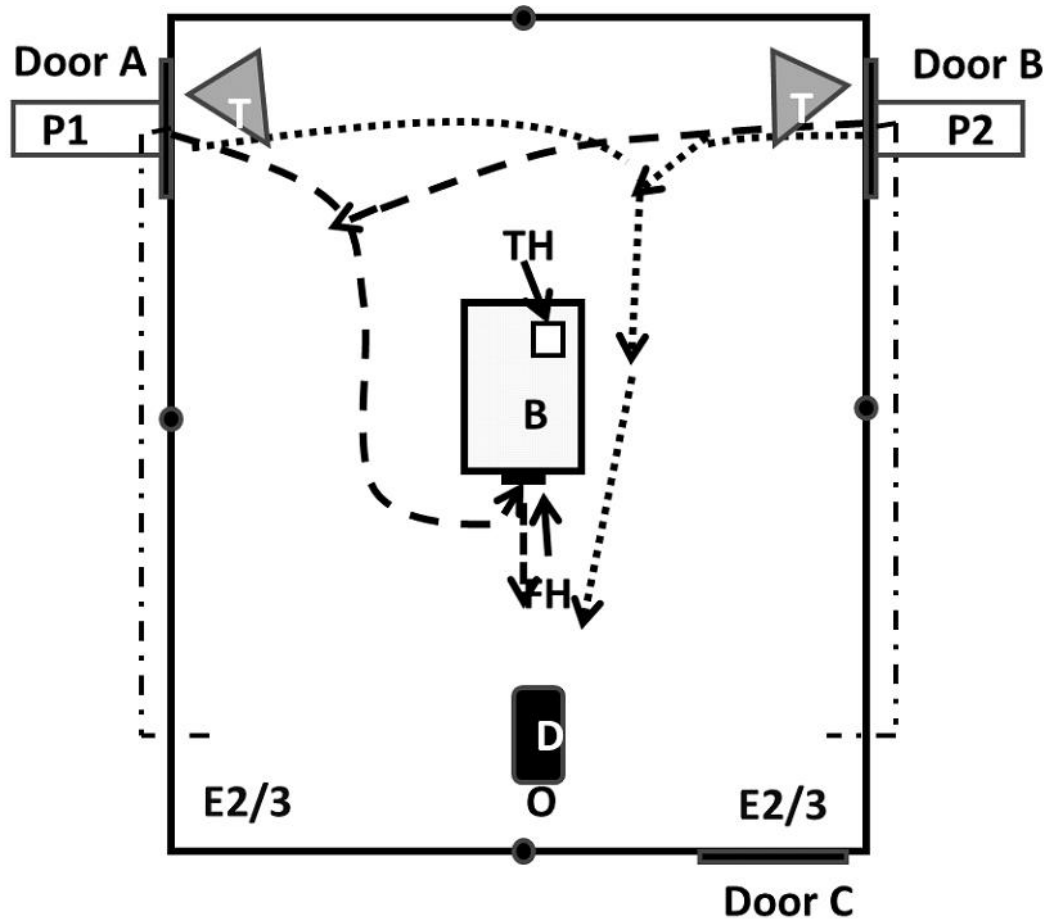
493   Door A and Door B with guillotine openings.

494

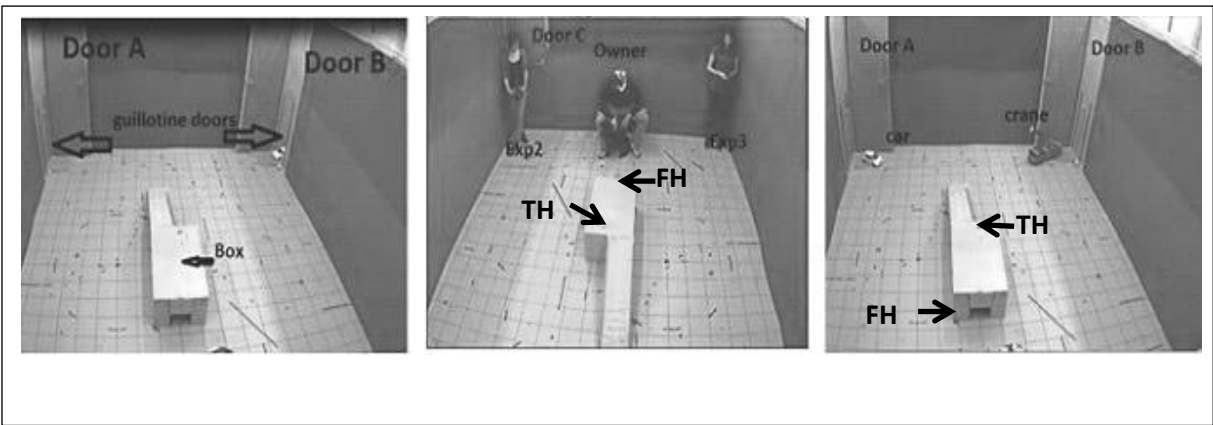495   **Figure 2**

496

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499

500   Figure 3 Experimental arrangements from different views. (a) and (b) Starting arrangement of

501   the learning phase; (c) Staring arrangement of the testing phase with both UMOs standing in

502   front of the doors.
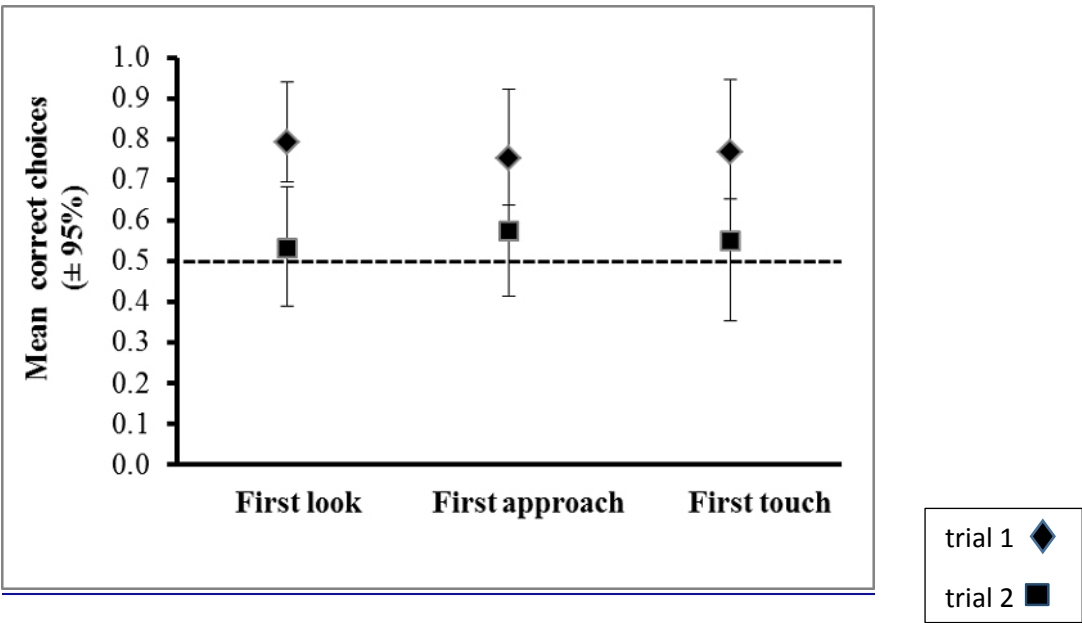
503

504   **Figure 3**

505

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508

509

510 Figure 4 Proportion of dogs' correct choices for 'First look at', 'First approach to' and 'First

511 touch' of the UMOs in test trials. Dotted line indicates chance level (0.5) * p<0.05

512 **Figure 4**

513

514