

Dogs, *Canis familiaris*, fail to copy intransitive actions in third-party contextual imitation tasks

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Contextual imitation of intransitive actions within a third-party copying setting was tested in 180 household dogs. A demonstrator dog, in sight of observer dogs, performed one of two trained actions upon hearing verbal commands given by an experimenter. Observer dogs were later tested to see whether they produced more target actions than control groups who had not seen demonstrations of those actions. In all conditions, except one, the demonstrated actions had been previously trained in the observer dogs by their owners, but had been attached to a different verbal command to that used in our study. For these 'pretrained' actions we further investigated whether reward contingency, the relationship of the dog to the human experimenter and ostensive cues had an effect. In no condition did we find any contextual imitation. A subsample of all tested dogs had, during their lifetimes, received extensive training in a diverse range of tasks outside of social learning, but this background similarly did not lead to contextual imitation. We conclude that dogs, even when highly trained, fail to show evidence of contextual imitation for intransitive actions within a third-party copying paradigm.

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Observational learning is a potentially advantageous behavioural acquisition mechanism, as it can reduce the cost to an individual of learning via trial and error. There are many forms of observational learning but only a few depend on the exact replication of a particular behaviour; this is, in a strict sense, what is commonly regarded as imitation (see Whiten & Ham 1992; Whiten et al. 2004; Zentall 2006). It is these precise forms of observational learning that are likely to underlie the cumulative character of human culture, since with true imitation novel behavioural variants can be passed on (Tomasello 1999). In addition, human adults have evolved teaching skills, with which they can guide children's cultural acquisition ('pedagogical stance', see e.g. Csibra & Gergely 2005). For marking and establishing such teaching events, human adults use so-called 'ostensive cues' (such as a high-pitched voice, calling of the child's name, gaze alternation, etc., e.g. Nielsen 2006).

Besides direct teaching in a one-to-one situation (i.e. adult and child, or 'second-person imitation') human children can also learn socially by way of 'eavesdropping' ('third-party imitation', Tomasello et al. 1989). Third-party copying involves three parties: the demonstrator, the receiver/interactor and finally the observer (or 'eavesdropper'). This phenomenon had not been recorded outside of humans until recently when one study was published that presented evidence for third-party copying in dogs (Range et al. 2007). Evidence for second-party copying has already been provided in dogs (Topál et al. 2006) in addition to a diverse range of other species including primates (see Voelkl & Huber 2000; Whiten et al. 2004; Byrne & Tanner 2006), dolphins (e.g. Kuczaj & Yeater 2006) and birds (e.g. Heyes & Saggerson 2002). Thus, dogs may be a good model species to study the evolution of copying abilities, especially for rare third-party copying. As humans communicate with dogs in much the same way as they talk to human children (Mitchell 2004), certain ostensive signals that are thought to enhance observational learning in humans (Csibra & Gergely 2005) may also play a role in dogs' observational learning (Pongrácz et al. 2004; Range et al. 2007).

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However, as mentioned above, observational learning is not a unitary phenomenon, and this differentiation extends also to the special case of behavioural acquisition. It is important to distinguish at this point two types of behavioural transfer and to set them apart from other learning mechanisms: copying of novel actions and copying of familiar actions, often referred to as response facilitation (Byrne 1994; but see also below). In action copying observers copy body movements or body orientations that are novel to them (see Call & Carpenter 2002; Whiten et al. 2004). Without such a detailed copying mechanism of novel actions, innovative behaviour gets lost, hampering the process of culture accumulation (Tomasello 1999). 'Response facilitation' fails in such a 'book-keeping' sense (Byrne 1994; but see Byrne & Russon 1998) because in response facilitation, the reproduced actions are not actually copied; instead, observers only need to recognize familiar actions in others, and subsequently to trigger those same actions within themselves. Recently, it has been suggested that response facilitation should be regarded as an umbrella term for all contagion-like processes, that is, processes that involve the prompt repeating of an observed action that was already part of the observer's repertoire (Hoppitt et al. 2007). Byrne (2002) further differentiated these processes, adapting a distinction originally made in the vocal imitation literature (i.e. Janik & Slater 2000). Byrne (2002) distinguished two types of imitation, where actions are learned to be used to achieve certain ends. The distinction is based on whether the copied actions are novel (i.e. production learning) or familiar (i.e. contextual imitation) to observers. In both cases, individuals learn via observation to apply an action in different circumstances (e.g. at different locations).

Based on a further distinction proposed by Hoppitt et al. (2007) and Byrne's (2002) original approach, we propose to distinguish between three processes: (1) automatic response facilitation, that is, the immediate re-enactment of observed familiar behaviours in an automatic and synchronized fashion within a short time frame; (2) contextual imitation, that is, the long-lasting copying of familiar actions across contexts (potentially outcome-sensitive as well, see below); and (3) production learning, that is, the long-lasting copying of novel actions across contexts. One can differentiate between these possibilities by measuring copying effects over time and across contexts (introducing time delays and testing across situations here act as a control against response facilitation) and by demonstrating either novel or familiar actions (where copying of a novel action excludes the first two possibilities). In theory, there could be a fourth option, namely the automatic, immediate and synchronous copying of novel actions, which we may call 'action facilitation', but for which there seems to be little evidence. Here we concentrate on contextual imitation.

Contextual imitation may be outcome-sensitive (this process is also called R–O learning; see Saggerson et al. 2005). However, contextual imitation does not always need to depend on outcomes (Hoppitt et al. 2007; this process is also called S–R learning or 'blind imitation': McGregor et al. 2006). Currently, there exist two studies with clear positive findings for observational learning of familiar actions in dogs, in the sense of contextual imitation (Topál et al. 2006; Range et al. 2007; but see also Kubinyi et al. 2003b; Miller et al. 2009). For evidence on other forms of social learning in dogs, for example stimulus/local enhancement, see Pongrácz et al. (2001, 2003a, b, 2004, 2005), Rooney & Bradshaw (2006) and Slabbert & Rasa (1997).

Topál et al. (2006) examined whether 'Philip', a highly trained assistant dog for his disabled owner, would copy familiar intransitive actions (i.e. actions not targeted towards an object) performed by a human demonstrator. For this, Philip was trained in the so-called 'Do as I Do' task (see Hayes & Hayes 1952; see also Custance et al. 1995). In the training phase, Philip was first trained

to perform actions corresponding to the 'same' actions of the human demonstrator whenever the verbal command 'Do it' was given. In the test phase, Philip matched his actions to those of the human demonstrator, and this was true also for some actions that, while not novel to Philip, were not explicitly trained before. Since all tested actions were familiar to Philip, contextual imitation most likely accounted for the dog's performance (more precisely: second-person contextual imitation).

Range et al. (2007) investigated third-person copying of transitive actions (i.e. functional actions targeted towards an object) using a human experimenter and a dog demonstrator. Furthermore, during demonstrations observer dogs were also provided with ostensive cues. Dogs in this study had to perform one of two transitive actions towards a reward-dispensing box ('two-action task'; reviewed in McGregor et al. 2006). The manipulandum on the box was a bar that had to be pulled down. This set-up allowed the food reward to be gained using two different styles of action: dogs could either use their snout or their paw to work the bar. Prior to the study each observer dog was trained until it was able to perform both styles of action on a different object. Range et al. (2007) showed that the choice of observer dogs' actions significantly depended on the actions that they had observed. This meant that the observed actions were not always those later used by observer dogs. Depending on the situational constraints of the demonstrator dog, observer dogs seemed sometimes able to suppress the urge to use the observed actions. The authors concluded that observer dogs not only copied, but also selectively copied only when demonstrator dogs were unrestrained in their choice of actions, much like human children do (Gergely et al. 2002). However, since the observers were pretrained on both possible target actions, it is conceivable that these results represent selective contextual imitation for transitive actions in these dogs (but see Range et al. 2007 for a different view). Unlike the Topál et al. (2006) study, observer dogs in the Range et al. (2007) study had never been explicitly trained to copy. The fact that these observer dogs could also select for themselves those actions that matched the actions they had seen demonstrator dogs use further shows a potential for contextual imitation in dogs, especially within the third-party paradigm.

Following and extending this previous work, we decided to test whether dogs would show evidence for contextual imitation within a third-party setting (as they did in Range et al. 2007) when the demonstrated actions were 'intransitive', that is, not targeted towards an object (as in Topál et al. 2006). To answer this question, we adapted some of the basic methodological features of Range et al. (2007), as well as parts of a methodology previously used to test great apes (Tomasello et al. 1997). Tomasello and colleagues trained several chimpanzees to perform novel begging gestures towards humans who were controlling a food resource. Trained chimpanzees subsequently used their newly acquired begging gestures while a group of conspecifics watched. Demonstrators were contingently rewarded (with pieces of food) by the human experimenter. Observer chimpanzees failed to copy. In this study we present the results of a comparable third-person contextual imitation task in dogs. In sum, the results of previous studies (Topál et al. 2006; Range et al. 2007) suggested that dogs might be able to copy under circumstances in which apes had failed (i.e. to copy transitive actions within a third-party paradigm, at least if the actions are familiar).

We used five conditions to test whether dogs would show contextual imitation within a third-party setting when the demonstrated actions were intransitive (i.e. when they did not involve an object). In the first condition (untrained action condition) a demonstrator dog was rewarded to perform an intransitive target action that observer dogs were never trained to perform. The

demonstrator dog performed this action repeatedly upon receiving a verbal command (chosen so that it was a novel command for observer dogs). The observer was then tested individually for target actions, first without and then with the same verbal command. The remaining conditions were similar in design, but used a pretrained intransitive target action (pretrained action conditions). In these latter conditions, we also investigated whether the following had an effect on performance: reward contingency, use of the observer dog's owner or provision of ostensive cues. In addition to analysing target actions, we recorded a commonly occurring behaviour ('sit'). We also noted the immediately occurring behaviour of observers during the demonstration phase (as a general control for 'automatic response facilitation') and the attention levels of observers. Finally, we looked at the results obtained from a subset of highly trained dogs, and tested whether their background of training had an effect on their performance.

METHODS

Subjects

All dogs tested ($N = 202$) lived as family dogs with their owners. The dog owners volunteered to take part in the studies and were listed in a volunteer database. Only dogs older than 1 year were tested (mean = 5.5 years). The overall sex ratio of dogs was balanced (males: 100; females: 102). Only dogs that were known to be food motivated were included in the study.

Dogs were randomly assigned to conditions and each dog was tested only once (between-subjects design). Overall, 22 dogs had to be rejected from the study (e.g. because they never paid attention to the demonstrator dog or because of problems with videotaping).

After completion of the study we questioned the dog owners to gather additional information concerning the training status of their dogs. As the majority of dogs tested in the Range et al. (2007) study had a special training background, for example agility, rescue, service, or dancing dogs, we also defined specified highly trained dogs as those having one or more of the following: a rescue, protection or hound examination, those that had been intensively trained in dog dancing or as guide dogs for the blind, as well as those that actively took part in agility contests. We were able to determine training backgrounds for 94% of the dogs that had entered the final data set, and identified 12 dogs that fitted into one or more of these 'highly trained' criteria.

Procedure

Prior to the study, we trained the demonstrator dog (henceforward 'demonstrator'), 'Mora', a 9-year-old female German Shepherd mix, to lie down on her belly and be motionless at the verbal command 'tennie' (resulting in a sphinx-like posture, henceforward 'sphinx') as well as to lie down laterally and be motionless at the command 'josep' (resulting in a sleeping posture, henceforward 'playing dead'). She was trained to stay in this position until a reward had been given to her. The rationale for selecting the two verbal commands was that they were likely to be novel for the observer dogs (henceforward 'observers'), while they were matched to contain only two syllables each. The rationale for training of the two actions was that one action (lying down on the stomach) is a near-universally trained action for dogs, while the other, lying down sideways, was an untrained action for those dogs we tested (see below for more details).

The study took place in two rooms. The observer dog remained in the test room throughout the demonstration phase and trial. Before demonstrations started, all observer dogs were allowed to examine their new surroundings, and we only started our

procedure if observers were not showing any signs of distress. Thus, observer dogs were minimally familiar with the test environment. During demonstration phases the demonstrator room was occupied by either the experimenter (E) plus the demonstrator dog (experimental groups, see Fig. 1) or by E without the demonstrator dog (control groups). Both rooms were always divided by a transparent Plexiglas barrier, fixed in an open door frame. Since the Plexiglas barrier did not reach all the way to the top of the door frame, verbal cues produced on either side of the barrier were clearly audible on its other side.

Conditions

Experimental groups

Five demonstrations were conducted before observers were tested. For each demonstration, E and the demonstrator positioned themselves next to the observer, with the transparent barrier between them. Thus, E and the demonstrator were both in full view of the observer (see Fig. 1). When the demonstrator was in the starting position (sitting or standing in front of E), E gave the necessary verbal command (i.e. 'josep' or 'tennie', depending on the condition) upon which the demonstrator performed the responding target action. While giving the verbal command, E's hands were placed behind his/her back.

Once the demonstrator had performed the target action, E used his/her left hand to take a reward from a hip bag and gave it slowly to the motionless demonstrator. E then turned 180 degrees (i.e. turning his back to the demonstrator) during which the demonstrator returned to the starting position. E turned around again facing the demonstrator dog. If, at this point, the demonstrator was not yet in her starting position, E gently pulled her up. The demonstration phase was aimed to last about 60–90 s in total. In the few cases where the demonstrator failed to perform the requested target action, a further demonstration was given (before the start of the study we set the maximum of such extra demonstrations to five; however, Mora never made more than four mistakes, and thus no dog had to be excluded on this criterion). During demonstrations, E observed whether or not the observers were attentive (i.e. whether their heads were positioned so that they could observe). Observers that failed to watch at least one demonstration were excluded from testing.

The demonstrator was then moved out of sight before E went into the test room and stood looking at the observer, waiting for target actions without giving any further command. After 30 s had

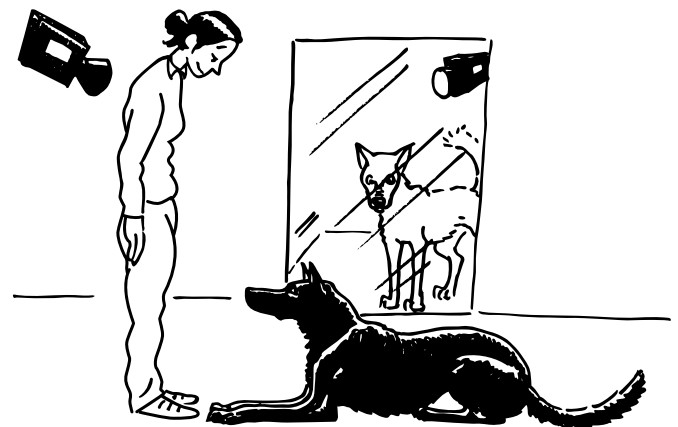


Figure 1. Experimental set-up (here depicted: demonstration phase). Side view from demonstration room, with E and demonstrator dog (in 'sphinx' position) in front, and subject in the background (behind the Plexiglas separation).

elapsed, E noted down the behaviour that had occurred and then gave the same verbal command that was used during demonstrations. In all conditions (except in condition 3, see below) observers received a reward if they then performed the target action, independent of whether they performed that action before or after hearing the command. This test procedure was repeated five times for each dog. In all other respects the test procedure resembled that of the demonstration procedure. In addition to the target actions we also recorded other obedient behaviour, that is, how often dogs sat down ('sit': the dogs' forelegs were extended perpendicular to the ground while the hindlegs were flexed with the tarsus resting flat on the ground). All target actions as well as 'sits' performed by observers were counted and separated into those occurring either 'before' or 'after' the command. Actions performed by one dog during more than one test bout were counted only once.

Altogether there were five experimental groups with 20 dogs tested in each condition.

Condition 1: untrained action condition. The demonstrator performed the target action 'playing dead' upon the verbal command 'josep'. We only tested those observers whose owners had clearly stated that they had never been trained to perform this particular action.

Condition 2: pretrained action condition: basic. The demonstrator performed the target action 'sphinx' upon the verbal command 'tennie'. Observers had been previously trained by their owners to perform this target action. However, crucially, observers had been trained to perform this target action upon hearing a different command from the one we used in our study.

Condition 3: pretrained action condition: noncontingent rewards. This condition resembled condition 2, but in test phases, observers always received at least one reward, regardless of whether they performed the target action or not.

Condition 4: pretrained action condition: dog owner as experimenter. This condition resembled condition 2, but E was the owner of the observer. The former experimenter instead always stood behind the owner (i.e. now E). This was necessary to have an overview of the owner's actions and, sometimes, in order to give short instructions and reminders.

Condition 5: pretrained action condition: ostensive cues. This condition resembled condition 2, with two differences. The first change concerned the demonstration phase. Before each of the five demonstration phases, E looked at the observer and called both the dog's name and 'guck mal' (meaning 'look here'), using a high-pitched and friendly voice, accompanied by lifted eyebrows and slight head-raise (i.e. ostensive cues). E then looked at the demonstrator, in an attempt to shift the observer's attention to the demonstrator. E looked back at the observer, and again provided the ostensive cues then once again faced the demonstrator. After these two ostensive cues the demonstrator received the verbal command ('tennie') and the demonstration commenced. The second change concerned the test phase: the observer was first addressed with its name before the verbal command was given.

Control groups

We ran a control condition for each of the experimental conditions (see methods below) except the untrained action condition where it was statistically not necessary. Again we tested 20 dogs in each control group.

The procedure of the control groups was the same as that of the experimental groups. The only difference was that there was no

demonstrator present during demonstration phases, hence no target actions could be seen by the observers. Instead of handing rewards to a demonstrator during control group 'demonstrations', E placed a reward into a little opaque box that was fixed to the frame of the Plexiglas barrier, at the approximate height of the demonstrator's head.

Data Collection and Analysis

All sessions were videotaped by two wide-angle cameras. Both cameras filmed in the direction of the Plexiglas barrier, but from opposite sides of the Plexiglas. One camera filmed from the demonstrator room; the other camera filmed from the test room (see Fig. 1).

We recorded the number of dogs that performed the target action ('sphinx' or 'playing dead') and also the number of dogs performing 'sit'. In each case we differentiated between the behaviour occurring within the first 30 s (i.e. before the verbal command was given and where the experimenter had only looked at the observer) and the behaviour occurring after the command was given. Observers that sat down in between the initial 30 s but before the first verbal command (i.e. the few seconds in which E noted down the behaviour) were excluded from the analysis of sitting behaviour. We also recorded how often observers performed these three types of action during the demonstration phase itself.

To establish further that observers had really been attentive during observations, a second person, blind to the research question, recorded the subjects' behaviour during demonstrations from videos taken by the camera filming from the test room. We recorded five randomly chosen subjects per experimental condition (i.e. 20% of all experimental subjects; $N = 25$). The recorder was instructed to record attentiveness if the following criterion was met: the dog's head was positioned in front of the Plexiglas barrier and was also directed towards anywhere between the experimenter and the demonstrator. Three types of measures were taken: 'demonstration time', that is, the time the demonstration lasted (as measured from command giving to reward giving); 'observation time', that is, cumulative observation time for a given demonstration and 'crucial observation', that is, observation of command giving, demonstrator's target behaviour and reward giving (where all three parts had to be observed during a given demonstration to fulfil the criterion).

A reliability test for target actions was performed. A third person, blind to conditions and groups, recorded 34% of randomly chosen subjects ($N = 62$) and the agreement reached was 100%. Owing to the nature of our data as well as the low response rate we used binary logistic regression with the factors 'condition', 'experimental or control' and the interaction of both as predictor variables. We analysed only conditions 2–5, as no control was available or necessary for condition 1 (since no target acts appeared in that experimental condition). All statistical tests reported are two tailed and no error level corrections were applied.

RESULTS

Observer dogs were highly attentive. Observation times closely matched demonstration times (mean demonstration time was 4.5 s, while mean observation time was 3.8 s). Also, in 100 of the 125 recorded trials, observers fulfilled the 'crucial observation' criterion (i.e. they had seen all three major components of the demonstrations). Furthermore, 17 of the 25 recorded dogs fulfilled the 'crucial observation' criterion in all five demonstrations they had received.

Table 1

Number of dogs that performed the target action in conditions 1–5 before and after they received the verbal command and overall number showing target actions before or after the command

	Condition 1		Condition 2		Condition 3		Condition 4		Condition 5		Sum 2–5		Sum total	
	E	C	E	C	E	C	E	C	E	C	E	C	E	C
Before receiving command														
Target	0	NA	2	2	0	1	2	0	2	1	6	4	6	4
No target	20	NA	18	18	20	19	18	20	18	19	74	76	94	76
After receiving command														
Target	0	NA	1	4	3	3	4	1	7	6	15	14	15	14
No target	20	NA	19	16	17	17	16	19	13	14	65	66	85	66
Overall*														
Target	0	NA	3	5	3	4	4	1	7	7	17	17	17	17
No target	20	NA	17	15	17	16	16	19	13	13	63	63	83	63

NA: not applicable; E: experimental; C: control.

* Dogs that showed target actions both before and after the command were counted only once.

Observers' Behaviour During Test

Condition 1

No dog performed the target action in condition 1 (untrained action condition) either before or after the verbal command. Hence, we did not find any evidence for copying of the target action in this condition and thus we abstained from running a control for condition 1. In the following, we analysed only conditions 2–5, as controls were available in each case.

Target actions before the verbal command (conditions 2–5)

Before the verbal command was given six of the 80 subjects in experimental groups and four of the 80 subjects in control groups performed the target action (Table 1). We could not find any evidence for observational learning, as the omnibus test of the binary logistic regression was not significant (binary logistic regression, omnibus test of full model including the interaction: $\chi^2 = 6.919$, $P = 0.437$).

Target actions after the verbal command (conditions 2–5)

After the verbal command was given 15 of the 80 subjects in experimental groups and 14 of the 80 subjects in control groups performed the target action (Table 1). We could not find any evidence for observational learning, as the omnibus test of the binary logistic regression was not significant ($\chi^2 = 11.388$, $P = 0.123$).

Target actions both before and after the verbal command (conditions 2–5)

Regardless of when the verbal command was given (i.e. counting both before and after) 17 of the 80 subjects in experimental

groups and 17 of the 80 subjects in control groups performed the target action (Table 1). We could not find any evidence for observational learning, as the omnibus test of the binary logistic regression was not significant ($\chi^2 = 6.961$, $P = 0.222$).

Sits before the verbal command (conditions 2–5)

Before the verbal command was given 45 of the 80 subjects in experimental groups and 44 of the 80 subjects in control groups performed 'sit' (i.e. sat down; Table 2). We could not find any evidence for any experimental effect, as the omnibus test of the binary logistic regression was not significant ($\chi^2 = 3.491$, $P = 0.836$).

Sits after the verbal command (conditions 2–5)

After the verbal command was given 61 of the 75 subjects in experimental groups and 49 of the 75 subjects in control groups performed 'sit' (i.e. sat down; Table 2). Here the omnibus test was significant ($\chi^2 = 24.230$, $P = 0.001$). However, none of the tests of the individual predictors nor their interaction was significant (all $P > 0.34$). Thus, we could not find evidence for any experimental effect.

Sits both before and after the verbal command (conditions 2–5)

Regardless of when the verbal command was given (i.e. counting both before and after) 68 of the 80 subjects in experimental groups and 60 of the 80 subjects in control groups performed 'sit' (Table 2). Here the omnibus test was significant ($\chi^2 = 19.017$, $P = 0.008$). However, none of the tests of the individual predictors nor their interaction was significant (all $P > 0.46$). Thus, we could not find evidence for any experimental effect.

Table 2

Number of dogs that performed sit in conditions 1–5 before and after they received the verbal command and overall number showing sits before or after the command

	Condition 1		Condition 2		Condition 3		Condition 4		Condition 5		Sum 2–5		Sum total	
	E	C	E	C	E	C	E	C	E	C	E	C	E	C
Before receiving command														
Sit	12	NA	11	10	10	11	10	13	14	10	45	44	57	44
No sit	8	NA	9	10	10	9	10	7	6	10	35	36	43	36
After receiving command														
Sit	11	NA	12	10	17	15	13	10	19	14	61	49	72	49
No sit	5	NA	7	7	1	4	6	9	0	6	14	26	19	26
Overall*														
Sit	16	NA	13	13	19	16	16	14	20	17	68	60	84	60
No sit	4	NA	7	7	1	4	4	6	0	3	12	20	16	20

NA: not applicable; E: experimental; C: control.

* Dogs that sat both before and after the command were counted only once.

Highly trained dogs

Regardless of when the verbal command was given (i.e. counting both before and after) one of six highly trained subjects in experimental groups and two of six subjects in control groups performed target actions (Fisher's exact test: $P = 1.0$). Thus, highly trained dogs did not copy more than the remaining (untrained) dogs.

Observers' Behaviour During Demonstrations

Observers' behaviour during demonstration phase (condition 1)

During the time of the demonstrations one of 20 subjects performed 'sphinx' (i.e. the target action of conditions 2–5) and four of 20 subjects performed 'sit'. However, observers never showed the target action ('playing dead') during the demonstration phase of condition 1. Hence, we did not find any evidence for immediate copying (automatic response facilitation) of the target action in this condition. In the following, we analysed conditions 2–5 for behaviours occurring during the demonstration phases.

Observers' behaviour during demonstration phase (conditions 2–5)

Six of the 80 subjects in experimental groups and one of the 80 subjects in control groups performed the target action 'sphinx' during the time of demonstrations. We could not find any evidence for automatic response facilitation, as the omnibus test was not significant ($\chi^2 = 11.706$, $P = 0.111$).

Of the 80 subjects in experimental groups and the 80 subjects in control groups, 35 and 28, respectively, performed 'sits' during the time of demonstrations. We could not find any evidence for any experimental effect, as the omnibus test was not significant ($\chi^2 = 10.885$, $P = 0.144$).

None of the dogs in any condition ever performed 'playing dead' during the demonstration phase. Thus, for 'playing dead' no statistics were necessary.

DISCUSSION

Despite high levels of attention during demonstrations, dog observers in our study were no more likely to perform the observed intransitive target actions, nor was their 'sitting' behaviour in any way different from that of the control dogs. This result remained robust regardless of the following: whether observers had previously been trained to perform the target action, whether observers received a reward for reproducing the action, whether the command that observers received was given by their owners or by an unfamiliar experimenter, and whether the demonstration was accompanied by ostensive cues or not. The lack of target actions seemed also not to be caused by the training backgrounds of observer dogs. Furthermore, we found no evidence for automatic response facilitation during the demonstration phases preceding test phases. Hence, here we did not find evidence for contextual imitation or automatic response facilitation of intransitive actions within a third-party setting in dogs (nor did we find evidence for a general elevation of responsive behaviour, i.e. 'sit'). Our findings are thus seemingly in contrast to other studies which have suggested that dogs can and do learn in observational learning situations (Kubinyi et al. 2003b; Topál et al. 2006; Range et al. 2007; see also Pryor 2001).

One could argue that our task was methodologically too difficult or unnatural for the observer dogs. However, we do not think that this was likely to be the case for three reasons. First, our study design followed in many ways the design of Range et al. (2007) where dogs copied readily, with one of the main exceptions that in our study the actions were not performed towards an apparatus and thus were intransitive instead of transitive. Second, there is evidence that children copy even novel actions in studies

comparable to ours. Recently it has been shown that children aged 18 months and above significantly copy actions (even novel ones, unlike in our study) in third-party settings similar to those in Range et al. (2007) as well as this study (Nielsen 2006, experiment 3; Herold & Akhtar 2008). The performance of human children, as well as the performance of dogs in Range et al. (2007), in tasks similar to those in our study suggests that the reason why dogs in our study did not copy was not methodological, but reflects a true deficit in the dogs' ability to copy intransitive actions spontaneously. Third, Floor & Akhtar (2006) showed that children as young as 18 months can learn novel words by eavesdropping on third-party conversations. This is not to say that we believe that our observer dogs needed also to learn the novel verbal command together with the demonstrated action. Instead, we also allowed observer dogs to perform target actions outside the command context, and thus the ability to learn novel commands was actually not required (especially not during the demonstration phase, i.e. in our automatic response facilitation control). Similarly, Range et al. (2007) found positive results without any need to give their chosen novel verbal command ('Ring') to observer dogs. The use of verbal commands by us, as well as by Range et al. (2007), was instead simply helpful to elicit demonstrations.

It may be further argued that the prospect of receiving a reward may have occupied observers to the extent that they were thus blocked from showing contextual imitation. However, condition 3, in which observer dogs received a reward even before showing the target action, suggests that this is not a valid criticism. Furthermore, since observer dogs in experimental conditions, but not in control conditions, saw another dog receiving a reward, sitting behaviour at least should have occurred more often in the experimental conditions if this was a valid criticism, but this was not the case. If this had been the case, the same 'reward-expectancy' would have been present in the study of Range et al. (2007) but this did not prevent dogs showing contextual imitation in this instance.

Dogs are highly social creatures which form strong bonds with their owners (Topál et al. 1998), and it might be argued that they consider information coming from their owner as more relevant, or that they are simply more attentive when their owner is present. Following this argument one might predict that they would be more successful in an observational learning situation with their owner rather than with a stranger. However, dogs in our study performed equally poorly regardless of whether the experimenter was their owner or a stranger (condition 4).

The use of ostensive cues (condition 5) also did not increase the dogs' performance, even though the results of Range et al. (2007) suggested that such cues might have an effect. Furthermore, it has also been argued elsewhere that such cues may be important for observer dogs (Pongrácz et al. 2004). However, it is worth noting that Pongrácz et al. (2004) did not investigate copying of novel actions, contextual imitation or automatic response facilitation and thus a comparison with our study may be of limited value. While in Pongrácz et al.'s (2004) study dogs were more successful when a human demonstrator spoke to the dog than when he/she remained silent during demonstrations, these dogs were required to learn about separate locations, and not actions. Thus, the human voice may have simply acted as another cue to mark a location ('local enhancement', Thorpe 1963). Evidence that local enhancement may have been the underlying mechanisms in the Pongrácz et al. (2004) study comes from another more recent study in which dogs performed equally well when a human called them or when a small, remote-controlled plastic car produced some noise (D. Mersmann, J. Call, J. Kaminski, M. Taborsky & M. Tomasello, unpublished data). In sum, it currently remains unclear whether ostensive cues help dogs to reproduce observed actions (be they familiar or novel).

Production Learning (Copying Novel Actions)

Even though the target action we used in condition 1 resembled the normal sleeping posture of dogs, one could argue that the performance of this particular action to gain a reward has some novel component to it (note also that the dogs we tested were never trained to perform this action upon command). This relatively novel action was not performed by observers in the test phase (i.e. via contextual imitation) or during demonstrations (i.e. via automatic response facilitation). One potential criticism of our choice of target action could be that we selected an action from the general class of comfort behaviour (i.e. sleeping, but this criticism might also apply to the case of sphinx behaviour). Perhaps this choice might not have been appropriate to observe copying. While this is possible, we point out that, in practice, it is actually rather difficult to derive tests for dogs that present truly novel intransitive actions, and even the choice of familiar intransitive actions is limited: observer dogs do not possess many degrees of freedom that are left unexplored during their ontogeny and by the same token it is difficult to train demonstrator dogs in truly novel actions (even the numerous actions used in Topál et al. 2006 lacked novel actions). Thus, we believe that the target action we used in condition 1 ('playing dead') approximately fulfils some criteria of novelty for (observer) dogs. If this view is correct then the results of condition 1 at least suggest that dogs may not copy novel, intransitive actions. This would be the first (but tentative) evidence that dogs do not (or cannot) copy novel intransitive actions, and thus seem to fail in production learning (see Introduction). At the very least, we can conclude that we found no evidence of contextual imitation (i.e. copying familiar actions) for an untrained, intransitive action within a third-party setting (conditions 2–5).

Why should one expect dogs to be able to copy novel actions? It seems that, during the domestication of the dog, what humans unconsciously selected for in dogs was mostly based on naturally occurring behaviour. Dogs probably did not experience the necessary selection pressure to develop true action copying skills. For most evolutionarily relevant time, humans used dogs for guarding and hunting, both of which represent action patterns that are already part of the dog's natural repertoire. Humans selected dogs for their ability both to inhibit some natural action patterns (e.g. to inhibit aggression) and to show other natural action patterns (e.g. to bite and bark at intruders or to hunt). In sum, we propose that dogs needed to become especially sensitive to the where, the what and the when, to activate or deactivate their innate or trained action patterns, but without any need to learn novel actions by observation (see also Frank & Frank 1983). In this context, we note that dogs are the classic case of conditional learning (Pavlov 1923). Indeed, dogs can quickly learn even extremely arbitrary associations (Kubinyi et al. 2003a), and their learning rate seems to be in general very fast (McKinley & Young 2003; Bentosela et al. 2008).

Our negative results are at first sight in strong contrast to other contextual imitation studies (i.e. Topál et al. 2006; Range et al. 2007). However, dogs in those two studies were highly trained, either specifically for contextual imitation (Topál et al. 2006) or in a more general way (see Range et al. 2007). Training backgrounds have already been found to have an effect on action copying in great apes. For example, 'enculturation' (see also Tomasello & Call 2004) has so far been responsible for all known cases of action copying in great apes (Hayes & Hayes 1952; Custance et al. 1995; Call 2001). It is possible that training effects might also influence some cognitive abilities and/or motivations in dogs (see Cooper et al. 2003; Miklósi et al. 2004). Thus, it may be the case that the dogs we tested in our study failed because we used a random sample of mainly 'normal' household dogs instead of testing highly trained dogs. Our subsample of highly trained dogs showed no signs of contextual

imitation which speaks against any such training effects. However, owing to the small number of highly trained dogs studied, we cannot draw firmer conclusions.

Instead, we believe the most likely explanation for why we, unlike others, did not find contextual imitation in dogs is that here we combined the third-party imitation paradigm (as in Range et al. 2007) with demonstrations of intransitive actions (as in Topál et al. 2006). It therefore seems likely that, while dogs are able to learn by observation within the third-party paradigm, they do this only when their actions are anchored on an object in the environment (as in the transitive actions of Range et al. 2007). When intransitive actions are used instead, dogs may need to be explicitly and intensively trained and be tested within a second-person imitation paradigm (as in Topál et al. 2006). Thus, it seems that, in analogy to the case of production learning (see above), contextual imitation in dogs is externally driven as well, in this case to the where (i.e. objects are acting as targets or anchors for behaviour). A methodological distant relative of the third-party imitation method, the so-called model rival technique (Todt 1975) also often focuses on objects, that is, on the where or the what. The model rival technique has worked with great success in studies of animals, possibly again because it is object-centred (e.g. African grey parrots *Psittacus erithacus*: e.g. Pepperberg 2002). When objects are at the focus (unlike in our study) then the model rival method seems to work with dogs, too (McKinley & Young 2003; but see Cracknell et al. 2008 for a critique). The focus on objects (i.e. the transitivity of actions) thus seems to be a likely candidate for why dogs in Range et al.'s (2007) study, but not dogs in our study, could reproduce the actions that they had seen.

One may raise some further criticisms of our study. First, the types of actions we used were very different to the ones used in the task of Range et al. (2007): while these authors tested mouth versus paw use (two behaviours often associated with food acquisition in dogs, and thus very familiar to any dog) we used more arbitrary actions foreign to the normal food acquisition context (and both from the comfort behaviour class). So, potentially, the food acquisition context may trigger (and possibly restrict) contextual imitation in the dog, at least outside of a 'Do as I Do' context (Topál et al. 2006). Second, in Range et al. (2007), but not in our study, observers were able to scrounge food during demonstrations, which may have boosted their motivation to learn (but see Girardeau & Lefebvre 1987 for a different view on scrounging). Third, in Range et al. (2007) observers were given more demonstrations than in our studies. We only provided five demonstrations because a pilot study indicated that observers lost interest after more demonstrations. Fourth, our observers were separated from demonstrators by a Plexiglas barrier, which may have had a detrimental effect. There are no strong a priori reasons to think that any of these four criticisms applies, but at the current stage we also cannot discount them. Future studies will be needed to test directly the possible influences of these factors.

Finally, there are four more potential concerns about our general method. First, for observers the demonstrator's actions may have been perceived as general 'begging'. Because of this potential preoccupation of the observers, they may have failed to pay attention to the relevant actions used by the demonstrator. Furthermore, one may argue that an observer dog in such a situation may not need to learn a new begging gesture if she is already proficient in using other begging gestures, as nearly all dogs are (a similar criticism was acknowledged by the authors when applied to the great ape study upon which this study is partly based: Tomasello et al. 1997). However, even though observer dogs in our study had seen live demonstrations they failed subsequently to show a higher level of their normal begging behaviour (i.e. 'sits'). Thus, we discount this criticism. Second, it may be that we have tapped

into the domain of command learning that may simply have been too demanding for the dogs (i.e. to learn to respond to a new command by observing another dog responding to it). However, when tested, observers produced no more target actions before E presented the verbal command than they did after that command (and this extends to the demonstration phase as well); thus we discount this criticism also (and in Range et al. 2007 commands were given to demonstrators as they were in our study). Third, there may have been a problem of overriding an established command for the already familiar behaviour in conditions 2–5. However, this cannot account for the lack of target behaviour in our first condition as the action we sought to elicit was not previously attached to any command. Also, we recorded whether observers showed any target actions during the demonstration phase, which they did not. Fourth, dogs possibly copy more readily if the demonstrator is a human because dog behaviour can be very human-centred (Miklósi et al. 2003; Topál et al. 2005). While we exclusively used dog demonstrators, this is not a major concern, as other authors with positive findings have used dog demonstrators as well (see Range et al. 2007). In sum, we found no evidence supporting the idea that dogs spontaneously copy intransitive actions, regardless of whether these are within their repertoire or not. Future studies should be devoted to test this idea further under a larger variety of conditions so that firmer conclusions can be drawn on this topic. In addition, future studies should also test the remaining possibility that mere methodological differences between Range et al. (2007) and our study (e.g. using a Plexiglas separation) might have resulted in dogs failing to copy in our study.

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