Report

Selective Imitation in Domestic Dogs

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Summary

The transmission of cultural knowledge requires learners to identify what relevant information to retain and selectively imitate when observing others' skills. Young human infants—without relying on language or theory of mind—already show evidence of this ability. If, for example, in a communicative context, a model demonstrates a head action instead of a more efficient hand action, infants imitate the head action only if the demonstrator had no good reason to do so, suggesting that their imitation is a selective, interpretative process [1]. Early sensitivity to ostensive-communicative cues and to the efficiency of goal-directed actions is thought to be a crucial prerequisite for such relevance-guided selective imitation [2]. Although this competence is thought to be human specific [2], here we show an analog capacity in the dog. In our experiment, subjects watched a demonstrator dog pulling a rod with the paw instead of the preferred mouth action. In the first group, using the "inefficient" action was justified by the model's carrying of a ball in her mouth, whereas in the second group, no constraints could explain the demonstrator's choice. In the first trial after observation, dogs imitated the nonpreferred action only in the second group. Consequently, dogs, like children, demonstrated inferential selective imitation.

Results

Recent advances in child psychology demonstrate that already 3- to 12-month-old infants interpret others' behavior as goal directed [3–8] and, as a result, predict the most efficient action to achieve a goal within the constraints of a given situation [9]. This inferential competence does not require the attribution of mental states to others but relies simply on the evaluation of the observable facts: the action, the goal state, and the situational constraints [9]. One situation in which human infants are thought to manifest this nonmentalistic inferential process is their selective imitation of goal-directed actions. Fourteen-month-old children, who watched a demonstrator illuminate a light-box by leaning forward and touching its top with her forehead while her hands were occupied (pretending to be cold and holding a blanket wrapped around herself with both hands), did not imitate the head action but used predominately the more efficient method (touching the box with their hands) to achieve the goal [1]. If, however, the less effective action (head) is demonstrated without any obvious reason to do so, they do copy the demonstrated action. Interestingly, for copying to occur, it also seems to be necessary that the demonstration is accompanied by communicative cues of the model targeted at the infants [2]. One hypothesis currently discussed to explain the importance of the communicative context is that the ostensive cues (e.g., eye contact and addressing the subject) given by the model might induce in infants a special interpretational attitude, thus making them receptive toward novel information that violates their expectation of efficiency and preparing them to learn this information quickly and persistently.

Exceptional among nonhuman animals, domestic dogs are also sensitive to human-given communicative cues [10–12] and can easily be trained to perform actions that are not causally linked to a reward [13]. These abilities are probably affected by domestication [14, 15]. On the other hand, dogs, like other animal species, optimize their behavior on the basis of efficiency, for instance, choosing the shorter route instead of a detour to reach a reward [16].

The selective-imitation task provides an opportunity to test whether dogs (1) automatically copy a demonstrated action because they do not understand the importance of the situational constraints, (2) use their preferred method to solve the problem unaffected by the demonstration of the model, or (3) like children, selectively re-enact the demonstrated action depending on the constraints of the situation.

We designed an instrumental problem-solving task comparable to the paradigm used by Gergely et al. [1], a paradigm that required the dogs to pull down a wooden rod to open a food container and gain a food reward (Figure 1). In this situation, as shown by dogs who were allowed to manipulate the wooden rod without seeing any demonstration (control group, C), the preferred action for dogs to manipulate the wooden rod is by using their mouth. Dogs of two experimental groups, however, could observe an adult female dog that had been trained to produce food from the apparatus by using only her paw, thus using this "inefficient" action instead of applying the method preferred by dogs. In one group, she carried a ball in her mouth (mouth-occupied group, MO), whereas in the second group, her mouth was not occupied (mouth-free group, MF). Consequently, in the first group (MO), using the "inefficient" action was justified by the constraints of the situation

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A

Food Container

Spring

Metallic Chain
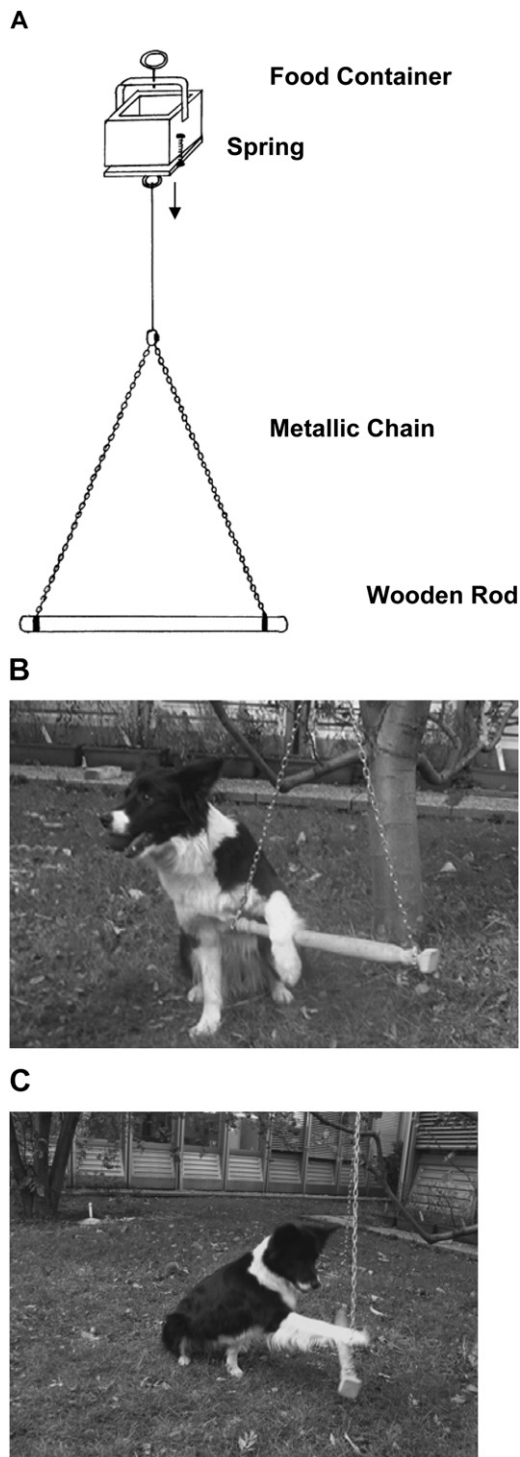
Wooden Rod

B

C

Figure 1. Testing Apparatus and Pictures of the Model during the Demonstrations

(A) To release a food reward from the apparatus, the dogs had to either pull the wooden rod with their mouth or push it down with their paw. The food was released from a trap door at the bottom of the apparatus.

(B and C) Demonstrator producing a food reward by pushing the wooden rod down with her paw in the mouth-occupied group (B) or the mouth-free group (C).

(analogous to the hands-occupied group in Gergely et al.'s study [1]), whereas in the MF group, no constraints were present to explain the demonstrator's ineffective choice (analogous to the hands-free group). In the experiment, all 54 dogs (C: n = 14; MO: n = 21; MF: n = 19) were first tested and if needed shortly trained in a different but analogous situation to use both their mouth and paw to manipulate a ring. Note that all dogs, including the control dogs, went through that pretest procedure. Dogs of the mouth-occupied and mouth-free groups and the owners of the control dogs were allowed to watch the model dog that was obtaining food from the test apparatus by using her paw. The demonstration was accompanied by communicative cues both from the humans and the model (see the Supplemental Data available online for details). Between each of the ten demonstrations, the observer dogs were allowed to retrieve the food produced by the model. Each dog paid attention to the demonstration in at least eight trials. It is important to note that the owners of all three groups had the same expectation of how the apparatus should be operated by their dog because the owners of the control dogs also watched the mouth-free demonstration of the model dog several times. In addition, for ensuring that cues by the owners (e.g., "Clever Hans" effect) did not influence the performance of the dogs, one-third of the owners in each experimental condition were blindfolded during the demonstration (please see the Supplemental Data for detailed information).

In a subsequent test, the subjects were encouraged to manipulate the apparatus to get the food by themselves to see whether they match their behavior to the demonstrated action. A trial was terminated when the dog stopped manipulating the apparatus or a reward was obtained. Following Meltzoff's [17, 18] and Gergely et al.'s [1] method, we measured the number of attempts and successful actions the dogs used to manipulate the wooden rod on the first trial.

All but one subject in the control group, 19 of 21 in the mouth-occupied group, and 18 of 19 in the mouth-free group manipulated the apparatus at least once. The three groups showed no differences from each other in either the latency from approaching the apparatus to successful manipulation in the first trial (Kruskal-Wallis test: KW = 1.438; df = 2, p = 0.487) or the number of actions performed to gain access to the food (Kruskal-Wallis test: KW = 1.007; df = 2; p = 0.605). In all three groups, therefore, the animals showed similar activity and achieved similar success (see Table S1).

However, when analyzing which methods the subjects used in the three groups, we found that only two subjects in the control group (15.38%) and four subjects in the mouth-occupied group (21.05%) manipulated the rod with their paws, whereas 15 of 18 subjects used their paws in the mouth-free group (83.33%) (Fisher's exact test, C–MO: p = 1.0; C–MF: p = 0.0003; adjusted p value: p < 0.001; MO–MF: p = 0.0002; adjusted p value: p < 0.001; Figure 2 and Table S3). This analysis was conducted to be comparable with the infants' study. Note that all but three dogs (MF: n = 2; MO: n =1) who used their paws in the first trial were successful in retrieving a food reward with this method.

The same difference between the three groups was found when we calculated the percentage of paw use
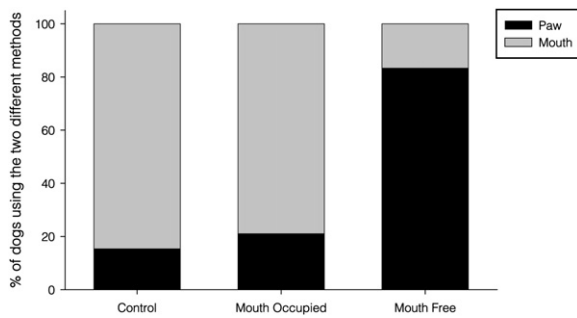
Figure 2. Results of the First Test Trial

The proportion of dogs using their paw or only their mouth to manipulate the apparatus in the control group (left bar), after watching the paw action used by the demonstrator dog under the two experimental conditions (middle bar, model had mouth occupied; right bar, model had mouth free), recorded in the first trial. Black portion for the bars represents that paw action was re-enacted; light-gray portion of the bars represents that only mouth action was used.

of all manipulations (% paw = [paw/(paw + mouth)]*100 in the three groups (Kruskal-Wallis test: KW = 16.639; df = 2, p = 0.0002; Dunn's multiple-comparisons test: C–MO: p > 0.05; C–MF: p < 0.01; MO–MF: p < 0.01; Figure 3 and Table S2). Interestingly though, most dogs in both experimental groups used the mouth action first (MO: n = 17; MF: n = 13) (Fisher's exact test, p = 0.232). These differences between the experimental groups are comparable to those obtained by Gergely et al. in the children's study. However, to analyze whether the observed pattern would persist over further trials, we conducted seven additional trials. Already in the second trial, subjects in the mouth-occupied group showed a high paw-use percentage similar to the dogs in the mouth-free group, whereas control subjects continued using their mouth (Figure 3; Tables S1–S3).
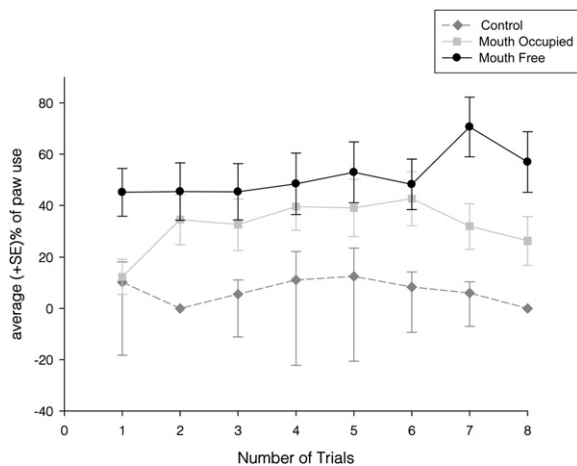

Figure 3. Paw Use across All Eight Test Trials

The mean percentage of mouth and paw actions of all manipulations in the two experimental groups and the control group over all trials (mean ± SE). Because of the fact that some dogs refused to continue working after a few trials, the number of subjects varies in the control and mouth-free group across trials but does not drop below seven in any group. Further details are available in the Supplemental Data.

Discussion

To our knowledge, these data provide the first evidence that animals imitate in an inferential, selective manner. Two alternative explanations may be raised. First, one could argue that watching the model carrying a ball in her mouth might have socially facilitated dogs in the mouth-occupied but not in the mouth-free group to engage in mouth manipulation and stronger pulling with the mouth because of energizing of the mouth muscles activated by mirror neurons [19, 20]. However, because all dogs engaged first in mouth manipulation, readiness toward mouth action did not differ between experimental groups. Moreover, stronger pulling would have led to faster success in the mouth-occupied compared to the mouth-free group, but this did not occur. Furthermore, one could argue that, because the ball was only present in the mouth-occupied condition, the two experimental groups differed in their perceptual complexity. However, nine dogs in the mouth-occupied conditions started to use their paws as early as the second trial, suggesting that the presence of the ball did not, in fact, prevent them from acknowledging the paw action of the demonstrator.

These findings encourage us to draw parallels between dogs and children in the sense that the dogs' selective re-enactment of the demonstrated action in the first trial, like the children's, seems to be influenced at least by the inference about efficiency. Whether the selectivity of the two experimental groups is really due to a learning effect triggered by the communicative context [2] needs to be elucidated in further studies. In any case, these results reveal an interesting similarity between dogs and human infants, a similarity that is probably not shared with chimpanzees. In Horner and Whiten's [21] study, chimpanzees did not imitate an action when it was clearly irrelevant in order to gain access to the reward. This is contrary to the reaction of dogs and infants, who imitated the demonstrated action when its use was not justified. Whether this reflects simply procedural or real species differences should be revealed by more precise comparative studies. Moreover, whether the observed selective re-enactment in the dogs would also be persistent after a time delay as in case of the infants, who showed the same performance after a 1 week delay, also remains to be tested.

The additional test trials in our study—not available from the infant study—revealed that the dogs in the mouth-occupied group increased their paw use after the first trial. This might reflect a differential memory of the demonstrated paw action and the presence of the ball. The manipulation of the rod and gaining a food reward in the first trial might have decreased the motivational value of the ball and at the same time triggered the memory of the observed demonstration.

The observed adoption of the paw action in the experimental groups demonstrates for the first time that dogs are able to show an imitative form of social learning. This type of social learning from a conspecific model clearly exceeds purely motivational and perceptual forms of social influence, such as social facilitation and stimulus enhancement [22], as already demonstrated in dogs [23]. It also deviates from simple forms of behavioral matching, such as response facilitation, i.e., the priming of an

action already in the repertoire of the observer [24], because, even though the pretest showed that all animals had paw use in their repertoire, observers of both experimental groups started out by using their mouth instead of the demonstrated paw action to manipulate the rod. The quick and radical shift in the mouth-free group to adopt the paw action, for which there is no tendency in the control group, indicates an imitative form of social learning according to Thorpe [25], e.g., "as a significant elevation in the frequency of an observed action over the normal probability of its occurrence" [26] (reviewed in [27–31], but see also [32, 33]).

The fact that the observers of the mouth-occupied model did not adopt the "nonpreferred" model action in the first trial compared to the mouth-free model suggests that dogs, like children [1, 34], engage in inferential selective imitation. Further studies need to determine (1) the influence of ostensive cues on the performance of dogs in a selective-imitation task, (2) whether this ability is restricted to the domestic dog or shared with other nonhuman animals, and (3) if it is restricted to dogs, whether it results from their evolutionary history of domestication or their developmental training by humans.

Experimental Procedures

Details of the training and the experimental procedures are given in the Supplemental Data. Videos were coded by an observer blind to the experimental conditions. Interobserver reliability for mouth and paw actions, based on coding ten dogs from video records, was calculated as Cohen Kappas: mouth action: 83.5% (percentage of agreement was 95.0%) and paw action: 96.8% (percentage of agreement was 99.4%).

Supplemental Data

Additional Experimental Procedures, three tables, and four movies are available at http://www.current-biology.com/cgi/content/full/17/10/868/DC1/.

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