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PAPER

Domestic dogs comprehend human communication with iconic signs

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Abstract

A key skill in early human development is the ability to comprehend communicative intentions as expressed in both nonlinguistic gestures and language. In the current studies, we confronted domestic dogs (some of whom knew many human 'words') with a task in which they had to infer the intended referent of a human's communicative act via iconic signs – specifically, replicas and photographs. Both trained and untrained dogs successfully used iconic replicas to fetch the desired item, with many doing so from the first trial. Dogs' ability to use photographs in this same situation was less consistent. Because simple matching to sample in experimental contexts typically takes hundreds of trials (and because similarity between iconic sign and target item did not predict success), we propose that dogs' skillful performance in the current task reflects important aspects of the comprehension of human communicative intentions.

Introduction

One of the most important skills in young children's early development is the ability to understand the communicative intentions of others. This enables them to begin acquiring language in earnest (Tomasello, 2003) and to profit from instruction as adults endeavor to show them things (Csibra & Gergely, 2006; Gergely & Csibra, 2006; Gergely, Egyed & Kiraly, 2007).

Infants are able to make appropriate inferences and behavioral responses to adult communicative intentions (i.e. more than just following the direction of a pointing gesture) by around their first birthday. For example, when an adult points to an opaque box in the context of a finding game, infants as young as 14 months can infer the location of the hidden toy (Behne, Carpenter, Call & Tomasello, 2005). They can also make appropriate inferences and behavioral responses to adult communicative intentions in similar situations as expressed in human iconic gestures from at least 18 months of age (Tomasello, Striano & Rochat, 1999). And of course children begin acquiring the active use of linguistic symbols during this same 12–18-month period (Bates, 1979). Infants' ability to respond appropriately to physical symbols – for example, to infer what an adult wants when she brandishes a replica of an object in front of the child – emerges closer to the child's second or even third birthday (Callaghan, 2000; DeLoache, 1987; Tomasello *et al.*, 1999). In the theoretical framework of DeLoache and colleagues, physical symbols are more difficult to comprehend than gestures or language because they involve dual representation: a toy replica of a hammer is still an object in its own right as well as a symbol of the real object (DeLoache, 2000; DeLoache, Miller & Rosengren, 1997).

A number of nonhuman animal species are able to 'comprehend' human linguistic symbols – at least in the sense that they can learn to make appropriate responses. Best known are of course the linguistic apes, who acquire receptive vocabularies of several hundred words (e.g. Savage-Rumbaugh, Murphy, Sevcik, Brakke, Williams & Rumbaugh, 1993). But apes in general do poorly in making appropriate inferences when humans point for them, for example, to indicate the hidden location of food from among several possible hiding locations – a task human children find trivially easy (see Call & Tomasello, 2005, for review). And they also do poorly in a similar experimental paradigm when humans use iconic replicas (without any other spatial cues) to indicate the container (out of three possible) in which some hidden food is located – whereas young children do well in this same task (Herrmann, Melis & Tomasello, 2006; Tomasello, Call & Gluckman, 1997; see Tschudin, Call, Dunbar, Harris & van der Elst, 2001; Scheumann & Call, 2004, for similar negative results in dolphins and fur seals). This raises the possibility that linguistic apes may be 'comprehending' linguistic symbols without comprehending the communicative intentions behind them in the same way as young children (Tomasello, 2006).

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Another nonhuman animal that is able to 'comprehend' human linguistic symbols is the domestic dog. Many dogs understand a few verbal commands, but a few special dogs have been taught many dozens of words as names of objects. In experimental contexts, some of these special dogs can fetch a named object with high reliability, with an estimated vocabulary of 200 words (Kaminski, Call & Fischer, 2004). Interestingly, dogs in general understand different communicative intentional gestures quite well (see Miklosi & Soproni, 2006, for a review) and they do this more skillfully than great apes (Bräuer, Kaminski, Riedel, Call & Tomasello, 2006; Hare, Brown, Williamson & Tomasello, 2002). This suggests the possibility that these 'linguistic' dogs 'comprehend' their words in a more human-like way than do 'linguistic' apes. But it is also possible that the dogs understand their words in a fairly low-level, associative way (Bloom, 2004; Markman & Abelev, 2004), and they understand pointing in some other low-level way based on attentional queuing, perhaps deriving from a specific biological adaptation during the domestication process for responding to human directional commands in space.

One way to investigate these alternatives further would be to give dogs a totally novel communicative task involving neither words nor pointing but rather iconic signs. As noted above, apes and other mammals seem to be incapable of using iconic signs communicatively without further spatial information. (The best evidence for comprehension of iconicity in general is some language-trained chimpanzees' ability to use scale models as a kind of map to find food hidden in a nearby area; Kuhlmeier, Boysen & Mukobi, 1999; Kuhlmeier & Boysen, 2002, but, again, spatial cues are intimately involved in this task.) Of course many species may simply learn in these experimental settings to match the two visually identical samples. However, animals normally need hundreds of trials before solving matching to sample problems, which is then best explained in terms of associative learning (D'Amato, Salmon & Colombo, 1985; D'Amato, Salmon, Loukas & Tomie, 1985). Therefore, a quick use of a replica is most likely based on an understanding of it as a communicative device.

In the current study, therefore, we investigated the skills of domestic dogs – some language-trained and some not – to make appropriate inferences and behavioral responses to human communicative intentions as expressed in their use of iconic signs, specifically physical replicas and photographs. It should be noted that dogs do not seem to have difficulties perceiving two-dimensional representations (see e.g. Adachi, Kuwahata & Fujiita, 2007, for evidence that dogs can perceive their owners in photographs), but it is unclear whether dogs can understand the representational aspects of a picture.

All of the dogs were totally naïve to communication in these media. Success in this task would therefore show two things. First, it would show that these dogs' skills in use of human forms of communication are flexible as they generalize immediately to a new perceptual modality (vision versus audition) and a new type of communicative sign (iconic versus arbitrary). Second, if the dogs were to use the iconic signs quickly, simple matching to sample would be ruled out. Instead we could assume that dogs understood something of the communicative or referential intent of the human and the iconic sign as an indicator of what the human wants them to do. In a second step we further explored dogs' understanding of pictures (using the method that Preissler & Carey, 2004, used with human infants) and tested whether a linguistic dog could learn the names of new objects simply by observing their photographs being named.

Experiment 1

The aim of this experiment was to test whether domestic dogs (*Canis familiaris*) are able to fetch the correct object after being presented with an iconic sign of it (e.g. a replica or photo of the target object) in a communicative context. We also compared the performance of dogs previously trained to identify objects by their linguistic labels with that of dogs who had received no such training.

Method

Subjects

Five Border-Collies (three males, two females) participated in this experiment. All dogs were family dogs that lived as pets with their owners. Three of the dogs were experienced in fetching objects by their labels while two were naïve.

Materials

Objects were children's or dogs' toys and were all familiar to the dogs. The naïve dogs received the objects as toys 6 weeks prior to the testing period to ensure that they were familiar with them. The replicas used were either identical to the object they referred to or a miniature version of this object. The photos (297 mm × 210 mm) presented the objects in life size and on a white background (see Figure 1).

Procedure

Testing took place in two adjacent rooms of the dog owner's house or apartment. While the owner waited with the dog in one room, the experimenter arranged a set of eight familiar items (out of which he randomly selected one object as the target) in one room and then joined the owner and the dog in the adjacent room. Next, the owner was instructed to request the target by presenting the dog with one of three possible visual cues depending on condition. The owner either held up an identical replica, a miniature replica, or a photograph

Figure 1 *Examples for each type of communicative sign: Identical Replica, Miniature Replica, and Photo.*

of the target object accompanied by the command 'Bring's her' (German for 'Bring it here').[1] The identical replica was the exact same object the dog would find in the adjacent room, while the miniature replica was sometimes made of a different material than the original but resembled the original in all visual features except size.

For the experienced dogs, the specific label of the target was not used at any time during the trial. While the dog searched for the requested item in the second room, it could not see the owner or the experimenter. If the dog retrieved a correct item the owner was allowed to reward the dog (vocally and /or with food). Then the dog proceeded to the next trial. If the dog retrieved an incorrect item the request was repeated up to three times before proceeding to the next trial. Dogs received eight trials per condition. Thus, in each experimental condition the dogs were requested to fetch a total of eight target items. An object was used only once as a target item, but distractor objects could serve as distractors in more than one set. All dogs were tested with the identical replica first, then with the miniature replica, and then with the photograph of the target.

For statistical analyses we compared each dog's behavior in each condition against chance. Chance probability was calculated by summing the chance probability for each trial (e.g. chance probability for first attempt would be 1/8 for the second attempt 2/8 and so on) divided by the overall number of trials.

Results and discussion

The three experienced dogs used the identical as well as the miniature replica well above chance, with some dogs being successful from the first trial. Overall, all three of these dogs retrieved the correct target well above chance (see Tables 1 and 2 for an overview of all results). The two naïve dogs failed to successfully use the identical replica; however, one, Gale, used the miniature replica successfully.

[1] Prior to the experimental phase the two naïve dogs participated in a pre-phase to ensure that they would fetch a specific object out of distracting ones upon request. Specificity was communicated by using a gestural (pointing) cue. Both dogs were able to fetch a target object out of eight objects if their owner pointed to it accompanied by the command 'Fetch'. Cooper correctly retrieved a total of 15 out of 16 items (binomial test, $p < .001$); Gale correctly retrieved a total of 14 out of 16 items (binomial test, $p < .001$).

Table 1 *Number of trials in which dogs chose the correct target object in the different conditions. P-values based on binominal test. *indicates results different from chance*

Subject		Identical replica	Miniature replica	Photo w/choice of objects	Photo w/choice of objects + photos
Rico		6/8* $p < .001$	6/8* $p < .001$	2/8 $p = .552$	11/12* $p < .01$
Paddy		5/8* $p < .05$	8/8* $p < .001$	2/8 $p = .519$	8/12 $p = .285$
Betsy		7/8* $p < .001$	5/8* $p < .01$	6/8* $p < .01$	8/12 (7/8*) $p = .096$ ($p < .05$)
Cooper	*Round 1*	4/8 $p = .16$	3/8 $p = .651$	5/8* $p < .05$	
	Round 2	5/8* $p < .05$			
Gale	*Round 1*	4/8 $p = .281$	6/8* $p < .01$	4/8 $p = .216$	
	Round 2	5/8* $p < .05$			

For the photograph, the pattern looked different. Here only one of the experienced dogs, Betsy, was able to successfully use the photo. Of the two naïve dogs, Cooper used the photograph successfully. To test whether the two naïve dogs had learned the general idea of the task over time we repeated the 'identical replica' condition at the end of the experiment using new target objects. Now both naïve dogs were able to successfully use the identical replica to find the target object.

Dogs' successful performance with the iconic signs used in this experiment is clearly superior to that of other animal species tested in comparable settings. Even though some chimpanzees show successful performance in using scale models (Kuhlmeier & Boysen, 2001, 2002), none seem to be able to use iconic cues lacking a spatial or indexical component (Herrmann *et al.*, 2006; Scheumann & Call, 2004; Tomasello *et al.*, 1997; Tschudin *et al.*, 2001). Performance with the photograph was less straightforward. In general dogs do not seem to have difficulties in recognizing two-dimensional illustrations (Adachi *et al.*, 2007; Fox, 1971), and so the mixed results may reflect their lack of familiarity and/or practice with photographs as representations. However, it may also reflect a more fundamental difficulty with comprehending the representational aspect of photographs. This is in contrast to human children, who generally find the symbolic status of photographs easier to identify than that of physical replicas (DeLoache, 2004; Preissler & Carey, 2004).

One may argue that dogs base their choice on scent as a stimulus and are therefore less successful with the photograph where this feature is not present. This is highly unlikely for three main reasons. First, in the two conditions in which dogs were presented with a real object, there were other objects made of the same material (e.g. rubber) presented as distractors. They most likely smelled very similar. Second, in the identical condition the replica was always a new object, purchased for this study in order

Table 2 *Number of attempts in which dogs chose the correct target object in the different conditions*

Subject	Identical replica			Miniature replica			Photo w/choice of objects			Photo w/choice of objects + photos		
Attempt	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd
Rico	6	0	0	6	0	0	1	1	0	3	4	4
Paddy	3	1	1	6	2	0	1	0	0	3	3	2
Betsy	5	2	0	4	1	0	2	2	2	4	3	1
Cooper	2	2	0	0	0	3	2	2	1			
Gale	1	0	3	4	1	1	1	2	1			

to match dogs' familiar and old one. Hence, the new replica should have smelled very different from the older object that both humans and the dog had previously handled extensively. Finally, the miniature replicas were not always made of the same material, again making it highly unlikely that they smelled similar. We therefore suggest that the most plausible explanation is that dogs based their choices on the visual stimuli.

However, it could also be that dogs struggle more with the photographs because they resemble their referents less exactly than do replicas. To test this latter possibility which suggests that the dogs were simply driven by the physical resemblance between the communicative cue and the target object – as might be suggested by their better performance with replicas than photos – we conducted a second experiment. We confronted dogs with a situation in which the human communicated what she wanted with a photograph, and the dog had to decide between an identical photograph and a real exemplar of the depicted object as the intended referent. If dogs were simply matching stimuli based on physical resemblance only, we would expect them to have a strong preference for the matching photograph, whereas if they understood the photograph as a communicative representation we might expect them to prefer the depicted object.

Experiment 2

Here we confronted the three experienced dogs (as due to health problems the naïve ones could not be tested anymore) with photographs used as communicative signs, and then gave them both photographs and real objects as potential target objects to fetch. This allowed us to investigate whether, when given the choice, dogs would choose purely based on physical similarity or based on an understanding of the picture as a representational device for something other than itself.

Method

Subjects and materials

The experiment was conducted with the three experienced dogs from Experiment 1 (Rico, Betsy, Paddy), and the materials used were familiar objects and their life-sized photographic counterparts. The photographs were presented standing up (mounted on small stands) such that dogs could easily perceive and fetch them. All dogs participated in a pre-phase during which they readily fetched a piece of paper or an object, depending on which their owner pointed to.

Procedure

The general procedure was the same as in Experiment 1, but now dogs were confronted with a situation in which they had to choose the target out of a sample of four different objects and their life-sized photographic counterparts (eight objects in total). All three dogs received 12 trials. In each trial the photograph corresponded with two items of the set, one object and one photograph.

Results and discussion

Rico chose a correct item (either photo or object) in 11 out of 12 trials (binominal test, $p < .01$). Within his correct retrievals, he had a strong preference to fetch the object rather than the photo (9 of 11, binominal test, $p < .005$). To see if Rico was at all capable of fetching photos as designated objects, in a follow-up control we gave him only photographs as choices, and he was not able to choose successfully (three out of eight trials correct, binomial test, $p = .481$), suggesting that his behavior in this task was mainly guided by a general preference for fetching objects. Paddy chose a correct item (either photo or object) in eight out of 12 trials. This performance was not above chance (binominal test, $p = .285$). In all cases of correct retrieval, Paddy chose an object. Finally, Betsy fetched a correct item (either photo or object) in eight out of 12 trials (binominal test, $p = .096$); in her last eight trials she chose correctly on seven out of eight trials ($p < .05$). Betsy chose the photo in six of eight correct retrievals (binomial test, $p = .109$). Betsy's choice for the object or photo was not a result of her first passing by either one of the two, as in half of her correct choices she chose the target closer to her while in the other half it was the target further away.

If a simple matching to sample strategy underlay dogs' behavior in this task we would expect them to prefer the photograph over the object in conditions in which both items are provided as potential referents. However, from the two dogs which chose a corresponding item, and hence understood something about the photograph, none had a preference for the photograph. Instead one dog, Rico, actually preferred fetching objects. However, the fact that Rico did not choose the correct item in a situation in which only photos were presented suggests that his choice was based on a preference for objects rather than a full understanding of photographs as representational devices. Interestingly the other dog, Betsy, showed a more flexible strategy. She chose randomly between photos and objects, indicating that she was not simply matching stimuli and also not simply developing a preference for objects. Instead, Betsy was probably interpreting the communicative command in two ways, sometimes referring to the depicted object and sometimes referring to the piece of paper itself. To further explore the flexibility of Betsy's behavior we conducted a follow-up experiment with her.

Experiment 3

This experiment concerned Betsy's learning of a new word following the procedure that Preissler and Carey (2004) used with human children. As Betsy's use of photographs as communicative signs was more flexible than that of the other dogs, the question was whether Betsy would also learn new labels for objects in a context in which only a photo of the target object was labeled.

Method

Procedure

Each trial consisted of a learning phase and, 1 minute later, the retrieval phase. In the learning phase the dog was presented with the photo of a target object and the owner labeled the depicted object using a novel label. The owner held up the photo in front of the dog, got the dog's attention, then pointed to the object presented in it and repeatedly labeled the photo (German for 'Look Betsy, that's the X, what a nice X'). After several repetitions the owner put the photo aside such that the dog had no visual contact with it and then waited for 1 minute to then ask the dog to 'Fetch X'.

For retrieval, the dog was presented with a selection of four objects and their life-sized photo counterparts in the adjacent room. The dog's choice was measured as the object or photo she brought back to the owner. In general, the procedure was identical to the other experiments. Betsy received eight trials in this experiment.

Results and discussion

Betsy retrieved a correct item related to the target in five out of eight trials. This performance was not above chance (binominal test, $p = .433$). All correct retrievals were objects. During this test, Betsy retrieved an object in 14 out of 17 choices (binominal test, $p < .01$). Thus, Betsy was not able to learn labels for new objects if they were taught to her in a photograph – even though in Experiment 1 she fetched objects on the basis of being shown their photograph. Probably this new pedagogical setting confused her, as she had for years been taught object labels in association with the objects themselves. However, it may also be that learning a new label for a photograph is simply too hard a task for a dog. Interestingly, Betsy changed her choice strategy over trials in the direction of preferring objects. This could be evidence that for her labels refer to objects and not to photos. Betsy's behavior in this task thus does not clarify what her understanding of photographs is. However, a simple matching to sample strategy again cannot explain her behavior as then we would expect her to develop a bias towards fetching photographs.

General discussion

All dogs in our experiment were skillful at using replicas, either life-sized or miniature, to identify the object a human wanted them to fetch. The three of them experienced at fetching objects by name did so right away; the two inexperienced dogs became skillful after only a few trials. Therefore it is unlikely that dogs' skillful performance here is simply matching to sample, which typically requires hundreds of training trials for dogs and other animals to be successful (Callahan, Ikeda-Douglas, Head, Cotman & Milgram, 2000; D'Amato, Salmon & Colombo, 1985; D'Amato, Salmon, Loukas & Tomie, 1985). Indeed, in tasks very similar to the current one, great apes and other mammals are unsuccessful in using replicas after receiving a much larger number of trials (Herrmann *et al.*, 2006; Scheumann & Call, 2004; Tomasello *et al.*, 1997; Tschudin *et al.*, 2001). Further, if dogs' performance in the current tasks was based simply on perceiving resemblances, without any understanding of the representational nature of the replicas, then when shown a photo of the item to be fetched, they should have a preference to retrieve a similar photo – which was not the case.

We therefore think that the most reasonable interpretation of dogs' success in the replica tasks is that they understood that by showing the iconic sign the human was trying to communicate something to them. Three of the dogs understood the 'fetching' communicative frame prior to the experiment from being trained to fetch objects by name; their performance here thus shows that their previous fetching of objects by name is, again, not some narrow routine, but rather a more flexible one in which a totally new communicative sign in the visual, as opposed to the auditory, modality may be inserted. The untrained dogs learned this task very quickly, showing that dogs can master this task even without a special background of fetching objects by name. The photographs were more difficult for the dogs (still, two dogs were above chance from the beginning). One reason for that could be that dogs do not have much experience with photographs, much less in using them as representational devices. Also using pictures as representational devices is perhaps less obvious than it seems. For example, young children do not initially understand that drawings can depict real objects but they can learn this referential function if adults provide them with the right experiences (Callaghan & Rankin, 2002). Perhaps if dogs had more experience of humans using photographs to depict or communicate about real objects, they would become as skillful as they are with replicas in the current task.

Interestingly, children use pictures in tasks similar to ours at an earlier age than they use replicas (DeLoache, 1987; Preissler & Carey, 2004). This is purported to derive from children's difficulties at dual representation: they find it difficult to conceive of an object as simultaneously both a physical object and a representation of something else (DeLoache, 2004). This opposite pattern of results again raises the question of whether dogs are doing something different from the children, something more low-level and associative based on the fact that three-dimensional replicas are perceptually more similar to their referents than are two-dimensional photographs. But the fact that dogs did not prefer photos over objects when shown a photo as the communicative sign shows that this is not the case. Our own hypothesis, therefore, is that the dual representation problem that human children experience is related to their strong propensity to grasp and manipulate objects – which is what actually conflicts with attempts to see an object as a representation for something else (Tomasello *et al.*, 1999). Obviously, dogs do not have this same manipulative predisposition and so are not subject to dual representation problems. Therefore dogs' greater difficulties with photos most likely reflect their lack of experience with them, and so perhaps they could be trained to be more skillful with photos.

How do we explain dogs' superior performance in the current tasks as compared with great apes and other species? It is unlikely that it has to do with anything perceptual, or with anything involving basic learning processes, as these should be similar across most mammals. More likely is the hypothesis that apes – as well as most other mammals without human training – do not fully grasp the informative and cooperative nature of human communication (Tomasello, Carpenter, Call, Behne & Moll, 2005). Dogs, however, are especially sensitive to human cooperative communication (for an overview see Miklosi & Soproni, 2006). This seems to be most likely a special adaptation to human societies and a result of dogs' long history with humans (Hare *et al.*, 2002; Hare & Tomasello, 2005; Miklosi, Kubinyi, Topal, Gacsi, Viranyi & Csanyi, 2003). The nature of this understanding is still at issue, however, as some argue that dogs are simply more attentive to such things as the human face, vocalizations, and gaze direction than are undomesticated animals (Call, Bräuer, Kaminski & Tomasello, 2003; Viranyi, Topal, Gacsi, Miklosi & Csanyi, 2004). It is also possible that they understand something deeper about human communication involving something like reference and representation. If dogs could also learn to identify specific referred-to objects in other communicative frames not involving fetching, this would be additional evidence of their skills in comprehending human communication in novel contexts.

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