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Do dogs distinguish rational from irrational acts?

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Range et al. (2007, *Current Biology*, **17**, 868–872) found that dogs, *Canis familiaris*, copy others' means to achieve a goal more often when those means are the rational solution to a problem than when they are irrational. In our first experiment, we added a further control condition and failed to replicate this result, suggesting that dogs in the previous study may have been distracted in the irrational condition rather than selectively attending to the irrational nature of the action. In a second experiment, the demonstrator used an unusual means (an extended leg) to communicate the location of food, either rationally (her hands were occupied) or irrationally (she could have used her hand). Dogs succeeded in finding the food irrespective of whether the leg action was rational or irrational. Our results suggest that dogs do not distinguish rational from irrational acts, instead simply being proficient at monitoring human behavioural patterns.

From an early age, human children interpret others' actions as goal-directed in social-learning situations, for example, copying their intended rather than their actually performed acts (Meltzoff 1995), and their purposeful rather than accidentally performed acts (Carpenter et al. 2005). In addition, Gergely et al. (2002) showed that 1-year-old children copy others' actions based on their 'rationality', that is, based on the assumption that actors take into account constraints on behavioural efficiency. Specifically, infants watched an adult turn on a lamp using her forehead. Half of the infants observed this action while the adult's hands were occupied by holding a blanket, making this a reasonable, efficient 'back-up action plan', whereas the other half of the infants saw the same action but here the adult's hands were free (while a blanket was merely placed around the adult's shoulder), which made her choice of means inexplicably inefficient. Infants who observed the adult perform the unusual means when she had a good alternative later reproduced this unusual action more than those who observed the adult being forced to use this action because of the lack of a good alternative. This study has been interpreted as evidence that children from an early age understand the efficiency or 'rationality' of others' actions (Gergely et al. 2002; Buttelmann et al. 2007, 2008).

In recent years several pieces of evidence have suggested that nonhuman species may also be able to interpret the rational dimension of others' actions. For example, Buttelmann et al. (2007) had human-raised and -trained chimpanzees, *Pan troglodytes*, observe a human perform actions using unusual means such as switching on a light with his foot rather than his hand. As in the studies with human infants, sometimes the means were rational because the experimenter's hands were occupied, but sometimes they were irrational, because his hands were free. Just like human infants, these chimpanzees copied the unusual means more when the experimenter's hands were free than when they were occupied, suggesting that they attend to the rationality of others' intentional actions (see also Buttelmann et al. 2008).

There is also evidence that a species more distantly related to humans, the domestic dog, *Canis familiaris*, copies others' actions more often when those actions are the efficient ('rational') solution to a problem than when they are not. Range et al. (2007) had a demonstrator dog move a rod attached to a box down to release a piece of food. This effect on the box could be achieved in two separate ways: the rod could be pushed down with the paw or it could be pulled down with the mouth. As established in a baseline condition, using the mouth was the preferred method employed by

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naïve dogs (i.e. witnessing no demonstration). The demonstrator dog, however, always used the less preferred action (the paw) to operate the rod. Sometimes this was the efficient/rational thing to do because the dog carried a ball in her mouth, making it impossible for her to use her mouth. Alternatively, using the paw was an inefficient/irrational thing to do, because the demonstrator did not carry a ball in her mouth, thus eschewing the preferred action for no reason.

In line with human infants and human-raised chimpanzees, observer dogs preferred to use the mouth when they had observed the demonstrator using the paw with her mouth occupied, but they preferred to use the paw when they had observed the demonstrator using the paw with her mouth free (Range et al. 2007). This indicates that dogs not only attend to others' goal-directed actions during demonstrations, but also that they copy others' choice of means to perform a certain action. The finding of both action copying and selectivity is difficult to reconcile with previous studies of social learning in dogs, which claim that dogs' social-learning skills may not be very sophisticated. For example, Tennie et al. (2009a) had a demonstrator dog perform one of two trained actions (e.g. rolling over) upon hearing a verbal command (followed by a reward each time). After observing this demonstration five times, observer dogs still failed to copy any of the demonstrated actions in this setting, even though observers saw the demonstrator receive food after each successful performance. This paradigm was substantially different from the Range et al. (2007) study, for example the actions were intransitive rather than transitive (object-directed), but still it seems that dogs may not be particularly robust imitators in all situations.

In most studies testing rational imitation in children or primates, researchers control for the differential influences of the potential distractor/activator objects. In the studies of Gergely et al. (2002) and Buttelmann et al. (2007) those objects (e.g. the blanket in the Gergely et al. 2002 study) had been present in both the restrained and unrestrained conditions. For example, in Gergely et al.'s study the blanket around the demonstrator's shoulders could have distracted the children and/or could have activated certain behaviours (perhaps 'placing the head to sleep'). Thus, if the blanket were present only in their hands-occupied condition, then this could have had the potential to explain their findings. In other words, it is important to control for the effects of such objects. The Range et al. (2007) study was missing such a key control condition. In Range et al.'s two main conditions observer dogs watched the demonstrator dog use her paw either with a ball in her mouth or with no ball present in the situation at all. This opens the possibility that the dogs tested by Range et al. may have been doing something other than taking into account the rationality/efficiency of the demonstrator's actions, and that they may have acted differentially across conditions based on the presence or absence of this object (i.e. the ball). Thus, an object control for this study is currently missing, which would be to have a ball present and visible, but not in the demonstrator's mouth, to see whether the mere presence of a ball affects observers' behaviour (e.g. by priming the observers' tendency to grasp things with their mouths).

In this study, we first attempted to replicate the findings of Range et al. (2007) using this alternative control condition. We then used a different experimental paradigm, with a completely different response measure, to test for dogs' ability to assess the efficiency/rationality of others' actions. Dogs routinely use the human pointing gesture to find hidden food (reviewed in Miklósi & Soproni 2006). In our second experiment, the human used an unusual means to communicate the location of a hidden piece of food: extending her leg in its direction. Sometimes this was the rational thing to do because her hands were occupied (by holding a heavy book) and sometimes this was irrational as her hands were free. If dogs attend to the rationality of others' actions, they should discriminate between the rational and irrational cue, performing better when the cue is rational because the irrational cue may represent a random movement, rather than a deliberate signal.

EXPERIMENT 1

This experiment aimed to replicate Range et al.'s (2007) finding that dogs reproduce others' actions selectively based on an interpretation of the efficiency of those actions. In this experiment, we used the same basic method used by Range et al. (2007) but we added two additional control conditions.

Methods

Subjects

We used 74 dogs, which lived as pets with their owners. Most dogs had a special training background with regard to certain activities such as dog dancing or agility (see Table 1 for a detailed description). Dogs were selected based on breed and training background to match the dog sample used by Range et al. (2007) to the highest degree possible. Dogs were tested with their owners present. The demonstrator dog was a 3-year-old female Border collie. Again this dog was chosen to match the breed and sex of the demonstrator dog in the original Range et al. (2007) study.

Materials and experimental set-up

The apparatus (Fig. 1) was a replica of the one used in Range et al. (2007). To release the food, the operator had to pull down a wooden bar in the direction of gravity. This then opened the baited box and let the food drop to the ground. The apparatus was attached to a large stable object, such that dogs could be tested outdoors or indoors, depending on the weather conditions. The apparatus was attached such that the wooden bar (the manipulandum) was hanging at the level of the dog's shoulder.

Each dog had to pass a pretraining task to enter the experimental phase.

Procedure

Pretraining. To ensure that dogs were able to perform both potential actions on the wooden bar ('mouth' and 'paw'), we first trained them in the task (again, to follow the method used by Range et al. 2007). This pretraining was conducted by the experimenter (M.N.), not the owner (as was the case in the original Range et al. 2007 study). In this pretraining, dogs did not act on the actual apparatus but instead on a toy ring (22 cm in diameter, 2.5 cm thick), which they had to pull with their mouth or paw. The mouth action resembled a tug of war game, familiar to most dogs, while the paw action resembled the 'Give paw' command (with which all dogs were familiar). The experimenter used a certain command for each action (e.g. 'Zieh', German for 'Pull' for the mouth action and e.g. 'Gib Pfötchen', German for 'Give paw' for the paw action). These were commands that the dogs were familiar with and that were not used in the actual experiment. Half of the dogs in each group began by learning the mouth action and then continued with the training for the paw action; the other half learned the actions in the opposite order. The training for each action was considered completed when dogs performed the action successfully in five consecutive trials. The experimenter continued with the training until the task was fulfilled. However, if dogs showed no interest in participating or did not want to touch the ring they were excluded from the experiment. Ninety-eight dogs had to be excluded, as they did not pass the pretraining task. Twenty-eight additional dogs passed but had to be excluded afterwards because they were not motivated or were scared to act on the test apparatus.

Table 1
Name, age, gender, breed and training background of the dogs participating in experiment 1

Name	Age (years)	Gender	Breed	Training background	Condition
Bert	4	M	Mongrel	Trick dog, Dog dancing, Companion dog	Ball
Anka	11	F	Border collie–Mongrel		Ball
Butch	8	M	Boxer–Mongrel		Ball
Capone	2	M	Golden retriever	Trick dog, Dog dancing	Ball
Duke	2	M	Giant schnauzer		Ball
Panda	12	M	Staffordshire terrier–Mongrel		Ball
Punk	7	M	Labrador–Mongrel		Ball
Cassy	2	F	Mongrel	Agility	Ball
Fara	7	F	Border collie–German shepherd		Ball
Frida	1	F	German shepherd–Mongrel		Ball
Lotte	1	F	Labrador retriever		Ball
Amy	4	F	Labrador retriever		Baseline I
Altai	8	M	Border collie	Rescue	Baseline I
Arthos	6	M	Labrador retriever	Rescue, Agility, Companion dog	Baseline I
Balou	3	M	Flat-coated retriever	Trick dog	Baseline I
Balou	5	M	Schapendoes	Dog dancing	Baseline I
Clash	3	M	Border collie	Trick dog	Baseline I
Linus	3	M	Golden retriever	Agility	Baseline I
Pitu	1	M	Border collie	Dog dancing	Baseline I
Theo	5	M	Labrador retriever	Agility, Companion dog	Baseline I
Carrie	2	F	German wirehaired pointer	Gun dog	Baseline I
Daisy	4	F	Labrador retriever	Agility	Baseline I
Laila	5	F	Labrador retriever	Agility	Baseline I
Luna	6	F	German shepherd–Mongrel	Trick dog	Baseline I
Maya	2	F	Labrador retriever	Dummy	Baseline I
Dusty	4	M	Border collie	Rescue, Companion dog	MF
Emir	3	M	Labrador retriever	Agility, Dummy	MF
James	9	M	Border collie	Agility, Obedience, Dog dancing, Companion dog	MF
Jazz	3	M	Border collie	Agility	MF
Emily	4	F	Labrador retriever	Agility, Companion dog	MF
Lennon	2	M	Border collie	Companion dog, Agility, Obedience, Trick dog	MF
Mo	1	M	Border collie	Agility	MF
Rudi	5	M	Airedale terrier	Companion dog	MF
Spike	2	M	Border collie		MF
Grappa	9	F	Border collie	Dog dancing	MF
Willow	8	M	Rottweiler	Agility	MF
Karah	4	F	Labrador retriever	Rescue, Companion dog	MF
Kira	2	F	Boxer–Mongrel	Agility, Trick dog	MF
Laika	7	F	German shepherd	Agility, Klicker	MF
Mia	3	F	Golden retriever	Rescue	MF
Momo	5	F	Border collie	Agility, Companion dog	MF
Tami	2	F	Australian shepherd	Dog dancing	MF
Asra	11	F	Mongrel	Agility	MO
Baghira	3	F	German shepherd–Mongrel	Agility	MO
Cassie	2	F	Australian shepherd	Agility	MO
Cheyenne	2	F	Malinois	Agility, Companion dog	MO
Gin	6	F	Border collie	Companion dog, Agility, Dog dancing, Obedience	MO
Arrow	4	M	Border collie	Agility, Trick dog	MO
Ben	7	M	Border collie	Agility	MO
BJ	7	M	Border collie	Companion dog, Agility, Dog dancing	MO
Bow	3	M	Border collie	Agility, Obedience	MO
Filou	7	M	Australian shepherd–Mongrel	Schutzhund	MO
Leya	1	F	Border collie	Companion dog, Agility, Obedience, Trick dog	MO
Fly	2	M	Border collie	Companion dog, Agility, Obedience	MO
Glen	6	M	Border collie	Agility, Companion dog, Trick dog, Dog dancing	MO
Jiminy	7	M	Border collie	Companion dog, Agility, Dog dancing, Obedience, Trick dog	MO
Maylo	7	M	German shepherd–Mongrel	Agility	MO
Nicky	3	F	Malinois	Agility, Companion dog	MO
Skaos	5	M	Border collie	Trick dog	MO
Pine	4	F	German shorthaired pointer	Gun dog	MO
Wanja	10	F	Altdeutscher huetehund	Agility, Companion dog	MO
Asta	1	F	Magyar vizsla	Agility	Baseline II
Cheyenne	8	F	Golden retriever	Companion dog, Obedience, Agility, Dummy	Baseline II
Luna	2	F	Labrador retriever	Agility, Dog dancing, Trick dog	Baseline II
Maxi	5	F	Beagle–Mongrel	Agility, Dog dancing, Trick dog	Baseline II
Arco	4	M	German shepherd	Agility, Schutzhund	Baseline II
Balu	4	M	Mongrel	Agility, Obedience	Baseline II
Ben	3	M	Golden retriever		Baseline II
Shati	1	F	Hollandse herder	Dog dancing, Trick dog	Baseline II
Dojan	5	M	Golden retriever–Mongrel	Companion dog, Obedience	Baseline II
Hook	1	M	Border collie	Agility	Baseline II
Taira	1	F	Labrador retriever–Mongrel	Agility	Baseline II
Lenny	7	M	Border collie	Companion dog, Obedience, Dog dancing	Baseline II
Merlin	4	M	Border collie	Agility, Obedience, Companion dog	Baseline II

See text for details of all conditions.

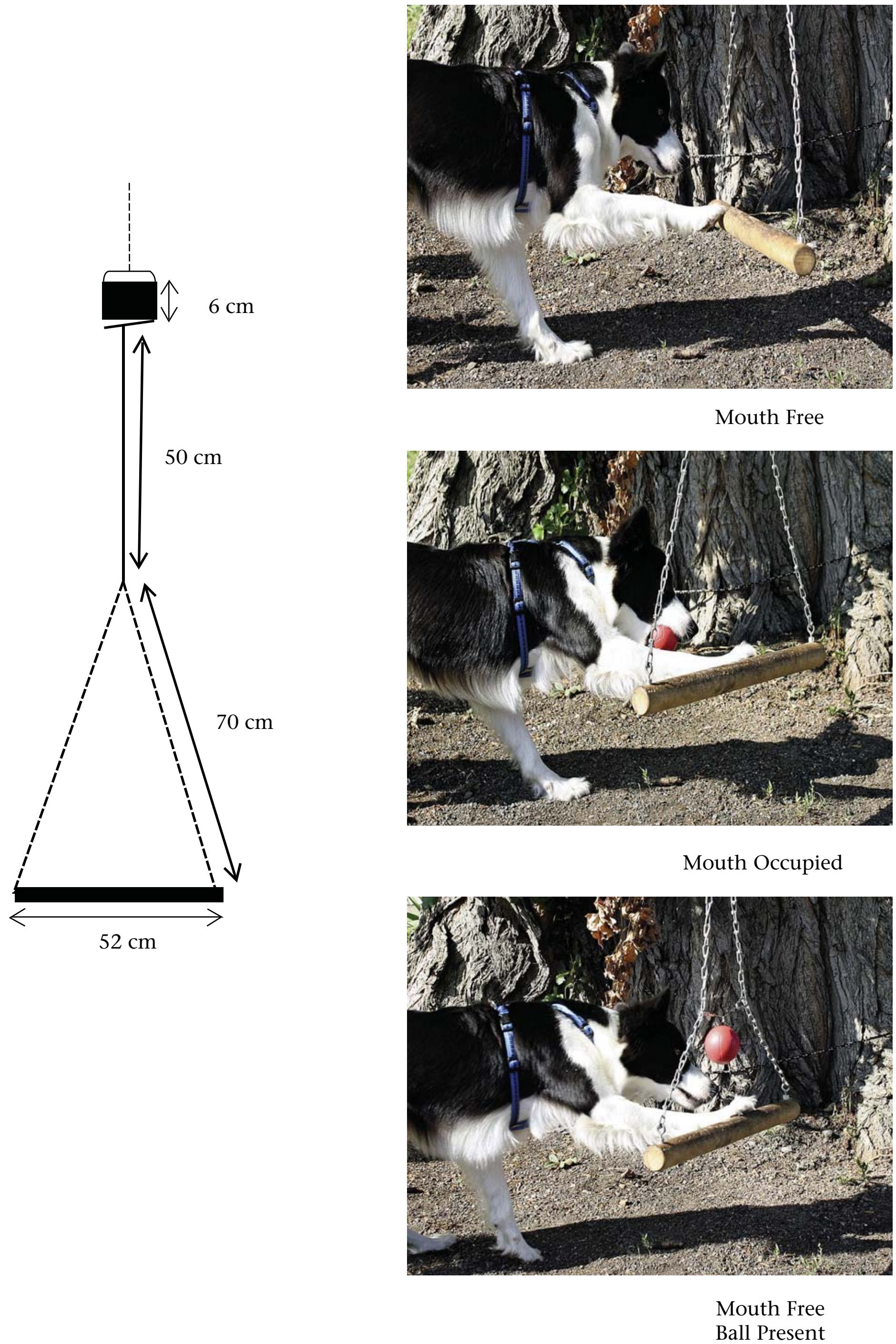


Figure 1. The apparatus used in and the general setting of experiment 1 and the behaviour of the demonstrator dog in the different experimental conditions.

Experimental phase. The general procedure for the experimental trials was identical for all groups. The owners of the dogs were present throughout the procedure. They were not informed about the purpose of the experiment; the only information they received was that their dog was going to see something and then later had to act on the apparatus. During demonstration, the owners wore a mask that covered their eyes, such that the owners did not know what their dog had observed (except in the 'No Demo: Owner Knowledgeable and No Ball Present' condition).

The subject was placed perpendicular to, and 2 m from, the apparatus (see Fig. 1) and was held by the owner. A curtain, which was opened or closed, depending on the condition, was placed in front of the subject. The demonstration started when the experimenter showed the subject the food and placed it in the apparatus in full view of the subject. Upon receiving the command 'Ring', the demonstrator dog performed the demonstration. Subjects were randomly assigned to one of five possible groups. There were 11–19 subjects in each group (see Table 1). Each group received 10 demonstrations before the experimental phase and then eight experimental trials altogether. The demonstrations depended on the condition.

(1) No Demo: Owner Ignorant and No Ball Present (Baseline I). The curtain was closed such that the subject saw no demonstration

before it had a chance to act on the apparatus. However, to ensure that the owners had the impression that the dogs actually saw something, the demonstrator dog acted on the apparatus behind the closed curtain such that the owner and the subject heard the demonstration but they did not see it.

(2) No Demo: Owner Knowledgeable and No Ball Present (Baseline II). The general setting was comparable to the previous condition with the only exception that in this condition the owners' eyes were not covered by the mask so that they knew that the subject had not seen a demonstration of any kind. The demonstrator dog was not present. This condition corresponds to Range et al.'s (2007) 'No Demo' condition.

(3) Demo: Mouth Occupied and Ball Present (Mouth Occupied). This condition was identical to the previous one except that subjects witnessed the demonstrator dog act on the apparatus, using the paw action and carrying a ball in her mouth. This condition corresponds to Range et al.'s (2007) 'Mouth Occupied' condition.

(4) Demo: Mouth Free and No Ball Present (Mouth Free). In this condition the curtain was open such that the observer dogs witnessed the demonstrator dog act on the apparatus, using the paw action and having the mouth free. This condition corresponds to Range et al.'s (2007) 'Mouth Free' condition.

(5) Demo: Mouth Free and Ball Present (Mouth Free + Ball). This condition was identical to the previous one except that subjects observed the demonstrator dog act on the apparatus using the paw action while a ball was hanging from the apparatus (which remained untouched during the demonstration).

After each demonstration, the subject could take the food produced by the apparatus ('scrounging') and was then led back to the initial location before receiving the next demonstration. Subjects received 10 demonstrations before they proceeded to the first (of eight) experimental trials and were allowed to act on the apparatus. After the demonstrations, the owner guided her dog to a predetermined point 1 m away from the apparatus. The experimenter baited the apparatus with food in full view of the subject. The owner was then allowed to motivate her dog to interact with the apparatus. The owners were not allowed to touch the apparatus or use any command known to the dog, but they were allowed to indicate the rod by extending their arms towards it and were also allowed to say things such as 'Where is the food' to motivate their dog. If the dog produced the food she was allowed to eat it. After that, the subject proceeded to the next experimental trial. If the dog was not successful within approximately 10 min, the subject also proceeded to the next experimental trial. Each dog participated in eight experimental trials altogether.

The majority of dogs were tested outdoors ($N = 53$), but 15 were tested indoors. The majority of dogs were familiar with the environment they were tested in ($N = 48$), but 20 were unfamiliar. Neither factor affected the dogs' behaviour.

Coding

We scored the paw and mouth actions directed to the rod in the apparatus. A paw action was defined as placing the paw on the bar such that the dog's leg was approximately parallel to the ground. A mouth action was defined as grabbing the bar between the dog's teeth. Dogs that consistently used other actions (e.g. jumping at the bar) to release the food were excluded from the analysis. A second coder naïve to the purpose of the experiment coded the first successful action for 20% of the dogs in each condition for reliability purposes. Reliability was 100% (Cohen's Kappa = 1, $N = 22$).

Results

Similar to Range et al. (2007), we first looked at subjects' first successful action irrespective of whether it appeared in the first or a subsequent trial. Table 2 gives an overview of the number of dogs performing paw or mouth actions in the first successful attempt to solve the apparatus in each of the five conditions. There was a significant difference between conditions in the percentage of dogs that used the paw to operate the apparatus ($\chi^2_4 = 21.71$, $N = 68$, $P < 0.001$).

In a second step we combined the first successful action data from different conditions based on two variables that we thought might affect dogs' behaviour. One variable was whether dogs saw a demonstration or not; the other was whether a ball was present or not (see Table 2). The presence of a demonstration had no effect on performance (Fisher's exact test: $P = 0.128$ based on comparing the baseline conditions with the other conditions; Table 2). In contrast, when a ball was present dogs used significantly more mouth than paw actions (Fisher's exact test: $P = 0.029$ based on comparing the 'Mouth Occupied' and 'Mouth Free + Ball' conditions with the other conditions; Table 2).

Next, we looked at the mean percentage of all trials in which dogs performed a paw action in each condition (note that these data mirror the mean percentage of trials in which dogs performed a mouth action). We conducted a one-way ANOVA to see whether condition had an effect on dogs' behaviour. Dogs' use of their paw did not depend on condition ($F_{4,67} = 0.707$, $P = 0.59$). We then pooled the data for the different conditions based on the same criteria as above (Demonstration versus No Demonstration, Ball versus No Ball; see Fig. 2) and compared the dogs' performance. When a ball was present dogs performed significantly fewer paw actions than when no ball was present (independent-sample *t* test: $t_{66} = 2.342$, $P = 0.022$). This result was also supported when both variables were compared to chance (with chance being 50%, since there were two possible actions that could be used). When there was no ball present, dogs did not prefer either of the two actions (one-sample *t* test: $t_{39} = 0.667$, $P = 0.509$). When a ball was present, dogs used the paw significantly below chance levels (one-sample *t* test: $t_{27} = 2.568$, $P = 0.015$).

The demonstration also tended to affect dogs' behaviour, as there was a nearly significant difference in the frequency of paw use between demonstration and nondemonstration conditions (independent-sample *t* test: $t_{66} = 1.982$, $P = 0.052$). However, here dogs used the paw (demonstrated) action significantly below chance when there was a demonstration (one-sample *t* test: $t_{43} = -2.033$, $P = 0.048$), while dogs behaved randomly when there was no demonstration (one-sample *t* test: $t_{23} = 0.962$, $P = 0.346$).

Comparison with Range et al. (2007)

To compare our data with Range et al.'s (2007), we combined the data from our two no demonstration conditions, which did not differ statistically (Fisher's exact test: $P = 0.42$; Table 2), in order to have a comparable number of dogs in each group. The behaviour of the dogs in the two experimental conditions did not differ from that of the dogs in Range et al. (2007). This was true for the 'Mouth Free' condition (current experiment: Mouth: 7; Paw: 9; Range et al. 2007: Mouth: 3; Paw: 15; Fisher's exact test: $P = 0.13$) as well as the

Table 2
The number of dogs in each of the conditions that performed mouth or paw actions in their first successful attempt at solving the apparatus

Condition	Demonstration	Ball present	Mouth	Paw	N
Baseline I	No	No	6	7	13
Baseline II	No	No	3	8	11
Mouth Occupied	Yes	Yes	11	6	17
Mouth Free	Yes	No	7	9	16
Mouth Free + Ball	Yes	Yes	8	3	11
Sum			35	33	68

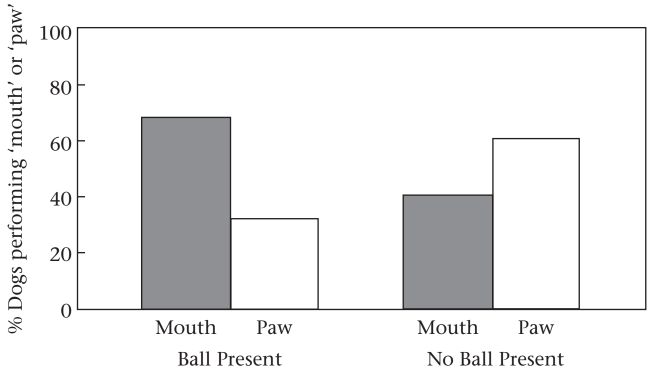


Figure 2. Mean percentage of dogs using paw or mouth actions in their first successful attempt at solving the apparatus.

'Mouth Occupied' condition (current experiment: Mouth: 11; Paw: 6; Range et al. 2007: Mouth: 15; Paw: 4; Fisher's exact test: $P = 0.46$).

However, dogs' behaviour in the 'no demo' condition differed significantly from the behaviour of the dogs in the Range et al. (2007) study. While in our 'no demo' condition dogs chose randomly between the two actions (Mouth: 9; Paw: 15), the dogs in the Range et al. study had a significant preference for the Mouth action (Mouth: 11; Paw: 2), which led to a significant difference between the two groups (Fisher's exact test: $P = 0.014$).

Discussion

We did not succeed in replicating Range et al.'s (2007) findings. Instead, our findings suggest that ball presence strongly affected dogs' behaviour and thus may explain Range et al.'s (2007) results in their demonstration condition. However, the most peculiar difference between their study and ours was between their baseline conditions and ours. While in our baselines (which both produced similar results) dogs did not have a preference for one action over the other, in the original Range et al. (2007) study naïve dogs showed a significant preference for the mouth action. This difference in dogs' behaviour between studies is difficult to interpret. We followed the protocol of Range et al. (2007) to the best degree possible. Within our setting, we replicated the findings for our baseline because we conducted two baselines, which both produced the same result. This is interesting in itself as it suggests that 'Clever Hans effects' (based on the owner's knowledge of what happened before their dog acted on the apparatus) do not seem to influence the dogs' behaviour. It is possible that Austrian and German dogs differ significantly in their dispositions for acting on a novel apparatus. This difference, paired with the confound of the ball's presence in the experimental condition, may have contributed to the observed differences between studies. However, to date there is no evidence of significant differences in any domain between Austrian and German dogs. Unlike Range et al. (2007) we found no support for the idea that dogs imitate selectively depending on the situational constraints faced by the demonstration.

It could be argued that even though the dog breeds and the training background of the current dog sample have been matched as closely as possible to that of Range et al. (2007), the dogs' random grouping may have caused the behavioural differences between the studies. Even though this explanation is rather unlikely, this would show that the effect presented by Range et al. (2007) is more than fragile and that it cannot be extended to the dog population in general.

An obvious difference is also that the drop-out rate in the current experiment was high, with most dogs failing the pretraining task in which both actions were trained. It may be that our criteria for dog inclusion were stricter than Range et al.'s (2007) and that for this reason the dogs in the current experiment treated both actions as similarly accomplishable (because we trained both actions similarly). This may explain why dogs in the baseline had no preference for one action over the other. However, only if both actions are in the dogs' repertoire can we ascertain whether witnessing a demonstration truly affects the dog's choice of actions; otherwise it could simply be that one action is more familiar than the other.

One important finding of the current experiment is that the mere presence of a ball can have a strong effect on the observer dogs' behaviour. Subjects in this experiment did not frequently copy the demonstrated paw actions. In fact, seeing such a demonstration, if anything, produced the opposite effect. Instead, the strongest determinant of performance was whether observer dogs had seen a ball before they acted on the apparatus themselves. Seeing a ball led to more mouth actions in observer dogs. This was irrespective of whether the ball was in the demonstrator's mouth (thereby forcing the demonstrator to use the paw), or whether it was simply hanging from the apparatus (without the demonstrator even touching it). This finding therefore need not be explained within a framework that includes the suggestion that dogs attend to the means that others use to fulfil their goal. It is conceivable that seeing the ball triggered the mouth response, irrespective of the context in which it was observed (contrary to the claims of Range et al. 2007). There is evidence that the exposure to a certain stimulus can trigger a certain action. Huffman & Hirata (2004) showed that if exposed to certain leaves, naïve chimpanzees start performing 'leaf swallowing', which includes complex action sequences of folding the leaves before swallowing them. This behaviour had previously been regarded as culturally transmitted. Thus even though leaf swallowing seems to be socially influenced to some extent, our results suggest that this behaviour is based on certain propensities to perform those actions when exposed to the leaves (see Tennie et al. 2009b for a review and interpretation of such studies).

Although our results cast some doubt on dogs' abilities for rational imitation, it is still conceivable that dogs may be capable of determining the rationality of others' actions based on situational constraints in other behavioural domains. Thus, in our second experiment we used a methodology in which dogs are known to excel: a communicative setting in which a human points for the dog to indicate the location of food. Dogs are known to be proficient at using a human-given pointing gesture (for an overview see Miklósi & Soproni 2006). However, it is still unknown whether dogs distinguish rational from irrational acts within this context.

EXPERIMENT 2

In this experiment we aimed to test whether dogs would distinguish rational from irrational actions in a communicative setting. We tested whether dogs would interpret an unusual communicative gesture (the extension of a leg) as communicative, depending on the situational constraints experienced by a human informant. In one context the human's hands were occupied (because she was holding a heavy book), so that using the leg was a rational means to communicate, while in another context, the human's hands were not occupied, making it irrational for the experimenter to use her leg. Therefore the extension of the leg in this context could be interpreted as a random action, not meant to communicate anything.

Methods

Subjects

Forty-two dogs (21 males, 21 females) living with families as pets participated in this study. Dogs were recruited via a database at the Max Planck Institute in Leipzig/Germany and tested without their owners present.

Materials

Food was placed under one of two identical boxes (23 × 14.5 cm and 12.5 cm high) 2 m apart and resting on a board, which was 1.5 m from the dog. In the rational condition the experimenter held a book (17 × 24 × 6 cm) in her hands.

Procedure

Warm up. Each dog received a warm up. The aim of the warm up was to ensure that dogs knew that there was only one piece of food at a time and also to familiarize them with the general procedure. Food was hidden in full view of the dogs in one of the two containers and then the dog was allowed to make a choice. The dog passed the warm up when it chose correctly in four consecutive trials. Location of the food was counterbalanced and semi-randomized with the stipulation that it could not be in the same location in more than two consecutive trials.

Experimental procedure. After a successful warm up, dogs were randomly assigned to one of two groups. Dog and experimenter faced each other at a distance of 2.80 m. The dog was held by a helper, who was standing behind the dog. First, a curtain placed in front of the dog was closed so that the dog did not see the baiting of the cups. The experimenter then hid food in one of the two containers, always touching the left container first. After the baiting, the curtain was opened and the experimenter performed an unusual action, a leg movement, to indicate the target location (Fig. 3). This leg movement was performed in one of two contexts.

(1) Rational context. The experimenter stood behind both containers, with her arms extended forward holding a heavy book in her hands. The experimenter obtained the dog's attention by calling the dog's name once. She then looked at the dog and repeatedly indicated the correct location by extending her leg towards it. The leg movement was repeated three times. Then the experimenter returned her leg to its original position and stood still, still holding the book in her hands, and the dog was allowed to make a choice. While the dog was choosing, the experimenter did not indicate the food's location in any way.

(2) Irrational context. The procedure in this context was identical to the one above with the only exception that in this condition the experimenter was not holding a book in her hands. Instead she only extended her arms forward with her hands remaining empty.

One group of dogs observed the rational context while the other observed the irrational one. All trials were videotaped and later coded. A dog was considered to make a correct choice when it approached the correct container within 10 cm. If the dog approached the correct container, the food was presented to him and he was allowed to eat it. If the dog approached the incorrect container, the dog was shown that it was empty and where the food was hidden but was not allowed to eat it. In the rare case that dogs made no choice after 1 min or if the experimenter made a mistake, the trial was repeated at the end of the session (for two subjects two trials had to be repeated and for another three dogs one trial had to be repeated). Dogs in both groups received 12 trials, which were presented to them in a single session. The location of the food was counterbalanced and semirandomized with the stipulation that food could not be in the same location in more than two consecutive trials.

A second coder, naïve to the purpose of the study, coded 20% of the original material for reliability purposes. Reliability was excellent, as the coders were in 100% agreement (Cohen's Kappa = 1.0, $N = 107$).

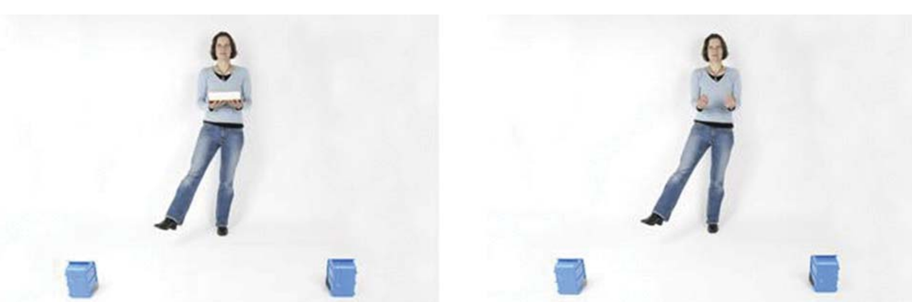
Results

We looked at the mean percentage of trials in which subjects used the leg movement as a cue to the target location (Fig. 4). A comparison of the rational with the irrational context revealed that subjects followed the leg movement equally irrespective of the context (independent-sample t test: $t_{20} = 1.02$, $P = 0.31$). Subjects used the leg movement to locate the food above chance levels (50%) both in the rational (one-sample t test: $t_{20} = 4.69$, $P < 0.0001$) and irrational conditions (one-sample t test: $t_{20} = 2.71$, $P = 0.014$).

We also looked at the first trial data. In the rational condition 14 dogs followed the cue in the first trial, while seven dogs chose incorrectly (binomial test: $P = 0.19$). In the irrational condition 11 dogs followed the cue while 10 dogs chose incorrectly (binomial test: $P = 1.0$). The conditions were not significantly different from each other (Fisher's exact test: $P = 0.53$).

Discussion

We found no conclusive evidence that dogs take into account the situational constraints faced by an experimenter when interpreting the communicative actions of a human informer. Dogs used the leg movement as a cue to find the hidden food irrespective of whether it was the rational or an irrational means to communicate. In the context in which the experimenter's hands were free, dogs could have interpreted the human's action as a random movement not related to finding the food. There is evidence that dogs indeed distinguish random from intended movement in a communicative setting (J. Kaminski, L. Schulz & M. Tomasello, unpublished data; see also Soproni et al. 2001). However, in the previous studies intentionality was established through eye contact, which may be easier for dogs to assess. In the current experiment, dogs needed to interpret the human's goal of using her hand, if it were free. Instead dogs seemed to interpret the cue as it was given, as a hint for the location of the food, irrespective of the rationality of the action.



Rational Irrational

Figure 3. The gesture used in both contexts of experiment 2, rational and irrational.

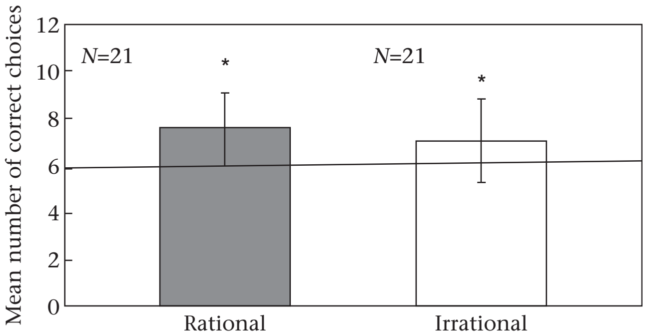


Figure 4. The average number of correct choices with the rational or irrational communicative means. Vertical lines indicate SEs. An asterisk indicates significantly different from chance.

It could be that dogs do not understand that when a human is holding a book her hands are occupied and therefore are no longer available to use. Even though dogs will certainly have experienced situations in which a human's actions were restricted because her hands were occupied, the fact that she is holding a book may not be a piece of contextually relevant information for the dog. Also, it is possible that dogs are so motivated to follow a human's cues that the means by which the human communicates are not relevant. Soproni et al. (2002) demonstrated that dogs ignore communicative means that are too arbitrary, such as using a stick to point instead of the hand. Thus it seems that as long as the behaviour is within the repertoire of normal human movements, dogs will use the action as a cue to the location of hidden food whether it is a rational act on behalf of the cue-giver or whether the act is completely arbitrary (see also Udell et al. 2008).

GENERAL DISCUSSION

Our experiments provide no conclusive evidence that dogs take into account the rationality underlying others' choice of means in either social-learning or communicative situations. The first experiment showed that dogs' choice of action towards an apparatus did not depend on seeing a demonstration of a certain action. This experiment therefore provided no evidence that dogs attend to others' means of accomplishing a goal. Our second experiment also demonstrated that dogs do not attend to the rationality of others' means in a more communicative setting. Dogs followed the unusual means to communicate irrespective of whether it was a rational or irrational choice. Therefore the current experiments suggest that dogs utilize their own means to achieve a goal, and will capitalize on humans' cues to find hidden food, without regard to the intentions of a social demonstrator or cue-giver.

There is evidence that dogs monitor others' behaviour. Dogs can benefit from observing others in social-learning situations (Pongrácz et al. 2001, 2003a, b, 2004; Miller et al. 2009). Even though most findings can be explained by local or stimulus enhancement, dogs are capable of observing others to their own benefit. The same is true in more communicative settings. Dogs benefit greatly from exploiting humans' communicative information, and a large body of evidence suggests that dogs use several visual communicative gestures (e.g. pointing gestures) to find hidden food or a target object (Hare et al. 1998, 2002; Miklósi et al. 2003; Bräuer et al. 2006; Riedel et al. 2008; Udell et al. 2008). It is, however, still an open question whether dogs monitor others' behaviour under the assumption that others have goals of their own, or a goal to share information. The only piece of evidence so far that suggests that dogs may indeed interpret others' behaviour as goal-directed comes from the Range et al. (2007) study discussed here. We failed to replicate the findings from Range et al. (2007) and instead offer an alternative explanation of the dogs' behaviour. Our findings are best explained as evidence that the sheer presence of the ball triggered a mouth response and that no further interpretation of the context occurred. This may also explain why in the original Range et al. (2007) study the effect of condition vanished after the first trial.

Interpreting others' behaviour as goal-directed and attending to the means by which others perform certain actions would surely be beneficial in predicting others' behaviour, especially in novel situations (Schwier et al. 2006). However, for dogs this may not be (and may not ever have been) necessary for survival. Dogs may simply be able to monitor humans and 'predict' their behaviour on the basis of past experience (e.g. when the owner takes the leash a walk in the park is likely) or to follow certain communicative directives.

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