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Reproducing human actions and action sequences: "Do as I Do!" in a dog

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Abstract We present evidence that a dog (Philip, a 4-year-old tervueren) was able to use different human actions as samples against which to match his own behaviour. First, Philip was trained to repeat nine human-demonstrated actions on command ('Do it!'). When his performance was markedly over chance in response to demonstration by one person, testing with untrained action sequences and other demonstrators showed some ability to generalise his understanding of copying. In a second study, we presented Philip with a sequence of human actions, again using the 'Do as I do' paradigm. All demonstrated actions had basically the same structure: the owner picked up a bottle from one of six places; transferred it to one of the five other places and then commanded the dog ('Do it!'). We found that Philip duplicated the entire sequence of moving a specific object from one particular place to another more often than expected by chance. Although results point to significant limitations in his imitative abilities, it seems that the dog could have recognized the action sequence, on the basis of observation alone, in terms of the initial state, the means, and the goal. This suggests that dogs might acquire abilities by observation that enhance their success in complex socio-behavioural situations.

Keywords Dog · Imitation · 'Do as I do' · Social skills

Introduction

Social learning by observation can take many forms. Observers can learn about places, predators, objects or foods by observing their companions (Laland 2004); learning actions by imitation, however, is often considered to be 'special' (e.g. Whiten 1998). Although imitation learning has some human-specific features (Csibra and Gergely 2005) and the ability to learn imitatively has often been associated only with humans, there is increased interest to search for convincing evidence that other species, mainly great apes (see Whiten et al. 2004, 2006 for reviews) and some birds (see Zentall 2004 for review), might be able to learn and/or use a motor pattern by observing others. Imitative processes has been defined as the acquisition of novel or otherwise improbable behavioural action in the observer as a result of observation of this action in another individual (Thorpe 1956), or as an animal learning some part of the form of the behaviour by observing other animal (Whiten and Ham 1992).

In order to side-step this academic discussion, Zentall (2004) has even proposed to define imitation in a 'negative way', describing what imitation is not. Accordingly, 'imitation is a form of social learning that remains when one has ruled out or controlled for all of the alternative mechanisms (mimicing, response facilitation, stimulus and local enhancement) that might contribute to the higher probability of a copied response' (Zentall 2004, p. 18).

In our investigation of the imitative abilities of the domestic dog, we focus on a fundamental feature–contingent be-

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havioural similarity between the observed and the replicated behaviour. The process which is often defined as response facilitation (Byrne 1994) involves detection and encoding of a perceived action, and selection and control of an already known motor response, so that there is clear similarity between the observed action (as perceptual input) and the motor response. Selection of matching behaviour thus depends on the ability to *recognize* behavioural similarity, and it is this ability on which our experiments focus, by simplifying other aspects of the learning situation. Importantly, there are other "lower level" mechanisms that identify contingent behavioural similarity (e.g. contagion–an unconditioned release of an instinctive behaviour, where the demonstrator's act is merely stimulus for similar act by observer individual; see Galef 1988). Regarding the neural correlates of imitative behaviours, studies with apes and monkeys have pointed to the fact that mirror neurons could serve as a neural basis for recognizing when the subject is being imitated (Paukner et al. 2005; Nielsen et al. 2005).

Although phylogenetically distant from humans, dogs provide a useful model for understanding the evolution of human social cognition (Miklósi et al. 2004; Hare et al. 2002). Dogs are not only intelligent social carnivores with complex intraspecies interactions, including cooperative tactics and with intricate species-specific communication (Bekoff 1995) but also domesticated animals. Many assume that over the course of their extended history of domestication (Savolainen et al. 2002) dogs acquired behavioural and cognitive traits that enabled them to adapt to human social life (Miklósi et al. 2003; Byrne 2003; Topál et al. 2005; Hare et al. 2005). Human social living is challenging for dogs by virtue of its complex social nature and linguistic communication system.

A number of recent observations suggest that dogs show sophistication in situations where they acquire information from humans. For instance, although dogs did not show significant improvement in a detour task around a V-shaped fence by trial and error learning, even after six repetitions, they were able to master this task after one human demonstration (Pongrácz et al. 2001). Moreover, dogs tended to follow the already learned (human demonstrated) solution of this task even if a simpler way, a shortcut through the fence, was opened for them (Pongrácz et al. 2003). This suggests that socially acquired information can be dominant over trial and error learning and that dogs might be in some sense predisposed to copy human behaviour. The importance of the social nature of demonstration has been underlined by an additional study (Pongrácz et al. 2004), in which it was found that detour demonstrations were ineffective when the human did not give any verbal attention-getting signals (even though the target object was visible in the hand) and did not make eye contact with the dog. Talking to the dog and shared attention, however, proved to be effective: dogs learnt to detour the fence after such demonstrations even when the

human acted with empty hands. Dogs were influenced by the behaviour of their owners, even when the goal of the human behaviour was opaque (Kubinyi et al. 2003). When dogs repeatedly witnessed aimless detouring behaviour of their owner, made after their usual daily walks, they gradually started to develop a similar habit, although the owner neither rewarded nor encouraged the dog's behaviour. Such an influence suggests that a capacity for action matching in the dog, and thus for cultural learning (Pryor 2001), may have been overlooked.

The present study was designed to investigate whether a dog is able to show imitative behaviour, just in the sense of being able to use the behaviour of a human demonstrator as the basis for performing matching actions, either a single action or a sequence of actions. We used the so called 'Do as I do' paradigm (Hayes and Hayes 1952), which has been widely used for studying a subject's ability to imitate specified actions in great apes (Call 2001; Custance et al. 1995; Myowa-Yamakoshi and Matsuzawa 1999), parrots (Moore 1993), and dolphins (Herman 2002). For success, a subject must perform matching behaviour in response to a variety of actions demonstrated by a human. The procedure involves training the subject to perform a small set of actions presented by the experimenter on verbal command (e.g. "Do it!"). After the subject reaches high levels of correct performance with the training set, they are tested with novel demonstrators and/or with novel (untrained) actions. Successful transfer to copying novel actions is taken as evidence that the subject has acquired the basic rule needed for imitative performance; that is, repeat an action after having observed it (Zentall 2001).

In the first experiment, we limit our aims to provide evidence for recognizing of an imitation rule in a dog. The question was whether the dog would be able to choose a single, matching action from his repertoire in response to a variety of actions demonstrated by a human. In a second study, we presented the dog with a novel procedure, again using the 'Do as I do' paradigm. We aimed to test the ability to analyse and thus duplicate a particular sequence of human actions on the basis of observation, when the actions occurred in a framework with which the dog was already familiar. Importantly, in this experiment, the subject received no training and none of his actions were rewarded or punished.

Experiment 1: 'Do as I do' task

Methods

Subject

The subject was a castrated male Belgian tervueren, Philip, who was 4 years old at the beginning of the experiment.

Philip was originally trained to assist his disabled owner by the trainers of a Hungarian charity (Dogs for Humans) for 6 months when he was 1.5 years old. Being an assistant dog, Philip was trained to open and shut doors, pick up items, fetch named items (e.g. mobile phone), switch on/off lights, pick selected items from supermarket shelves and put them in a basket, etc. Importantly, however, his training was based on traditional operant conditioning methods and "imitative" techniques" (see below) were never used by the trainers. Subsequently, two members of our research team observed the dog over 3 years, in weekly 2-h visits, testing him on various sociocognitive and communicative tasks (e.g. Soproni et al. 2002; Virányi et al. 2004). Apart from familiarisation to the various tasks, the researchers had never explicitly trained the dog at the start of the experiment. All visits were recorded on video.

Procedure

We defined the match between the human's action and the trained action of the dog on the basis of functional correspondence (i.e. behaviours performed by the human/dog entail the same goal and–given the species-specific differences in the behaviour repertoire of humans and dogs–were executed in similar ways). For detailed description of the actions used in the "Do as I do" training, see Table 1. Importantly, all of the dog's actions had been previously trained by conventional methods (operant conditioning in the course of training for assistance work, or later by the disabled owner). However,

these pairings of human demonstrations and expected dog responses were novel (i.e. dog was never taught to perform an action in response to human behaviour demonstrations) and somewhat arbitrary (i.e. pairings were arbitrarily predetermined from among possible alternatives). For instance, in response to human's jumps ("Jump in the air"), the dog was trained to jump in the air by *raising only the two forelegs*, while other possibility could have been rising on his hind legs (similarly to the standing human) and then jumping in the air.

Therefore, the task for the dog in this experiment was to recognize a human demonstration and to perform an action corresponding to it on the basis of the predetermined rule used in the training, i.e. functional correspondence, and the question of interest becomes whether the dog is in any way able to recognize and generalize this rule.

Training phase

Preliminary training

Three of the trained demonstration-action correspondences– 'Turn around', 'Jump in the air' and 'Bow'–had already been partly trained by the owner using non-standardized methods. In our preliminary training, we refreshed Philip's knowledge of these pairings using conventional operant conditioning with the command 'Do it!', using access to a favourite toy to reward success. The rewarded action al-

Table 1 List and description of actions that were used by the trainer training and testing

Short name	Action as performed by the demonstrator (H)	The dog's (D) expected action for full correspondence
Turn around	H spins fast around the vertical body axis by pushing off using one leg	D turns around with bent backbone, orienting his head toward his tail
Jump in the air	H jumps in the air by bending both legs at the knees	D jumps in the air by raising the two forelegs
Bow	H nods head slowly	D bows (play signal) by stretching both front legs forward and raising the hip
Lie down	H lies on the floor on the side of the body with partially retracted legs and arms	D lies on the floor on his belly
Put the bottle in the box	There are two plastic 0.5 l bottles on the floor next to a larger plastic container. H takes one of the bottles from the floor in right hand and places it into a container that is 30 cm away in front of the person	D takes the other plastic bottle from the floor in the mouth and places it into a container that is 30 cm away in front of the dog
Take the bottle to the owner (O)	There are two plastic 0.5 l bottles on the floor next to a larger plastic container. H takes one of the bottles from the floor in right hand and takes it to the O who was sitting 3 m-s away	D takes the other plastic bottle from the floor in the mouth and takes it to the O who was sitting 3 m away
Move stick	There are two sticks placed horizontally on two chairs (2 m apart), H takes one stick and puts in on the floor	D takes the one remaining stick in his mouth and removes it from the chairs
Jump over	There are two sticks placed horizontally on two chairs, H jumps over them	There are two sticks placed horizontally on two chairs, Philip jumps over them
Give a bark	H gives a short 'bark'	D barks

ways matched the just-preceding action of the owner, which was always one of 'Turn around', 'Jump in the air' and 'Bow'.

"Do as I Do" training

During spring of 2002 (26 February to 30 April), Philip was trained by one of the authors (JT) using operant conditioning, to perform on the command 'Do it!' one of an enlarged set of nine actions in response to functionally corresponding demonstration (in addition to 'Turn around', 'Jump in the air' and 'Bow', these were 'Lie down', 'Jump over' or 'Move a horizontally-placed stick', 'Put the bottle in the box', 'Take the bottle to the owner' and 'Give a bark', Table 1).

At the beginning of each training trial, the trainer made the dog stand at the same place (using verbal commands and hand gestures known well by the dog), about 2 m away and facing the demonstrator and verbally attracted the dog's attention ('Philip, listen!'). This was followed by a demonstration of one of the nine actions. After completing the action, the trainer took up his original standing position facing the dog and commanded the dog to perform the corresponding action ('Do it!'). If the dog remained passively in its standing position (i.e. did not act), then the command was repeated once at 5-s intervals, but no more than two repetitions were allowed. Philip received reward (a favourite toy) for some seconds only if he performed a correct response: the rewarded action always matched the just-preceding action of the trainer. Only the pre-trained three actions ('Turn around', 'Jump in the air' and 'Bow') were introduced in the first two sessions 1 and 2; then another three ('Put the bottle in the box', 'Lie down' and 'Jump over') were added in sessions 3 and 4; a further three ('Take the bottle to the owner', 'Move stick' and 'Give a bark') were added in sessions 5 and 6. Each of the nine actions was presented 17–28 times, giving 191 trials in total. The dog was trained regularly once a week in a session that lasted on average 15 min. The criterion of success was set as 80% correct responses of the total trials within a single session. Philip exceeded the criterion level in the 10th training session (when he reached 86% success). All trials were performed at the same location, and all objects used in any of the demonstrated actions were placed in the training area and were available for the dog before training commenced. This was done to ensure that the dog had the opportunity to do other actions in response to the demonstrated one if he chose to do so.

Testing phase

After 10 weekly training sessions, acquisition of the trained actions and generalization to untrained actions was tested

formally, in the same context as in training (30 April to 1 June 2002). The subject's performance was both tested systematically by the trainer (JT) and subsequently by a novel demonstrator (one of the authors, AM) under identical conditions.

Test of the trained actions by the original trainer

The trainer (JT) performed all the nine actions only once in each session, for 10 sessions, resulting in 90 trials of the match-to-sample task which were video-recorded for later analysis. Actions were presented in a pseudo-random order previously determined by drawing lots and no reinforcement was given.

Test trials with a novel demonstrator

To control for the possibility of unconscious cueing of the human demonstrator, a novel demonstrator then tested Philip under identical conditions. He was familiar to the dog but had never taught him before. Philip was tested on four of the trained actions ('Bow,' 'Turn around,' 'Lie down' and 'Jump in the air'), 14 trials with each action (56 trials in all, over 7 weekly sessions, each action was presented twice in each session). In this testing series, 'Control' trials were also included (one to three trials in each session), in which no action was shown prior to the 'Do it!' command. In this case, the demonstrator attracted the subject's attention ('Philip, listen!') and looked over the head of the dog for 2–3 s. Then the command ('Do it!') was given, and the demonstrator waited 5 s for the subject's reaction.

Test trials with untrained actions

Over the same time period, we tested Philip's response to demonstrations that had never been shown in the course of training (for the list of the demonstrations and the detailed descriptions, see Table 2.) Untrained actions were demonstrated by either the owner (seven cases) or the trainer (nine cases). Actions were chosen to differ from each other on the basis of type of action (body-oriented, manipulative, environment-oriented) and complexity (number and length of action sequences). In any one session, no more than three simple actions or complex action sequences (in total 16–see Table 2) were shown to Philip and followed by the 'Do it!' command. All demonstrations were shown to the dog only once. Importantly, all of the "untrained actions" consisted of behaviour element that are already part of the dog's repertoire (being an assistant dog, Philip was able to open doors, fetch objects, etc.). Therefore, these demonstrations were novel to the effect that the dog never met such action sequences in the 'Do as I do' tasks before.

Table 2 Schematic description of Philip's responses (based on the agreements of the different observers) and his correspondence scores in the demonstrations of the 16 untrained actions

Short name (type of action): M, manipulative; B, bodily/motor	Action level description		False action	Correspondence scores
	Human (H) demonstration	Dogs' (D) expected response		
Move shoe (M)	H bends body & picks up one of the two shoes by hand from the floor, moves shoe to the predetermined point, releases shoe	D picks up the other shoe from the floor by mouth[1], goes to the same point[2], releases shoe[3]		6
Throw bottle (M)	H bends body & takes bottle in right hand, throws bottle to other person	D takes bottle in mouth[1], goes to other person[2], gives bottle to him[3]		6
Go round human (B)	H goes to other person, goes around him, goes back to starting place	D goes to other person[1], goes around him[3], goes back to starting place[4]	Turns around with bent backbone, orienting his head toward his tail[2]	4
Pull arm (B)	H goes to other person, pulls his arm vividly by hand, goes back to starting place	D goes to other person[1], pulls his arm vividly by mouth, goes back to starting place[4]	Bows by stretching both front legs forward and raising the hip[2] snuffles at human's right hand[3]	3
Open/close door (M)	H goes to door, opens door by hand (using the door-handle), closes door,	D goes to door[1], opens door by mouth (using the door handle)[2], closes door[3],		6
Search in sand (B)	H crouches down, performs scratching movements in the sand by both hands, stands up	D bows[1], performs scratching movements in the sand[3], stands up	Jumps in the air by raising the two forelegs[2]	3
Take out put in object (M)	H opens cupboard door by hand, takes out object, puts object into the bin	D opens cupboard door by mouth[1], picks up and takes out object (by mouth)[2], puts object into the bin[3]		6
Go in/come back (B)	H goes through open door into other room, turns around, comes back	D goes through open door into other room[1], turns around[2], comes back		4
Pull cloth (M)	H goes to shelve, picks up the cloth by hand, pulls the cloth and releases it	D goes to shelve[1], picks up the cloth & pulls it by mouth[2] releases the cloth[4]	Goes to the owner with the cloth in his mouth[3]	5
Push swing (M)	H goes to swing, pushes swing by hand, goes back to starting place	D goes to swing[1], pushes swing by nose[2], goes back to starting place		4
Lying down on top of the cupboard (B)	H goes to cupboard (70 cm high), crawls on top, goes back to starting place	D goes to cupboard (50 cm high)[1], crawls on top, goes back to starting place	Lies on the floor on his belly[2]	2
Crawling into the cupboard (B)	H goes to cupboard, crawls into cupboard, comes back	D goes to cupboard[1], crawls into cupboard, comes back[2]	Goes to cupboard again and look in[3]	2
Put the tape on the chair (M)	H bends his body & picks up one of the two tapes from the floor by hand, moves tape to chair, releases tape	D picks up the other tape from the floor by mouth[1], moves tape to chair[3], releases tape[4]	Puts his left paw on the humans leg[1]	3
Go and turn (B)	H goes to the far end of the room (3 m), turns around (1.5 turns), comes back	H goes to the far end of the room (3m)[1], turns around (1.5 turns), comes back[2]		3
Drinking (B)	H goes to bowl on his hands and knees, laps from bowl, comes back	D goes to bowl[1], laps from bowl[2], comes back		4
Push childtoy (M)	H bends his body, pushes the toy forward by hand	D bows[1], pushes the toy forward by nose		2
				63/94

Action-level descriptions of the demonstrations and 'perfect' responses are given, with schematic data on Philip's actual response. Due to species specific differences between motor and manipulative abilities in dogs and humans, each action of the dog that are not identical but functionally homologue to human demonstration were regarded as correspondent response (e.g. while human uses his hand; dog picks up things by mouth). Actions performed by the dog in a given action-sequence are also given. 'False actions performed by the dog are in italics. Numbers in superscript indicate the order of presentation by Philip. 'False actions performed by the dog are in italics.

Data coding

Two independent observers watched videotapes of each test trial for trained actions, and recorded whether the dog's response corresponded with the demonstration or not. They were given detailed descriptions of the nine actions demonstrated by the trainer (see Table 1); however, they watched just the dog's action and could not see what the human demonstration was. Inter-observer reliability was found to be high (percentage agreement: 99%, Cohen's kappa coefficient: 0.95).

We assumed that chance performance would be success on 1/9 trials because altogether nine different match-to-sample pairs were demonstrated. Note that this is rather conservative, given the fact that theoretically the subject had the possibility to perform any other action at all, rather than just those trained in that situation.

For the analysis of the "untrained" actions (Table 2), similarity between the demonstrated action and the dog's behaviour was assessed by parallel coding of the recordings by two trained observers. They were asked to take account of two variables in measuring similarity: 'Content', i.e. whether a particular behaviour performed was part of the demonstrated sequence, and 'Sequential correspondence', i.e. whether it was enacted at the appropriate place of the action sequence. For example, a score of 2 was given if the first action in demonstration (labelled as "A") was the first element of the subject's response, whereas a score of 1 was given if action "A" was performed by the subject as the second or third element of his response; that is, if the action was displayed but not at the corresponding place in the sequence. Scores were summed for each action. All but one demonstration of untrained actions contains a sequence of three actions (one consisted of only two) so the maximum 'Correspondence score' for a demonstration of a three-action sequence could be 6 (and 4, respectively). Inter-observer reliability scores were measured between the two observers for the dog's performance. Percentage agreements and Cohen's kappa coefficients were calculated for both 'content' (91% and 0.75 respectively) and 'sequential correspondence' (85% and 0.57 respectively).

We should note that the scores for correspondence given by the two trained observers might have been biased because they knew each time which one of the demonstrations had been shown to Philip, and therefore they were looking for some resemblance between what the dog did and what they knew it had been shown. In order to guard against this possibility, we also used a blind observer. Video recordings about the behaviour of the dog in the 16 demonstrations of "untrained" actions were shown to this observer, who did not know each time what action or sequence of actions had been shown to the dog, and he was asked to describe what the dog had done. The occurrence and sequence of actions identified by the blind observer was compared to that of given by one of the trained observers and similar levels of reliability was found compared to the case of the two trained observers (87% and 0.66 for the contential agreement; 82.5% and 0.54 for the sequence of the observed actions).

This latter analysis suggests that the poor inter-rater reliability scores for "untrained" actions (especially in the case of sequential correspondence) allow only limited interpretation of the results. Therefore, in order to avoid overestimation of Philip's performance in case of any kind of disagreement between the raters, the dog's action was considered as 'mismatching' for the analysis.

Results

Test trials with the trainer

Overall performance in response to human demonstrations was markedly above chance (one-sample Wilcoxon signed-rank test $T(-) = 0$, $p = 0.007$). Philip showed 'mismatched' behaviour on 27.8% of the total trials and all of those could be either categorised as another of the nine trained actions (16.7%) or as 'no response' (11.1% of the total trials); we did not observe other types of action at all (Table 3).

Analysing the nine actions separately, Philip showed no significant variation in level of correspondence across the actions demonstrated by the trainer (Friedman ANOVA, $\chi^2 = 10.7$, $p = NS$), and performed significantly better than chance in all cases (binomial tests, $p < 0.001$ for all actions except for 'Bow', where $p < 0.01$ was found). We also examined whether there was a difference between 'manipulative' ('Put the bottle in the box', 'Take the bottle to the owner' and 'Move stick') and 'body-oriented' actions (the remaining six). Philip showed similar performance in response to these two types of actions (correct responses: 22/30–73.3% and 43/60–71.7%, respectively).

Test trials with a novel demonstrator

Philip's response matched the behaviour of the novel demonstrator significantly above chance (one-sample Wilcoxon signed-rank test, $T+ = 5$, $p = 0,041$) and this level was similar to that observed in the trials with the Trainer (68.6% versus 72.2%; Table 4).

Comparing Philip's performance in the four different tasks, we found that he showed more 'mismatched' behaviour when 'Bow' was demonstrated than when 'Jump in the air' (Friedman ANOVA, $\chi^2 = 15.3$, $p = 0.0016$; Dunn's post hoc comparisons: 'Bow' vs. 'Jump in the air' $p < 0.05$) was shown. However, the dog performed significantly better than chance in all cases (binomial tests, $p < 0.01$ for all action except for 'Bow', where $p < 0.05$ was found).

Table 3 Actions performed by the dog in response to different human demonstrations

Human demonstration	Action performed by the dog									Other	Correct (%)
	Turn around	Jump in the air	Bow	Lie down	Put the bottle in	Take the bottle to owner	Move stick	Jump over	Give a bark		
Turn around	**6**	1								3	60
Jump in the air		**7**								3	70
Bow		2	**5**	2						1	50
Lie down			2	**6**	1					1	60
Put the bottle in					**6**	4					60
Take the bottle to owner					1	**9**					90
Move stick				1			**7**			2	70
Jump over								**10**			100
Give a bark	1								**9**		90
Total											72.2

Importantly, Philip showed no sign of "guessing" the desired in the 'Control' trials. Instead, he gave a response corresponding to the behaviour performed by the novel human demonstrator in these as in other trials: i.e. in 92.8% of control trials, Philip performed no action in response to the command "Do it!" given by the (passive) demonstrator.

Test trials with untrained actions demonstrated

Matching performance in response to these demonstrations was found 67% (63 out of a total possible 94 in the correspondence score, see Table 2, and the Methods section for details of calculating scores). This is comparable to the dog's performance in test trials with trained actions.

The demonstrations of the 16 untrained actions contained 47 separate elements (15 demonstrations with 3 actions, and 1 with 2 actions). According to the agreed decisions of the observers, corresponding behaviours were observed to most of the demonstrated actions (36/47; 76.6%) and the majority of them (27/47; 57.4%) were performed by the dog in the same sequence as it was demonstrated. It is worth noting that the probability of this level of agreement by chance, on the null hypothesis of random performance, is very low.

We also categorized the demonstrations as 'manipulative' (8 cases–see the descriptions in Table 2) or 'bodily/motor' (the remaining 8) and found that Philip performed at a marginally lower level of correspondence in response to 'bodily/motor' actions than 'manipulative' ones $(T(-) = 90$, $p = 0.0899$, which approaches significance).

Discussion

Superficially, dogs do not seem ideal subjects for this experimental approach. In contrast to children and great apes, dogs have a very different body schema to that of humans. Nevertheless, we found clear suggestions of the presence of some imitative ability in the performance of the tervueren Philip. After a relatively short period of 'Do as I do' training, Philip was able to successfully choose the correctly matching action from his own repertoire, in response to a variety of actions demonstrated by a human. The dog was not only able to use the behaviour of a human demonstrator as a sample, against which to match his choice of a corresponding action, but seemed to grasp the idea of matching-to-sample in relatively short time. He showed transfer both to a new person to be observed, and new actions to be matched.

Test trials with the 'Novel demonstrator' shed light on the dog's ability to generalize while performing 'Do as I do' task. Although some stimulus generalization is expected

Table 4 Philip's performance to demonstrations by the Novel demonstrator (AM)

	Actions performed by the dog					
	Passive	Bow	Turn around	Lie down	Jump in the air	Correct (%)
Actions demonstrated by unfamiliar demonstrator (*AM*)						
Control (no demonstration)	**13**	1	0	0	0	92.8
Bow	2	**6**	0	5	1	42.8
Turn around	2	1	**8**	1	2	57.1
Lie down	2	2	1	**8**	1	57.1
Jump in the air	0	1	0	0	**13**	92.8
Total						68.6

even in associative learning, depending on what features of cue stimuli the subject actually discriminates/attends to, the dog's behaviour here suggest a flexible application of the "do same" rule. This was confirmed by his response to test trials with untrained actions. Philip transferred without explicit training to actions in his pre-existing repertoire that had never been used in the do-as-I-do paradigm before. Evidently, he understood the task as one of finding a functional match in his behaviour to the human behaviour demonstrated. Note, however, that Philip was not required to perform a wholly new routine in any of the 16 'untrained action-demonstrations': all that was required for a correct response was selection on the basis of behavioural correspondence.

Although the present study with Philip is only partly comparable to other "do as I do" studies (because in our case "untrained actions" were not really novel), some aspects of Philip's imitative performance within his physical/motor limits has shown similarities to that of found in great apes (Call 2001; Custance et al. 1995; Myowa-Yamakoshi and Matsuzawa 1999), parrots (Moore 1993) and dolphins (Herman 2002). Since we have observed this ability only in one dog, our conclusions cannot immediately be assumed true of dogs in general; however, we have no reason to think that Philip is atypical of tervuerens, or that tervuerens are atypical of dogs in general, in cognitive ability.

Philip's ability to recognize behavioural correspondence between his own and a human's actions extends beyond more-or-less exact correspondence (e.g. mouth licking) to cases of merely functional correspondence (e.g. human takes object in hand; dog picks up object in mouth). This feature of our data, a consequence of the obvious species-specific differences in the demonstrator's and the dog's manipulative capacities, fortuitously allows us to see that Philip's ability to generalize behaviour operates at a non-superficial level. However, dogs, like parrots, have a restricted motor ability to act on themselves (body-oriented actions) or on the environment, in comparison to apes, which may mean that they have correspondingly less sophisticated abilities to mentally represent such actions.

## Experiment 2: Dog's spontaneous response to human action sequences

Although some elements of the demonstrations in Experiment 1 had a sequential character, there was no specific attempt to test the dog's understanding of the sequential nature of real behaviour. In the second experiment, therefore, we aimed specifically to test the dog's ability to match a sequence of human actions, on the basis of observation. In the course of a 9-week period, a tester repeatedly demonstrated the same action sequence to Philip (transferring an object from location A to B), each time with different constituents, commanding the dog to do the same action ('Do it!'). Importantly, in this experiment, Philip received no training and none of his actions was rewarded or punished discriminatively.

Our question was whether the dog would show a spontaneous preference for repeating the particular sequence of actions of the human partner. We begin from the argument that, in order to understand everyday means–ends relationships and the intended outcomes of actions by human partners, the dog may possess some way of encoding the different relationships that exist between those behavioural actions and objects in the world (Byrne and Russon 1998). For instance, suppose a dog observes a human take an object and put it in a box. Although the actions themselves may be familiar ones in the dog's repertoire, in order to understand the human's behaviour sufficiently to copy it, the dog needs to distinguish the roles of agent, object and result of the observed action. Thus, the task of copying a sequence of human actions can be seen as a measure of the dog's understanding: in particular, if Philip's behaviour correctly matches the semantic roles of the objects and actions, then it suggests the possibility that he has at least some rudimentary understanding of some 'semantic relationships' that hold among the constituents of the action (Byrne et al. 2004).

Methods

Testing was carried out over a 2-month period (February–April 2004), in a large room in the owner's flat. During the

Fig. 1 Experimental
arrangement in Experiment 2
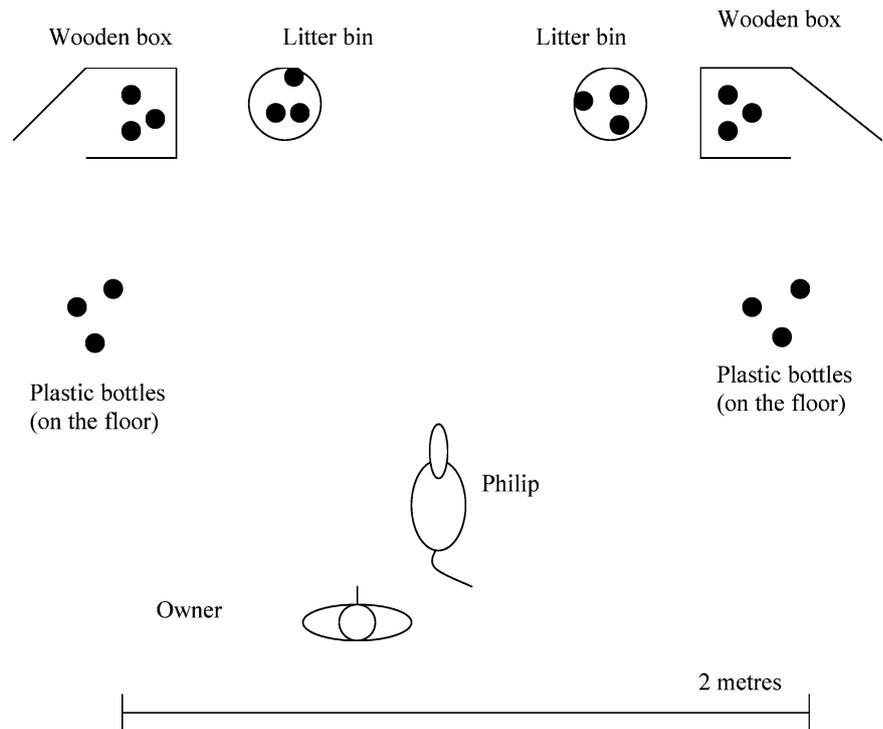
2 years break since Experiment 1, the dog had had regular opportunity to practice the 'Do as I do' task with the original nine trained actions and with demonstrations given by both the owner and the trainer. Neither of them had used the 'Do it!' command in other situations.

Two identical litter bins and two identical open wooden boxes were placed in line on the floor (Fig. 1). The cover of each litter bin could be opened by pressing a lever on the bin; the wooden boxes were open and lay on one side, turned away from the dog. Both bins and boxes originally contained three identical plastic bottles, and there were also three plastic bottles at predetermined points on the floor on both sides of the owner and the dog. This layout allowed for six potential target locations to which bottles could be carried or taken, with three plastic bottles already in each.

All commands were given by Philip's owner, following a precise protocol. Before each trial, the owner made the dog sit at the same, predetermined place, so that the owner stood about 2 m away from the line of the boxes and bins, while the dog's nose to the box/bin line was 1.25–1.75 m. The dog faced toward the targets and was thus not in visual contact with the owner who was positioned behind the dog. He then verbally attracted the dog's attention ('Philip, listen!'), and then gave the demonstration. All demonstrated actions had basically the same structure: the owner picked up a bottle from one of the six places and transferred it to one of the five other places; thus, there were $6 \times 5 = 30$ different possible sequences. After completing the action, the owner took up his original position (behind the dog) and commanded

the dog to perform the corresponding action ('Do it!'). The command was repeated once in every 5 s until the dog transferred one of the bottles (in most cases Philip responded after the first command and there were no trials on which he did not respond after three commands). The trial was considered complete if the dog released the bottle at any place in the room. After each trial (regardless of the dog's performance), Philip was praised verbally and petted by his owner. As human's transferring the bottle may result in a "trail of odour," which marks the route between the start and goal location, we needed to eliminate the discriminative effect of human odour cues. Therefore, before each trial, when the owner placed the 18 plastic bottles in the 6 potential target places without the dog being present, he fingered all the bottles and passed all possible routes.

The owner demonstrated each of the 30 possible sequences once, in a randomised order, and repeated the same procedure after a 2-week break. The first set of trials took 3 weeks to complete (10 trials per week, not more than 2 trials per day: 12 February to 2 March 2004). The second set of trials took 4 weeks to complete (6, 10, 10 and 4 trials per week, less than 3 trials daily: 18 March to 15 April 2004).

Note that the litter bin had to be opened by pressing the lever in order to put in or take out an object, whereas no action was needed in the case of the wooden box. As a fully trained assistance dog for his disabled owner, Philip was already used to tasks of this structure in his work; and, moreover, he was familiar with the basic behaviour patterns that made up the sequence, such as going to a box or litter bin, taking

out an object and dropping it somewhere else. Thus, the key variables to which the dog needed to pay attention in order to copy the transfer sequence were just the location of start and finish.

Data coding

We classified the locations of the objects into five categories: 'Start', where the owner had picked up a bottle; 'Goal,' where the owner had put the bottle; the symmetrical places to each of these, which we termed 'Start-twin' and 'Goal-twin'; and the two other locations in the experimental arena, lumped as 'other'. In order to analyse the dog's success in copying the sequence, assuming that he does indeed copy the basic structure of the action, we note that there are six places from where he could pick up a bottle, and there are also the same six places where Philip could drop the bottle ($6 \times 6 = 36$ possible responses). Accordingly, the chance performance was calculated as 1/36 for the action involving bottle transfer from 'Start' to 'Goal' sequence and the observed frequencies of different action-sequences were compared to chance frequency by binomial tests.

Results

In every trial, Philip was successfully induced to copy the basic structure of the demonstrated action: that is, he took a bottle from one place to another, without discriminative reward. Philip tended to pick up the bottle from and take it to the same places as had the human demonstrator significantly more often than expected by chance ("same start" 28 cases out of 60 trials, binomial test, test proportion $= 0.167$, $p<0.0001$; "same goal" 21 cases out of 60 trials, binomial test, test proportion $= 0.167$, $p<0.0001$).

Analysing the whole sequence of the dog's actions shows that Philip executed the exact same sequence of bottle-transferring actions as demonstrated by the owner in 16/60 trials (Table 5), which is again markedly more frequent than expected by chance (binomial test, test proportion $= 0.028$,

Table 5 Number of Philip's different actions as response to the demonstrations (picking a bottle from start location and transferring it to the goal location)

	Place where the bottle is dropped off				
	Start	Goal	Start-twin	Goal-twin	Other
Place from where the bottle is picked up					
Start	0	**16*****	0	**6****	6
Start-twin	0	1	0	0	2
Goal	**7****	2	2	3	1
Goal-twin	2	0	0	0	2
Other	2	2	0	2	4

Difference from chance level: ** $p = 0.001$, *** $p<0.0001$.

$p<0.0001$). Moreover, some of Philip's errors were close to the correct response. For instance, when the bottle was picked up at the correct start but dropped off at the goal-twin location, the confusion amounts to merely a left/right confusion of goal location. This 'erroneous' response was observed significantly more frequently than expected by chance (6/60 trials, test proportion $= 0.028$, $p = 0.001$). Interestingly, we also observed a precisely reversed sequence of the demonstrated actions more frequently than expected by chance (7/60 trials, test proportion $= 0.028$, $p = 0.02$); in these cases, Philip picked up a bottle at the goal location and moved it to the start location.

Finally, we should consider the possibility that Philip was being shaped by unconscious cueing (given by the owner) and the dog's performance mirrors a Clever Hans effect. Assuming that Philip has a sophisticated behaviour-reading ability regarding his owner and in the test situation his response was 'governed' by the subtle behaviour cues of the owner, we should expect a gradual improvement in his bottle-transferring accuracy over the course of the trials. However, comparing the results in the first and last 10 trials (trials 1–10 vs. trials 50–60.) we did not find significant differences ($N1 = N2 = 10$, $U = 50$, $p = 1$), suggesting that Philip did not learn to utilize unconscious cueing as testing proceeded.

Discussion

The dog was able to organise his behaviour on the basis of the human actions, translating not only the basic type of familiar action (carrying an object from place to place) from the observed demonstration to his own behaviour but also copying the details of start and finish locations more frequently than chance performance.

Although individuals can manipulate and use relational phenomena without understanding the cause–effect relationships involved (see e.g., tool-using in capuchins; Visalberghi 1993), our results raise the possibility that the dog had some understanding of the action sequence in terms of the initial state, the means and the goal. Seeing the demonstration, he not only carried out "place to place carrying" but tended to match the specific location at which the object was picked up, and that at which it was dropped. Like many humans, he showed a distinct tendency to make left/right confusions, and if he were "given the benefit of the doubt" on the occasions when he carried the object from the correct starting place to the mirror image of the correct finish (an improbable error, by chance), his copying of the sequence after only a single demonstration reaches 37%. However, he did also confuse the start and finish locations, though such errors occurred at a lower frequency (12%).

It may be helpful to view the dog's performance in terms of a theory developed to describe sentences in linguistics, case grammar (Byrne et al. 2004; Fillmore 1968). In case

of grammar, each verb (action) structures a set of semantic cases; for example, the verb 'carry' has cases for *agent* (the animate actor), *object* (the object or material moved), and optionally two locations, *from* and *to* (places from which and to which the object is taken). Although developed for natural language, case grammar terms can also be used to interpret animal behaviour. A wolf's behaviour in carrying food for its puppies, for instance, may be represented in terms of the 'carry' case frame with agent (wolf), object (meat), to-location (den) specified. Structuring in terms of a framework of cases can also be used to decode the action of others. If an animal is able to decode another's behaviour in this way, then their understanding of the other individual's behaviour would be a matter of first recognising the action, and then 'filling in the slots' in the case frame, for each of the semantic categories it specifies. We find this account helpful in understanding Philip's achievements in our experiments. A dog can be said to understand the meaning of carrying in some sense if it has the ability to perform the action, and since carrying is a part of the ethogram of the wolf, it is to be expected that all dogs have this ability. Transferring items from one place to another may be part of the species-specific repertoire of dogs; certainly, there was no doubt that Philip possessed this action routine in his repertoire before our experiment. However, carrying cannot be regarded as a simple movement pattern, but a structured framework with 'cases' or 'slots' for agent, object, and to-and from-locations. Thus, when a dog observes a human demonstrator carrying an object, it may be said to 'understand' what the other is doing if its representation includes the specific contents of each slot.

At the time of Experiment 2, Philip had already been trained to 'do as I do,' i.e. substituting himself for the human as agent of an observed action, so he was without further training able to copy (to a certain extent) the entire sequence of moving a specific object from one particular place to another. In contrast, 'to put an object1 on object2' is not part of the species-specific repertoire of dogs, so without learning this action individually, a dog cannot be expected to understand the meaning of this action without specific training. Experiment 1 showed that, given such training, Philip was able to augment his repertoire accordingly to some degree, and indeed his training as a helper for a disabled human focuses on developing an appropriate, human-relevant repertoire. We suggest that such experience plays a substantial role either in enhancing imitative performance or in generating imitative ability.

General discussion

Extensive testing of Philip clearly demonstrated that he was able to recognize similarity between the observed and the replicated behaviour and use the behavioural actions of a human demonstrator as cues for corresponding actions. It seems that dogs have some imitative abilities, and they are able to map observed behaviour of the human demonstrator onto the corresponding motor scheme of the self. Although data show fair performance in copying actions and action sequences, the possibilities of lower level underlying mechanisms (goal emulation and simple local enhancement) cannot be completely dismissed. While dolphins and great apes often regarded as imitative generalists (Herman 2002; Nielsen et al. 2005), based on these findings, Philip's imitation more closely resembles the narrower pattern characteristic of task specialists–with limited "case grammars".

Being a specially trained service dog, someone may assume that Philip's performance was based on a species-typical "transport item" routine. It seems that he succeeded well on transporting items to/from target locations (relevant task for an assistant dog and biologically relevant task for the species) and in some cases had more difficulty combining other actions with the transport-item routine (e.g. spin/turn around at the target location, climb into/onto target location, etc.). This suggest the importance of working experience and species-specific skills (fetching objects) in the dogs' imitative performance and points to the role of associative processes in mastering 'Do as I do' tasks. However, imitative processes in bird species (Zentall 2004, 2006) and the results of our dog here raise the question whether associative learning is sufficient to yield a capacity for such social learning or, alternatively, more sophisticated cognitive processes are necessary to understand the phenomena. This question is underlined by the present study pointing to the potential role of relational understanding in matching functional action sequences.

Results suggest that our subject may be able to detect and reproduce some semantic relationships among actions objects and places. Note that our view of imitative behaviour in the dog as a matter of mapping novel entities into pre-existing case slots may help explain some of the superior abilities of 'enculturated' subjects in imitating some actions demonstrated by humans (Call and Tomasello 1996; Tomasello et al. 1993), since these animals will have an augmented repertoire of actions with which to understand human actions. Since our subject already knew all test entities, Philips behaviour in the 'Do as I do' tasks could be explained by the insertion of some *known* entities into case slots. Some of the test entities may have been novel relative to a particular routine (i.e., twirling at a target location vs. picking something up), but Philip's extensive training history reduces the range of known entities that were possibly novel to specific routines. Concerning novelty, note that although Philip did not learn anything new in terms of his motor patterns, he was able to make clear distinction between different forms of human behaviour and learn to use these as samples, against

which to match his own, corresponding behaviours, on the basis of resemblance to the demonstrated action. This ability has sometimes been described as imitation (e.g. Heyes and Sagerson, 2002); however, scholars have traditionally reserved "imitation", or "imitation-learning" or "observational learning" for cases where a novel performance is acquired, at least in part, by observation (e.g. Byrne and Russon 1998; Thorndike 1911; Thorpe 1956). By traditional criteria, Philip's performance at copying single actions did not show imitation, and we suggest 'response facilitation' (Byrne 1994) is a clearer description, since the observed performance might have been caused by 'priming' or 'triggering' of some pre-existing behaviour of the dog. Although mirror neurons (Rizzolatti et al. 1996; Gallese et al. 1996) have not so far been detected in dogs, several researchers have noted that a mirror neuron system is a highly plausible mechanism for response facilitation (e.g. Byrne 2002; Rizzolatti et al. 2002). Philip's partial success in copying a structured sequence of action (Experiment 2) may go beyond response facilitation, since he showed a significant tendency to keep distinct the semantic roles of the action, in particular, the potentially confusing pair of to-location and from-location.

Although Philip failed to show any compelling evidence of action-level imitation, the interpretation of his copying behaviour in terms of "case grammar" is in some ways akin to programme-level imitation (Byrne and Russon 1998). Given the limited experimental data, however, the plausibility of case grammar hypothesis and its relevance to programme/action level imitation are unclear at present.

In addition to sophisticated forms of social learning (Pongrácz et al. 2001, 2003; Kubinyi et al. 2003) dogs show enhanced abilities in associating arbitrary cues with actions (Frank 1980), attachment to humans (Topál et al. 1998, 2005), rule following (Topál et al. 2006) and sensitivity to human behaviour (Miklósi and Soproni 2006). In line with these studies, present results call for further studies regarding the role of the social relationship between subject and demonstrator, a factor often neglected, for testing social learning. The ability we have shown in this dog strongly supports the idea that dogs have undergone selection for living in human groups. Rather than meaning that domestication enhanced imitative ability per se, we suspect that it acted on other behavioural traits that enabled imitation to surface more easily.

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