Functionally referential and intentional communication in the domestic dog: effects of spatial and social contexts

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Functionally referential and intentional communication in the domestic dog: effects of spatial and social contexts

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Received: 5 September 2010 / Revised: 8 May 2011 / Accepted: 12 May 2011 / Published online: 3 June 2011 © Springer-Verlag 2011

Abstract In apes, four criteria are set to explore referential and intentional communication: (1) successive visual orienting between a partner and distant targets, (2) the presence of apparent attention-getting behaviours, (3) the requirement of an audience to exhibit the behaviours, and (4) the influence of the direction of attention of an observer on the behaviours. The present study aimed at identifying these criteria in behaviours used by dogs in communicative episodes with their owner when their toy is out of reach, i.e. gaze at a hidden target or at the owner, gaze alternation between a hidden target and the owner, vocalisations and contacts. In this study, an additional variable was analysed: the position of the dog in relation to the location of the target. Dogs witnessed the hiding of a favourite toy, in a place where they could not get access to. We analysed how dogs engaged in communicative deictic behaviours in the presence of their owner; four heights of the target were tested. To control for the motivational effects of the toy on the dogs’ behaviour and for the referential nature of the behaviours, observations were staged where only the toy or only the owner was present, for one of the four heights. The results show that gazing at the container and gaze alternation were used as functionally referential and intentional communicative behaviours. Behavioural patterns of dog position, the new variable, fulfilled the operational criteria for functionally referential behaviour and a subset of operational criteria for intentional communication: the dogs used their own position as a local enhancement signal. Finally, our results suggest that the dogs gazed at their owner at optimal locations in the experimental area, with respect to the target height and their owner’s (or their own) line of gaze.

Keywords Dog · Human–dog interaction · Referential behaviours · Intentional behaviours · Communication · Social cognition

Introduction

Whether animals communicate referentially—about an event, an agent or a place and intentionally—according to social or spatial contexts is a challenging question in social cognition in animals (see for instance Gómez 2007; for deeper insights on the functionally referential properties of animal calls see Seyfarth and Cheney 2003). Leavens (2004) and Leavens et al. (2005) provided several operational criteria as evidence for referential and intentional communication: (1) there is successive visual orienting between a partner and distant objects or events (i.e. gaze alternation between an inaccessible target and a human, or visual checking), (2) apparent attention-getting behaviours are deployed (e.g. vocalisations), (3) an audience is required to exhibit the behaviours, (4) there is an influence of the attentional status of an observer on the propensity to exhibit behaviours, and (5) there is persistence in and (6) elaboration of communicative behaviour when apparent
attempts to manipulate the partner fail (e.g. the partner is not attending/responding). Criteria #1–#4, and more recently Criteria #5 and #6 have been established in the great apes (chimpanzees: Leavens et al. 2005; orang-utans: Cartmill and Byrne 2007).

In dogs who have witnessed where food or their toy had been hidden, the greatest frequency of behaviours directed towards the non-informed owner and the target was found when both were present, compared to the sole presence of the owner (Miklósi et al. 2000). These behaviours combine an apparently attention-getting component that directs the attention of the perceiver to the informer, and an apparently directional component towards an external target (Miklósi et al. 2000; for the behaviours displayed see Hare et al. 1998; Miklósi et al. 2000; Gaunet 2008, 2010). These results provide support for criteria #1 and #2 in dogs. In addition, when both the target and the owner were present in the room, the two types of behaviours were more marked than when only the target was present (Miklósi et al. 2000). These results are in line with the requirements that validate Leavens’s criterion #3. It may then be assumed that behaviours observed act as if (i.e. functionally) dogs were referentially and intentionally communicating (Miklósi et al. 2000). The successful use of these signals from the owner to locate the target is additional evidence that they act as intentional attention-getting and directional communicative signals (Hare et al. 1998; Miklósi et al. 2000).

Hare et al. (1998) tested criterion #4: no effect of the experimenter facing the dog with eyes open or with eyes closed, or back turned was observed on the communicative behaviours of the two dogs tested. Nevertheless, dogs are sensitive to the direction of visual attention of the observer (head+eyes) when they receive verbal commands (Virányi et al. 2004), perform forbidden actions (Call et al. 2003) or beg (Gácsei et al. 2004; Virányi et al. 2004). In addition, in a two-way object choice test, the dogs appropriately ignored a human’s gaze when the person looked into space (eyes direction only) above the correct hiding location; it was as if the dogs inferred human visual inattention towards the hiding location or had learned the non-usefulness of this human posture (Soproni et al. 2001). Additionally, in the presence of visual barriers, dogs make the decision not to approach forbidden food when they can see a human or when a human can see them (Bräuer et al. 2004). The authors concluded that dogs have knowledge about the visual perspective of others. Alternatively, the dogs may have been sensitive to stimuli, such as seeing a human’s body parts. Using a different paradigm, Kaminski et al. (2009) provided convincing results suggesting that, even in the absence of overt behavioural cues, dogs are sensitive to the visual access of others even if it differs from their own when asked to fetch a toy.

Criteria #5 and #6 were tested by Gaunet (2010). Gaze at a hidden target or at the owner, gaze alternation, vocalisations and contacts were analysed when dogs were asked by their owners to fetch an out-of-reach toy. Dogs were subsequently given either an unfamiliar object or their toy as the outcome of apparent unsuccessful communication or apparent successful communication, respectively. The dogs exhibited persistence, but not elaboration (i.e. new or multimodal behaviours), in their ‘showing’ behaviours in each condition except when the toy was returned.

Additional studies are however required to determine to what extent the dog communicates referentially and intentionally. The present study aims to contribute to this issue by 1) extending the study by Miklósi et al. (2000) so as to analyse the referential and communicative properties of multimodal behaviours—criteria #1 to #3, and 2) testing whether multimodal behaviours in dogs are sensitive to the visual access of others when a target has been hidden at different heights at which the owner gazes (criterion #4). Importantly, whether the location of the dog functions as a referential and intentional communicative cue was also analysed.

This last question indeed arises from the fact that domestic dogs have special skills in using human communicative postures (Hare and Tomasello 2005; Miklósi 2008): for instance they use human pointing to find food hidden in one of two hiding places (Miklósi and Soproni 2006; Udell et al. 2008). They may use it as a beacon. Dogs were more accurate when the experimenter continued to point at the container while the dog made its choice than in case of momentary pointing prior to the response by the dog (Bräuer et al. 2006). They were more accurate when the pointing hand extended close to the correct container (10–20 cm), though they still performed well above chance when the pointing hand was 70–80 cm from the target (Soproni et al. 2002; Miklósi et al. 2005). Dogs also readily use a cue marking the location of hidden food if they see a human placing an object near the correct location, but they fail to respond accurately when its appearance occurs in the absence of human placement (Agneta et al. 2000; Riedel et al. 2006). In Hare and Tomasello (1999)’s study, the human or the dog approached the location where food was hidden and then stayed beside it. Eight out of ten and 6 out of 10 dogs performed above chance when the informant was a human or a dog, respectively (see also Cooper et al. 2003; Heberlein and Turner 2009; Smith and Litchfield 2010). Dogs thus use the body location of a human/dog as a local enhancement cue (Udell et al. 2008). In addition, in everyday life, dogs often remain close by things they seem to like (food, access to another room, etc.). So, conversely to the previous data set presented, would dogs in turn use their own body as a local enhancement cue and as a referential and intentional communicative signal?
Firstly, to characterise a behaviour as a functionally referential and communicative signal, we expect it to be displayed when both the owner and the inaccessible toy (here hidden in a container) are in the experimental room and not (or significantly less) when the owner is present and the toy out of the room, and when the owner is out of the room and the toy present (hidden in the container; Miklósi et al. 2000; Hopkins et al. 2007). We further analysed whether the dog diverts gaze alternation and gaze at the target towards the door when the toy is behind it. The issue of whether dogs use their own location as a functionally referential and intentional communicative cue might also be studied. The study by Miklósi et al. (2000) would thus be significantly extended.

Secondly, will the dogs adjust their communicative behaviours and their locations in space with the co-variation of the height of the target and of the direction of gaze of the owner (at the target, in the present case)? We chose to study the effect of the attentional status of an observer towards the heights because this had never been investigated before and because the changes in the gaze directions of the owner are moderate. The sensitivity of dogs to the visual perspective of humans (e.g. Bräuer et al. 2004; Kaminski et al. 2009) predicts that the place where the communicative behaviours are delivered may be affected by the co-variation of the height of the target and of the direction of the owner’s gaze. For a better alignment of the human line of view, the dog and the target, we thus expect that, when the target is in a low location, more communicative behaviours would be emitted when the dog is near the container than when it is far from the container, and the reverse would be true when the container was located high.

Material and methods

Participants

Twenty-one adult pet dogs participated (mean age: 3.90 ± 3.12 years and mean height at shoulder: 0.53 ± 0.11 m; Table 1). On average, the pet dogs spent 3 h per day interacting with their owner (play, educational games, obedience training...), in addition to morning, evening and weekend walks. The selected dogs were known to have one or several favourite toy(s).

Experimental settings

The experiment took place at the owners’ home. The experimental room was adjacent to another room where the dog’s toy or the owner could be hidden. The whole experiment was videotaped by two camcorders for future behavioural data collection. An opaque plastic container (0.15 m high × 0.25 m diameter), covered by a lid that could be physically secured onto it, was fixed to a heavy board which prevented dogs to move it. These 3 items served as the ‘hiding device’. It could be located at four different heights: on the ground, at paw height, at dog head height and at an inaccessible height. The three last heights were defined according to the height of the dog (two statures, see Table 2): the depth of the container was adjusted to the size of the biggest toys. For dogs whose height was over 0.52 m, a wooden table (0.25 m × 0.25 m × 0.25 m) served to place the hiding device for the paw height location of the target; for other heights, owners’ pieces of furniture was used (Table 2). The owner and the hiding device were located on two opposite sides of a 1.50 m square plastic mat, in the middle of each side of the mat.

Procedure

Habituation stage

Two days before the experiment, the owner received the hiding device; owners of tall dogs also received a wooden table. The owner was asked to leave it all day long on the

<table>
<thead>
<tr>
<th>Breed</th>
<th>Sex</th>
<th>Height at the shoulder (in m)</th>
<th>Age (in years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>German Shepherd</td>
<td>F</td>
<td>0.62</td>
<td>3</td>
</tr>
<tr>
<td>Australian Shepherd</td>
<td>M</td>
<td>0.58</td>
<td>2.25</td>
</tr>
<tr>
<td>German Shepherd</td>
<td>M</td>
<td>0.61</td>
<td>2.5</td>
</tr>
<tr>
<td>Giant Schnauzer</td>
<td>F</td>
<td>0.64</td>
<td>1.5</td>
</tr>
<tr>
<td>Bernese mountain</td>
<td>M</td>
<td>0.65</td>
<td>1.9</td>
</tr>
<tr>
<td>German Shepherd</td>
<td>M</td>
<td>0.64</td>
<td>1.9</td>
</tr>
<tr>
<td>Australian Shepherd</td>
<td>M</td>
<td>0.58</td>
<td>1.3</td>
</tr>
<tr>
<td>Pyrenean Shepherd ×</td>
<td>M</td>
<td>0.54</td>
<td>1.9</td>
</tr>
<tr>
<td>Bernese Mountain</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pyrenean Shepherd</td>
<td>M</td>
<td>0.35</td>
<td>3</td>
</tr>
<tr>
<td>German Shepherd</td>
<td>F</td>
<td>0.62</td>
<td>1.3</td>
</tr>
<tr>
<td>Papillon Spaniel</td>
<td>M</td>
<td>0.30</td>
<td>1</td>
</tr>
<tr>
<td>Pyrenean Shepherd ×</td>
<td>M</td>
<td>0.55</td>
<td>1</td>
</tr>
<tr>
<td>Brittany Spaniel</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>English Bull Terrier</td>
<td>F</td>
<td>0.37</td>
<td>4</td>
</tr>
<tr>
<td>Shetland Sheepdog</td>
<td>M</td>
<td>0.40</td>
<td>11.4</td>
</tr>
<tr>
<td>Pyrenean Shepherd</td>
<td>F</td>
<td>0.34</td>
<td>8.2</td>
</tr>
<tr>
<td>Mongrel</td>
<td>M</td>
<td>0.60</td>
<td>7</td>
</tr>
<tr>
<td>Labrador Retriever</td>
<td>M</td>
<td>0.57</td>
<td>1.25</td>
</tr>
<tr>
<td>Border Collie ×</td>
<td>M</td>
<td>0.58</td>
<td>6</td>
</tr>
<tr>
<td>Beauce Shepherd</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>×Shepherd</td>
<td>F</td>
<td>0.56</td>
<td>9.7</td>
</tr>
<tr>
<td>Labrador Retriever</td>
<td>F</td>
<td>0.53</td>
<td>5</td>
</tr>
<tr>
<td>Shepherd × Golden</td>
<td>F</td>
<td>0.52</td>
<td>7</td>
</tr>
</tbody>
</table>
ground, in an area visited by the dog. In order to familiarise the dog with the properties of the device, the container was left open over the course of the first day and closed the second day. In addition, once a day, the dogs were asked by their owners to watch the owner successively positioning the hiding device at the four heights to be used during the experiment; this familiarised the dog with the variation in the height of the device.

On the day of the experiment, around 20 min were taken to install the mat and the camcorders, to talk and brief the owner, and for the dog to get used to the equipment installed and the experimenter, who never interacted with the dog.

Training stage

Firstly, it was shown to the dog that the container could not be opened without the owner’s intervention. For this purpose, the owner and his/her dog played for a few seconds with the toy; next the owner showed the toy to the dog, hid it in the container that he/she closed, then the owner immediately took back the toy and gave it to the dog. This play session was repeated four times: for each repetition the device was placed by the experimenter at one of the four heights. Secondly, the owner left the room leaving the experimenter and the dog in the room for 30 s to check that the dog could stay alone with the experimenter without displaying signs of distress because of the absence of the owner. Finally, the owner was given the instructions and trained without his/her dog about the procedure (see conditions below). Then, the owner and his dog resumed playing with the toy for a few seconds and the experimental stage began.

Experimental stage

The experiment consisted of six 30 second conditions presented once to each dog. The owner was 1.5 m in front of the container, gazing at it (Fig. 1 for details of the conditions).

*Toy and Owner present*: four target height conditions were tested: ground, paw, head and inaccessible heights. *Toy and Owner present* enables the investigation of the dog’s signalling behaviour in the presence of both the toy and the owner in the room.

*Toy present* (and Owner absent): only the ground target height condition was tested. *Toy present* controls for the

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**Table 2** Heights of the container according to the heights of the dogs

<table>
<thead>
<tr>
<th>Height of the dogs</th>
<th>Ground height</th>
<th>Paw height</th>
<th>Head height</th>
<th>Inaccessible height</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stature: ≥0.52 m</td>
<td>On the ground</td>
<td>On the wooden table</td>
<td>Piece of furniture</td>
<td>Piece of furniture</td>
</tr>
<tr>
<td>Mean: 0.58 ± 0.04 m</td>
<td>0 m</td>
<td>0.25 m</td>
<td>Mean: 0.75 ± 0.03 m</td>
<td>Mean: 1.49 ± 0.07 m</td>
</tr>
<tr>
<td>Stature: ≤0.40 m</td>
<td>On the ground</td>
<td>Owner’s furniture</td>
<td>Piece of furniture</td>
<td>Piece of furniture</td>
</tr>
<tr>
<td>Mean: 0.35 ± 0.04 m</td>
<td>0 m</td>
<td>Mean: 0.13 ± 0.02 m</td>
<td>Mean: 46.4 ± 0.02 m</td>
<td>Mean: 1.08 ± 0.11 m</td>
</tr>
</tbody>
</table>

**Fig. 1** Description of the *Toy and Owner present* conditions (ground, paw, head and inaccessible heights), *Toy present* condition (ground height) and *Owner present* condition (ground height)
effects of presence of the hidden toy only. Signalling behaviour that emerges when the dog is left alone should be attributed to the motivational effects of the toy.

- **Owner present** (and Toy absent): only the ground target height condition was tested. **Owner present** controls for the general effects of the presence of an audience, and also provides a ‘baseline’ measure for any signalling activity in the absence of a desired toy.

A balanced Latin squares design was used to randomise the conditions (Bradley 1958). The experimenter supervised the movements and actions of the owners by signalling and controlling their gestures, entries and exits. The experimenter remained in the room during the experimental stage, a few metres away from the experimental area, without interacting with the dog or looking at it. If a dog was not interested in the task during two consecutive conditions, i.e. it explored the room or lay down without displaying behaviours directed at the owner or at the target over a period of 30 s, the experiment was stopped; these criteria were set on the basis of numerous preliminary observations of the dogs in such situations. Of 31 dogs initially recruited, 10 did not perform the whole experiment and were thus excluded. The 21 dogs studied for referential and intentional communication were thus dogs still motivated by their toy once the play session was interrupted by their owner. Therefore, subsequent analyses concerned 21 dogs. Additionally, one dog failed one of the height conditions; the comparison of subsequent analyses concerned 21 dogs. Additionally, one dog failed one of the height conditions; the comparison of the target heights thus involved only 20 dogs.

### Data collection and analyses

We collected multimodal communicative behaviours and locations of the dogs (cf. list below). Note, however that many behaviours were not recorded, e.g. position and movement of the tail and the ears, scratching, standing versus lying down versus sitting, etc. Actogram Kronos software (Octarés Edition) was used to collect the behaviours. Despite all our efforts, the duration of the conditions varied (between 0 and 2 s. after 30 s.), so raw data were converted into relative durations and numbers.

For each dog, overlapping behaviours (i.e. not mutually exclusive—cf. Miklósi et al. 2000), with or without movements by the dog, during the six 30 s periods were defined (see Hare et al. 1998; Miklósi et al. 2000; Gaunet 2008, 2010):

- **Vocalisation**: the dog barked and/or whined.
- **Contact**: the dog pawed the owner, touched him/her with its nose or head, or performed any form of bodily contact.
- **Mouth Licking**
- **Gaze Owner**: the dog’s head/nose was oriented towards the owner’s head.
- **Gaze Target**: the dog’s head/nose was oriented at the container. Sniffing (at) the container and pawing the container while gazing at the target were not included. We also recorded the gazes at the target when the toy was behind the door during **Owner present**.

For each trial, the sum of the durations of the non-overlapping behaviours that were used for the 5 overlapping behaviours plus the durations of two additional non-overlapping behaviours not submitted to analyses in the present study (i.e. duration spent sniffing the ground and gazing neither at the owner nor at the target or at the door) was 30 s. The total duration of the trial was used to compute relative numbers and durations further analysed.

We also recorded **Gaze alternation**. It consists in looks at the owner followed directly by a look at the target (or vice versa) (i.e. at the container) if this occurred within a time window of 2 s. We also recorded the gaze alternations between the owner and the door when the toy was behind the door during **Owner present**. The absolute numbers were collected and analysed.

To evidence if the dogs use their own location as a local enhancement signal, the relative duration spent in mutually exclusive areas (see below) during the 30 s periods were computed for each dog. The location of the two front legs was used.

- **Target area**: when the dog was in the 0.50 × 1.50 m carpet rectangle closest to the container for **Owner and Toy present** (four target heights), for **Owner present** and for **Toy present**. Time spent sniffing (at) the container and pawing the container were disregarded. We also recorded when the dog was at most 50 cm from the door when the toy was behind the door for **Owner present**.
- **Centre area**: when the dog was located in the 0.50 × 1.50 m rectangle between the container area and the front owner area, for **Owner and Toy present** (four target heights).
- **Front Owner area**: when the dog was located in the 0.50 × 1.50 m carpet rectangle closest to the owner, for **Owner and Toy present** (four target heights).
- **Back Owner area**: when the dog was at most 50 cm behind the owner, for **Owner and Toy present** (four target heights).
- **Out area**: when the dog was not in any of these areas, for **Owner and Toy present** (four target heights).

Analyzing **Toy and Owner present** versus **Toy present** and versus **Owner present** for ground target height

These comparisons enable identification of functionally referential communicative signals. The comparisons were first applied to the relative durations and numbers of the five...
behaviours and to the absolute numbers of gaze alternations (see Analysis of behaviours). The comparisons were secondarily applied to the relative duration of time spent in the target area only (see Analysis of locations). For the comparison of Toy and Owner present versus Toy present, the Wilcoxon signed-ranks test was used for the frequency and relative durations of vocalisations, mouth licking and gaze target behaviours and for the relative duration spent in target area. Because the owner was absent during Toy present, the one-sample Wilcoxon test was used for both the relative numbers and durations of contacts and gaze owner and for numbers of gaze alternation; this was done to determine if the behaviours displayed during Toy and Owner present were almost none or significantly more than none. For the comparison of Toy and Owner present versus Owner present, the Wilcoxon signed-ranks test was used for the frequencies and relative durations of the six behaviours and for the relative duration spent in target area. Additionally, the relative duration and number of gaze target (in which the target is the container), absolute number of gaze alternation (in which the target is the container) and relative duration spent in target area (here in the container area) recorded during Toy and Owner present were also respectively compared to the relative duration and number of gaze target (in which the target is the door), absolute number of gaze alternation (in which the target is the door) and relative duration spent in target area (here in the door area) recorded during Owner present; the Wilcoxon signed-ranks test was used for these comparisons.

Effect of the four target heights for Toy and Owner present

This makes it possible to determine whether the dogs’ behaviours depend on the co-variation of the height of the toy location and the direction of gaze of the owner. The analysis was applied first to the relative durations and numbers of the five behaviours and to the absolute numbers of gaze alternations (see Analysis of behaviours), and second to the relative duration of time spent in the target area (i.e. close to the container), centre, front owner, back owner and out areas (see Analysis of the locations). The difference in relative durations and numbers of the behaviours and in relative durations of time spent at the different locations for ground target height and paw height, and for head height and inaccessible height, was analysed. Because no differences were found for relative durations and numbers of the behaviours and for relative durations of time spent at the different locations (see below in the Results section), the corresponding data on ground and paw target heights were pooled, as were the data for head and inaccessible target heights. Relative numbers and durations of the behaviours and relative durations of locations for low target heights (ground and paw height data) and high target heights (head and inaccessible height data) were then compared. Finally, the analysis was applied to another variable (see Analysis of simultaneous behaviours and locations): for each dog and for each of the five behaviours, the relative durations of time spent in the five locations were computed for the low and high target heights. These durations for low and high target heights were compared. The Wilcoxon signed-ranks test was used for all the comparisons.

To correct for multiple comparisons, the false discovery rate correction was applied (FDR BL adjustment, Benjamini et al. 2001). Two trained observers not informed of the aim of the experiment, considered as a single judge (they worked and decided together the name, beginning and end of a behaviour), and another trained judge recorded the dog’s behaviours and locations independently. Before data analyses, inter-observer agreement was assessed for the most frequent and relevant behaviours by means of parallel coding of 100% of the sample for duration of the behaviours. Kendall’s concordance coefficient was calculated for behaviours obtained for the ground target height. For Toy and Owner present and Owner present conditions, this yielded respectively $W = 0.97$ and $W = 0.98$ for gaze owner; for Toy and Owner present, Toy present and Owner present conditions, this yielded respectively $W = 0.9$, $W = 0.66$ and $W = 0.77$ for gaze target and $W = 0.99$, $W = 0.74$ and $W = 0.88$ for target area. The results indicate good agreement between raters.

On the figures, non-parametric data are represented as medians, and the box indicates the interquartile range of 50% of the data. Whiskers extend to the smallest and largest values and exclude outliers; with *: $P < 0.05$, **: $P < 0.01$, ***: $P < 0.001$.

Results

Analysis of Toy and Owner present versus Toy present and versus Owner present for ground target height

Analysis of the behaviours

The comparison of Owner and Toy present with Toy present was intended to reveal the dogs’ communicative behaviours per se (i.e. vs. motivational behaviours) as they differ according to the presence of the owner in the room (see statistics in Table 3). The relative duration and number of vocalisations and noisy mouth licks did not differ significantly between the two conditions. The relative number and duration for contacts and gaze at the owner scored significantly higher when the toy and the owner were present than when only the toy was present (that is, with respect to no behaviours because the owner was absent). Finally, both the relative duration and number for gaze at the target and
the absolute number of gaze alternations (at container for both behaviours) scored also significantly higher when the toy and the owner were present than when only the toy was present (Figs. 2, 3, respectively). The comparison of Owner and Toy present with Owner present was intended to detect the dogs’ referential behaviours in relation to the toy, as these conditions differ by the presence of the toy in the room, see statistics in Table 4. The relative duration and number of vocalisations, contacts, noisy mouth lickings, and gaze at the owner did not differ significantly between the two conditions. The relative number and duration for gaze at the target and the absolute number of gaze alternations (at the container for both behaviours) were in contrast significantly greater when both the toy and owner were in the room than when only the owner was present (Figs. 2, 3, respectively).

During the Owner present condition did the dogs change their gaze alternations and their gaze at the target according to the actual location of the toy, i.e. looking towards the door rather than the container, compared to when the toy was in the container? The relative number and duration of gazes at the container when both the owner and the toy were in the room and gazes at the door when the toy was behind it did not differ \( (n = 21; \text{duration: } T = +99, P = 0.0071; \text{number: } T = +78, P = 0.31; \text{Fig. 2}). \) In contrast, the absolute number of gaze alternations was significantly greater when both the owner and the toy were present than those directed at the door when the toy was behind it, i.e. during Owner present \( (n = 21, T = +7, P = 0.0071; \text{Fig. 3}). \)

Overall, there was no effect of the absence of the owner or of the toy on the vocalisations and mouth licks. Gaze at the owner and contacts were not affected when the target was behind the door. In contrast, as expected, the relative duration and number of gazes at the target and the absolute number of gaze alternations (directed at the container) scored greater when both the owner and the toy were in the

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**Fig. 2** Relative duration (left) and number (right) of gaze target during Owner and Toy present, Toy present and Owner present (at the container), and during Owner present but at the door behind which the toy was hidden (cf. O present At the door), at ground height, with \( n = 21 \). FDR BL adjustment was applied

**Table 3** Comparisons of Owner and Toy present (O and T present) and Toy present (T present) at ground height for the relative durations and numbers of the behaviours

<table>
<thead>
<tr>
<th>Behaviours</th>
<th>Duration</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Median</td>
<td>( T )</td>
</tr>
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<td></td>
<td>O and T present</td>
<td>T present</td>
</tr>
<tr>
<td>Vocalisation</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Contact</td>
<td>0</td>
<td>–</td>
</tr>
<tr>
<td>Mouth lickingN</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Gaze Owner</td>
<td>38.1</td>
<td>–</td>
</tr>
<tr>
<td>Gaze Target</td>
<td>8.8</td>
<td>2.1</td>
</tr>
<tr>
<td>Gaze alternation</td>
<td>/</td>
<td>/</td>
</tr>
</tbody>
</table>

|                     | Median   | \( T \) | \( P \) | Median   | \( T \) | \( P \) |
|                     | O and T present | T present |   | O and T present | T present |   |

Medians and Wilcoxon test results, with \( n = 21 \). ‘-’ indicates that there is no data (and that the one-sample Wilcoxon test was used). Significant differences are in bold, with *\( P < 0.05 \), **\( P < 0.01 \), ***\( P < 0.001 \). After the FDR BL adjustment only the \( P \) values shown in italics remain statistically significant.
room compared to when the owner was behind the door. In addition, these three variables (directed at the container) increased when both the toy and the owner were present compared to when the toy was absent. Furthermore, gaze directed at the toy when it was in the container was replaced by gazing at the door behind which it was located, unlike gaze alternation.

Analysis of the locations

To study to what extent the location of the dogs close to the target (container or door) can be characterised as a functionally referential communicative signal, the duration of time spent in the container area during Owner and Toy present was compared to that during Owner present and Toy present conditions, and to the duration of time spent near the door during Owner present condition.

The dogs spent significantly more time near the container when both the owner and the target were present (median = 47.4) than when only the toy (median = 16.7) or the owner (median = 0) was present (Owner and Toy present vs. Toy present: \( n = 21, T = +30, P = 0.003 \); Owner and Toy present vs. Owner present: \( n = 21, T = +7, P = 0.00016 \)); Fig. 4. Moreover, the dogs spent almost no time at the door when the toy was behind it (median = 0), demonstrating significantly more positioning close to the container during the presence of both the toy and the owner in the room than close to the door when the toy was behind it (\( n = 21, T = +20, P = 0.0009 \)).

To sum up, whereas the co-presence of the toy and the owner in the room was associated with longer positioning close to the container than when only the owner or the toy was in the room, positioning close to the toy was not diverted towards the door when the toy was behind it.

Effect of the four target heights for Toy and Owner present

Analysis of the behaviours

The effect of the co-variation of the height of the toy and the direction of the gaze of the owner on the behaviours of the dogs was studied. The first analysis sought to determine whether ground and paw target heights on one hand and head and inaccessible target heights on the other were differently processed by the dogs, see S1 for the detailed results. Ground and paw target heights did not differ in relation to duration (\( n = 20, 0 \leq \text{medians for ground height} \leq 34.65, 0 \leq \text{medians for paw height} \leq 29.4, 0 \leq T \leq +79, 0.26 \leq P \leq 0.99 \)) or in relation to number (\( n = 20, 0 \leq \text{medians for ground height} \leq 38.2, 0 \leq \text{medians for paw height} \leq 31.65, 0 \leq T \leq +73, 0.044 \leq P \leq 0.99 \)) for any of the behaviours. Head and inac-
cessible target heights did not differ in relation to duration \((n=20, 0 \leq \text{medians for head height } \leq 21.55, 0 \leq \text{medians for inaccessible height } \leq 24.5, +4 \leq T \leq +100, 0.27 \leq P < 0.85)\) or to number \((n=20, 0 \leq \text{medians for head height } \leq 31.2, 0 \leq \text{medians for inaccessible height } \leq 33.3, +4 \leq T \leq +88, 0.4 \leq P < 0.93)\) for any of the behaviours. The data for the ground and the paw target heights (low locations) were therefore pooled, as well as of the data for the head and inaccessible heights (high locations).

The behaviours for low and high locations were compared, see S2 for detailed results. Only one behaviour differed between low and high locations: the relative duration of gaze at the owner was greater when the toy was hidden in the lower locations (median = 36.05) than in the higher locations (median = 25.97) \((n=20, T = +29, P = 0.0079)\). For the other behaviours, no effect of the two target locations was found: for relative duration of the behaviours \(n=20, 0 \leq \text{medians for low heights } \leq 9.87, 0 \leq \text{medians for high heights } \leq 13.85, 0 \leq T \leq +64, 0.059 \leq P < 0.15;\) for relative number of the behaviours (gaze owner included) \(n=20, 0 \leq \text{medians for low heights } \leq 36.32, 0 \leq \text{medians for high heights } \leq 33.52, 0 \leq T \leq +71, 0.067 \leq P < 0.2\).

To sum up, the dogs looked longer at their owner when the toy was in low locations than when it was in high locations.

**Analysis of the locations**

The locations of the dogs according to the co-variation of the target heights and the direction of gaze of the owner were analysed. The first analysis sought to determine whether ground and paw target heights on one hand, and head and inaccessible target heights on the other affected the locations taken up by the dogs differently, see S3 for the detailed results. Ground and paw target heights did not differ with regard to relative duration \((n=20, 0 \leq \text{medians for ground height } \leq 56.05, 0 \leq \text{medians for paw height } \leq 65.25, 0 \leq T \leq +70, 0.24 \leq P < 0.99)\) for any of the areas. Head and inaccessible target heights did not differ with regard to relative duration \((n=20, 0 \leq \text{medians for head height } \leq 17.8, 0 \leq \text{medians for inaccessible height } \leq 47, +5 \leq T \leq +53.5, 0.027 \leq P < 0.89)\) for any of the areas. The data for the ground and the paw target heights (low target locations), and that for the head and inaccessible target heights (high locations) were therefore pooled.

The dog locations in the experimental room for low and high target locations were compared, see S4 for detailed results. The relative duration of time spent did not differ for any of the areas according to the low or high target locations \((n=20, 0 \leq \text{medians for low heights } \leq 55.85, 0 \leq \text{medians for high heights } \leq 39.7, 1 \leq T \leq +53, 0.036 \leq P < 0.19)\).

To sum up, the dogs did not process the low and high target locations differently for any of the areas.

**Analysis of simultaneous behaviours and locations**

Finally, the durations of each behaviour were studied according to each area distinguishing between low and high target locations; see S5 for the statistical results and S6 for the medians. Contacts were recorded only in the front owner and in the back owner areas. It was found that only the relative duration of gaze at the owner differed between low and high target locations: for the target area the relative duration of gaze owner was greater for low target heights than for high target heights \((n=20, T = +27, P = 0.011)\), whereas for the centre area the relative duration was lower for low target heights than for high target heights \((n=20, T = +18, P = 0.0056; \text{Fig. } 5)\). For the other behaviours, no effect was found \((n=20, 0 \leq \text{medians } \leq 78.62, 0 \leq T \leq 74, 0.32 \leq P < 0.99)\).

The dogs thus gazed longer at the owner when the toy was at low heights than when it was high up when the dogs were near the container, whereas the reverse effect was observed when they were in the centre area.

**Discussion**

The present study confirms the conclusion reached by Miklósi et al. (2000): gaze at the container and gaze alternation can be considered as functionally referential and intentional communicative behaviours. It also shows for the
first time that another behaviour, the position of the dog, which acts as a local enhancement cue, has part of these properties. Finally, the results suggest that dogs gaze at their owner from an optimal location in the experimental area, depending on the height of the target location and the line of gaze of the owner or their own. These observations are valid for pet dogs sufficiently motivated by their toy (cf. the selection of the participants).

As in Miklósi et al. (2000), it was found that gaze at the container and gaze alternation scored greater when both the owner and toy were in the room compared to when the toy or the owner was absent from the room. This confirms that these two behaviours are functionally referential communicative behaviours, and intentional to a certain extent, given the validation of some of the other criteria (see Introduction); criteria #1 to #3 are thus confirmed in the dogs. Vocalisations and mouth licks do not however show these properties in the present study (for mouth licks this may be explained by the fact that the target was a toy and not food, see Gaunet 2010 for a discussion). In addition, gaze at the owner and contacts did not decrease when the toy was out of the room compared to the co-presence of the owner and the toy in the room. This might be due to the fact that the owner him/herself hid the toy in the container, unlike the procedure used by Miklósi et al. (2000) where a familiar person hid the toy and then left the room. In the present study, the fact that the hider was also the recipient of the communicative signals of the dogs could lead the dogs to maintain gaze at the owner: the dogs behaved as if there was still a matter for interaction because both the owner and the dog had seen where the toy was hidden. Further studies are however required to confirm that dogs communicate differently according to what they have experienced about the recipient’s state of knowledge (e.g. Virányi et al. 2006).

In addition to gazing at a ‘desired’ object, it is common to observe dogs positioning themselves close to the door of the living room to get access to the garden (cf. also sitting close to the dog food location and waiting to be fed). In such circumstances, dogs behave as if they were performing local enhancement. Local enhancement (Roberts 1941) refers to cases in which an agent is attracted to a place or object by the current presence of an agent at the location, or by residues of the demonstrator’s activity at the site. The observer is attracted only to a particular location or object contacted/approached by the demonstrator. Here, the data suggest that the dogs performed what appears to be local enhancement behaviour, as if to attract the attention of the owner towards the location of the toy: positioning close to the toy lasted longer when both the owner and the dog were present than when the toy or the owner was absent. This behaviour can indeed be considered as analogous to that performed by a human when he/she comes and stays close to a baited container (Hare and Tomasello 1999), a marker is placed at the baited container (Riedel et al. 2006) or the pointing gesture extends close to the baited container (Soproni et al. 2002; Miklósi et al. 2005; Udell et al. 2008). It might thus be that the dogs use the position of their own bodies close to the target to ‘show’ the target to an observer (production) as well as using this behaviour from a human to locate a target ‘shown’ from the emitter (understanding/use). Importantly, this shows that the positions of the dogs verified the criteria for referential communication and displayed a subset of what is, originally, a subset of operational criteria for intentional communication. To show the full intentionality of this behaviour, the other criteria have to be validated.

We have further shown that whereas gaze alternation and apparent local enhancement behaviour were not diverted towards the door when the toy was behind it, gaze at the toy was. This last behaviour was thus more marked the first two when the toy was located farther away and less accessible (i.e. behind the door) than when it was in the container placed in the room. This suggests that gaze alternation and local enhancement on one hand, and gaze at the target on the other may not have the same function when the toy is out of reach. Further to this, the toy may have a different status in terms of accessibility when it has been placed in another room; it might be considered by the dogs as not ‘gettable’ or ‘showable’ in this spatial context. This
suggests that canine communicative behaviours are sensitive to the spatial context of the experimental layout in a fetch task.

The analysis of the location of the dogs in the room did not reveal any effect of the two low versus two high locations. However, the analysis of the communicative behaviours revealed that the dogs looked longer at their owner during the low target condition than during the high target condition. Further to this, when they were near the container the dogs gazed longer at their owner for low than for high locations, whereas positioning in the centre area was associated with a reverse pattern of durations (i.e. longer gaze at the owner for high than for low locations). The positioning of the dogs when they gazed at their owner resulted in two possibilities: (1) for the dogs of having both the target and the direction of gaze of their owner in their own line of gaze, i.e. in a position to optimally monitor the line of gaze of the owner or in an optimal position that would have been incidentally learnt during the course of their lives with their owner whereby dogs are rewarded for their ‘showing’ behaviours—these two options would be the parsimonious hypothesis; or (2) for the dogs to act as if ‘knowing’ the cone of sight of their owners whereby the owners have both the dog and the target in their own line of gaze, i.e. taking an optimal position for the owner to detect the attention-getting and deictic behaviours of the dogs—that is to say the dogs could be adopting the visual perspective of their owners. This is therefore the second result showing an effect of the spatial layout and line of view of the owner on the canine communicative behaviours in a fetch task (cf. Kaminski et al. 2009). Unfortunately, the results do not make it possible to disentangle the two hypotheses. The first possibility is in agreement with studies showing the sensitivity of dogs to the visual accessibility of parts of the human body for performing an action, e.g. the sensitivity to the orientation of the head of a human or to visible eyes for begging (Gácsi et al. 2004; Study 2 in Virányi et al. 2004); the second is in agreement with the notion that dogs are sensitive to the line of view of the human, e.g. when performing forbidden actions (Call et al. 2003; Bräuer et al. 2004) and when asked to fetch an object (Kaminski et al. 2009) according to the presence of various types of barriers between the owner and the dog. The present results however suggest the ability of the dogs to use the direction of the visual attention of their owner towards different heights for attention-getting or visual checking behaviours, a new finding in itself (criterion #4). It is furthermore interesting to underline that the dogs did not perform target-directed behaviours considering the best angle of view for themselves or for their owners. The fact that the dog had witnessed the owner hiding the toy may explain this lack of effect.

By reproducing the results obtained by Miklósi et al. (2000), and by adding the analysis of the behaviours directed at the door behind which the toy was hidden and the locations in space of the dogs, the properties of canine communicative behaviours were more deeply probed: the present study provides additional evidence for functional referentiality and some intentionality properties of two multimodal behaviours directed at the target; it also shows an apparent local enhancement behaviour that may have these properties. The study further shows two new instances of sensitivity of communicative behaviours of the dogs to the spatial arrangement of the hiding design. This depends on the degree to which the target is accessible (in the container vs. behind the door), and on the co-variation of the heights of the container and the direction of gaze of the owner. Altogether, these results show the flexibility of the communicative behaviours of dogs according to the spatial layout and the social context for the dogs selected.

Acknowledgments  This work was supported by Centre National de la Recherche Scientifique and conducted at the ‘Laboratoire Eco-Anthropologie et Ethnobiologie’ (Museum National d’Histoire Naturelle) and Ecole Nationale Vétérinaire Maison Alfort (Paris, France). The experiment complies with the current laws in France for animal and human research. Authors thank the pet dog owner dyads for their cooperation. Authors are especially grateful to S. Steiger who performed the experiment; part of her 2nd year of Master thesis training session was used for this paper. We also thank S. Steiger, S. Deldalle and E. Jarsailon for their help in the analysis of the videos, and C. Savalli-Redigolo and Fernanda Torello for helpful comments on earlier versions.

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