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Social learning and imitation in dogs (Canis familiaris)

Doctoral Thesis

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2014
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1.1 Social Learning

Social learning is defined by Galef (1976, 1988) as an increase in the probabilities of acquiring behaviors as a result of an interaction with a subject who already acquired it individually. For behavioral similarity among individuals to rely on a social learning process, the learner must be able to perform the action also after the end of the interaction between the subjects. Thus all the instances in which the behavior of an individual triggers a similar response in the other only as long as they interact are excluded. Galef (1888) proposed the general term 'social enhancement' to refer to those situations in which the social interaction influences the observer who will perform actions that are already part of his behavior repertoire. In his view the term 'social learning' would only refer to those situations in which the observer acquires (or extinguish) a behavior. In case the acquired behavior becomes part of the repertoire of the observer also after the end of the interaction with the model, Galef (1976) refers to the social transmission of behavior. Similarly Whiten and Ham (1992) distinguish between two categories of social processes that can determine behavioral similarity among individuals: social influence and social learning. The difference between the two is that through social learning the observer acquires some new information or behavior, while through social influence he is influenced by the model but performs a behavior that is already part of his behavior repertoire, thus he does not learn something specifically.

Social learning has received little attention from the comparative psychologists in the past, the main focus of their research being individual learning. The interest of biologists for the adaptive value of behavior for the survival and reproductive success of animals has led them to suggest that social learning fills an important niche between species-typical, genetically predisposed behavior and individual (trial and error) learning (Boyd and Richerson 1988). While species-typical behavior
reliable and does not vary if the environment is modified, it may sometimes be not functional. For example, a hungry animal may be forced to try new kinds of food, if its familiar one is no longer present, but not all new food is edible and sometimes it may be poisonous. Such changes in the environment may force animals to learn by experiencing the consequences of their actions (Zentall 2006), and, in some cases, to abandon a previous habit, if it is dangerous. The evolution of certain skills that allow the animal to learn from experience and adapt to new situations is often dangerous, because some species have been shown to be more successful in adapting to new situations by observing others.

Thus it is possible that a selective pressure for evolving some forms of social learning exists for species living in groups. Ethological observations indeed indicate that social interactions allow spreading information about the environment and behavioral habits that are kept constant through time, being transmitted from one generation to the next (e.g., van De Waal et al. 2012; Hide and Fiske 1951; Kawa 1965; Bzee 1980).

1.1 Mechanisms

Biologists and psychologists had two different approaches to the study of social learning: while biologists tended to focus on its adaptive value, psychologists were more interested in the mechanisms by which individuals learn from others. In different periods and for different reasons ethologists and psychologists have distinguished a variety of social learning processes and have introduced a large number of different definitions: instinctive imitation (Morgan 1980), stimulus enhancement (Spence 1937a), match-dependent behavior (Miller and Dollard 1941), and local enhancement (Thorpe 1963).

Unfortunately, often these terminological differences do not define different observable behaviors. Although, it is now widely recognized that several different processes can be responsible for...
behavioural similarity as a consequence of social learning (e.g., Visalberghi and Fargaszy 1990, Tomasello 1990, Zentall 2006; Froese and Leavens 2014), it is not trivial to distinguish among the same mechanisms, especially as there is no distinction between terms used with a merely descriptive function and terms used with an explanatory function (Galef 1988) and investigators of social learning refer to animal learning theory, even when they are discussing mechanisms (Heyes 1994). Furthermore, behavioural similarity can also be due to other non-social mechanisms (Galef 1976; Whiten and Ham 1992), such as mimesis, or processes of individual learning. Unfortunately, the debates on the classification of the various learning processes within the range of social learning did not end with a consensus among scientists on what is imitation and what are the other non-imitative learning processes (e.g., Galef 1988, Heyes 1994, Mitchell 1989, Whiten and Ham 1992, Zentall 2006).

Here the most important processes of social influence and social learning are described:

1.2.2 Mechanisms of social influence

Contagion: This term refers to those situations in which the behaviour of the model triggers a similar behavioural response in the observer, who performs an action that is already part of his species-typical repertoire (Zentall 2006). Thus the behaviour of the model acts as a releaser for the unlearned behaviour of the observer (Thorpe 1963). Tinbergen (1960) referred to this process for the coordinated movements between males and females during courtship displays. A typical case of contagion occurs when a satiated animal resumes eating upon the introduction of a hungry individual who starts eating (Tolman 1964; McFarland 1985). Evidence of contagion comes also from simultaneous barking in dogs (Humphrey 1921) and yawning (e.g., Thorpe 1963; Provine 1986; Beanninger 1997; Campbell 2009), which has also been investigated between humans and dogs (Joli-Mascheroni et al. 2008; Harr et al. 2009).
regarding the interpretation of the results of these studies are controversial regarding the underlying mechanisms which were sometimes (incorrectly) given higher cognitive explanations, such as evidence for empathy—defined as a spectrum of resonant emotional responses—or even ‘low level imitation’. In our opinion the word ‘imitation’ should be used only when some learning occurs, as this is what is agreed by most scientists (see below). The controversy between cognitive (empathy, imitation) and ‘lower’ (contagion) explanations of the observed behavioural similarity adds even more confusion to the terminological issue about imitation and on the classification of social learning and social facilitation processes. Even if imitation could be claimed as the underlying mechanism, the alternative explanations should have been specifically addressed by experimental conditions instead of assuming one or the other hypothesis.

The main characteristics of contagion are the following (Poli and Prato Previde 1994):

- The behaviour is already part of the species-typical repertoire of the observer who does not learn something socially;
- The behaviour of the model and that of the observer are simultaneous and those processes in which the observer performs the behaviour after the interaction ends are excluded;
- The behaviour of the observer can start or increase in frequency, but this occurs only in presence of other individuals performing the same activity, thus the passive presence of conspecifics is excluded.

Probably contagious behaviours facilitate synchronization in groups (Evans 1970; Birke 1974—who uses the term ‘facilitation’) and it is very likely that, after the environmental stimuli provided a more general synchronization, contagion supports a finer level of synchronization (Klopf 1959).

Social facilitation:
According to Zajonic (1965) the presence of a conspecific increases the probabilities of all the behavioural responses that would be elicited by the environment by affecting the motivational level. The presence of a conspecific (or of another individual) influences the motivational state of the subject, thus facilitating the performance of a response. The conspecific does not influence directly the acquisition of a specific information or behaviour, nevertheless its presence, by modifying the motivational state of the observer or reducing its fear (Galef 1988), leads to changes in its behaviours and consequently increases the probabilities of acquiring a similar response (Davis 1973; Gardner and Engel 1971). In this case, as in contagion, the subject does not learn something socially from the partner, however his behaviour is influenced by its presence. For example, a rat's arousal may be increased by the presence of a conspecific and, as a consequence, also its general level of activity would increase, thus the rat performs a response (e.g., a bar pressing response) faster by getting in contact with the bar sooner, because of its increased level of activity (Gardner and Engel 1971).

According to Davitz and Mason (1955) and Morrison and Hill (1967) an animal in isolation may be fearful, thus the presence of a conspecific, by reducing its fear, increases exploratory behaviour and leads to a higher probability of performing the target behaviour by chance. Some authors do not distinguish between contagion and social facilitation because they do not find a difference in the response of observers whether the model is just present or also performs the behaviour (Tolman and Wilson 1965; Galef 1971).

1.1.3 Mechanisms of social learning

Local enhancement:

Seeing a subject acting in a particular location draws the attention of the observer to that place. This attentional response, in turn, may allow the subject to notice something that he would not have seen otherwise (Thorpe 1963). Thus through local enhancement the observer learns something about a
The famous observations on great tits puncturing the top of milk bottles, for example, has been claimed to rely on local enhancement. Indeed this behaviour spread rapidly from one neighbourhood to the other (Fisher and Hinde 1949). It is not possible to exclude that the birds did not learn by imitation or goal emulation but a conservative explanation stresses that the attention of the observer birds has been probably drawn to the bottles thanks to the presence of the feeding model bird and then, once reached the bottles, the observers found the source of food and consumed it. Having learned to identify a food source in the bottles, the birds tried to drink from a sealed bottle and learned individually how to puncture the top of it (Sherry and Galef 1984; 1990).

Recently Hoppit et al. (2012) tested wild groups of meerkats on a social learning task that involves the observation of trained demonstrators that feed from a box using different options. Right after the demonstration the observer meerkats were more likely to interact with the same box used by the demonstrator and this effect did not generalize to the same option type on the other box. Thus the authors concluded that the social learning effect right after the demonstration is highly spatially specific and suggest evidence for local enhancement rather than stimulus enhancement.

It is thought that every time the behaviour of the model involves an object, to which the observer may later respond, local enhancement may be involved (Corson 1967; Jacoby and Dawson 1969; Oldfield-Box 1970; Herbert and Harsh 1944). Thus studies on imitation of object-related actions should include proper controls (Lefebvre and Palmeta 1988).

Stimulus enhancement: The activity of the demonstrator on a particular object may draw the attention of the observer towards that object (Spence 1937b) and, as a consequence, it may increase the probabilities that the observer comes in contact with the object. The notion of stimulus enhancement seems to be broader than that of local enhancement because 'stimulus' was defined by Spence (1937) as a class of events that share.
common attributes. In some studies a duplicate-chamber procedure has been used (Warden and Jackson 1935; Gardiner and Engel 1971). In this procedure two objects are present, one in the demonstrator’s chamber and one in the observer’s chamber. In this situation, if the observer increases its attention towards its own object, it is thought that this is due to stimulus generalization because his object is similar to that in the model’s chamber (Henning and Zentall 1981; Levine and Zentall 1974; Zentall and Levine 1972). A similar procedure was also applied by Hoppitt et al. (2012) in the field, by using two feeding boxes in which the demonstrators were trained to feed using two different options (go through a cat flap or push a sleeve to enter the same box from a tube). The ‘Two-box design’ allowed the authors to disentangle stimulus enhancement from local enhancement by assuming that stimulus enhancement would be inferred if observation increased interaction with the same option-type (flap or tube) on a different box more than the different option-type on the different box. The results indicated that, immediately after demonstration, social learning was more pronounced for the same option and box used by the demonstrator and the authors suggest that this is a case of local enhancement.

Stimulus enhancement may also be involved in the process of learning to respond to a certain discriminative stimulus, but not in the presence of another. In fact, in this case the activity of the model that makes contact with the correct stimulus—but not with the negative one—draws the attention of the observer to it and consequently facilitates responding to it (Kohn and Dennis 1972; Kohn 1976; Edwards et al. 1980; Vanayan et al. 1985; Fiorito and Scotto 1992).

Observational conditioning: The observer’s attention towards the object manipulated by the demonstrator is often followed by a specific consequence for the demonstrator (e.g., the presentation of food), thus the observation of a performing demonstrator may not only draw the observer’s attention to the object, but may also facilitate to establish an association (Whiten and Ham 1999). Pamaleta and Lefebvre (1985) found that...
Pigeons exposed to varying amounts of social information learned to solve a food-finding problem faster when exposed to a model pigeon eating after piercing the cover of the food container, as compared to conditions in which they were exposed to pigeons either only eating or only piercing. The authors thus suggest that the observers copied the model only if they saw that the action of the demonstrator had a certain consequence. This association can also be established with aversive consequences so that the object will be associated with the model's fear response (Mineka and Cook 1988). In observational conditioning the observer learns what to attend and the valence of the stimulus, but does not learn what action to perform. He performs a behaviour that is already part of his repertoire. However, in observational conditioning the observer also acquires information about the valence of the stimulus, for example that it has an aversive valence (Whiten and Ham 1992). As the observer does not experience directly the consequence of the model's action, observational conditioning is considered by some authors (Zentall and Hogan 1975) as a higher order conditioning because the onset of a stimulus followed by the presentation of the unconditioned stimulus, which is inaccessible for the subject, can produce the association even without a demonstrator subject. However, the presence of the demonstrator manipulating the object and receiving the reinforcer may further enhance the associative process (Zentall 2006). Further evidence of this process comes from the observation that, if the model is not reinforced or if its reinforcement cannot be observed, the acquisition of the response by the observer is impaired (Akins and Zentall 1998; Heyes et al. 1994; Pamaleta and Lefebvre 1985). Furthermore if the observer is reinforced at the same time as the demonstrator, the response is acquired faster (Del Russo 1971). An example of observational conditioning is given by Mineka and Cook (1988) who studied the acquisition of a fear response in laboratory-reared monkeys by exposing them to wild conspecifics that showed an avoidance response in the presence of snakes. It is thought that the fearful conspecific acted as an unconditioned stimulus and the snake as the conditioned one. The exposure to the fearful conspecific alone or to the snake alone is not enough to acquire the fear.
Observational conditioning may be the mechanism involved in social transmission of predator recognition and avoidance in mammals (Mineka and Cook 1988) and birds (Curio 1988). It has also been noticed that biologically relevant stimuli induce a more intense response than artificial ones (Curio et al. 1978; Vieth et al. 1980).

Birds show a more intense fear response if exposed to a model bird reacting to a natural predator compared to when they are exposed to a model bird reacting to a plastic bottle.

**Goal emulation:** Emulation occurs when, after observing a demonstrator interacting with objects, an observer becomes more likely to perform any action that brings about a similar effect on those objects (Hoppit et al. 2012). By this learning process the observer acquires socially the information about the goal to be reached. For example, after having observed a model performing a sequence of actions to reach a certain goal, chimpanzees try to reach the same result but using different actions, thus they do not copy the actions of the model (Tomasello 1990). When the demonstrator used a stick to reach a reward, the observers were quicker than controls in obtaining the reward, however they did not copy the technique used by the model, but learned it individually (Tomasello et al. 1987). According to Tomasello, in this learning process, learning about the results facilitates acquisition. Whiten and Ham (1992) define imitation as learning some parts of the form of a behaviour by observing a demonstrator, thus, according to this definition, goal emulation would be a case of imitation limited to the last part of the behavioural sequence. Whiten and Ham (1992) have used the term goal emulation to indicate the case in which the observer recognizes that the behaviour of the demonstrator has certain consequences and that these could be reached also by different actions than those performed by the demonstrator. Horner and Whiten (2005) suggest that when the observer understands the causal structure of a task, he uses emulation, while when this understanding is lacking he uses imitation. Mitchell (1987) describes a
similar process, which he calls fourth level imitation, in which the organism is not bound to reproduce the model, but recognizes the relationship between action and goal and copies to its own end.

Whether goal emulation implies re-cognising the other’s goals and thus should be considered a more complex process than imitation is an issue that is still debated (e.g. Froese and Leavens 2014). However, as emulation involves learning socially the goal to be reached, a clearer categorization might be where behaviour is learned through imitation of another’s actions and the observer reaches the same goal as the demonstrator, also using similar actions.

Imitation: The study of imitation has always been regarded with mixed feelings and the use of this term with different meanings has a long history: while Darwin and its contemporaries used the term ‘imitation’ to refer to blind and mindless copying, since the end of the 19th century, most students of animal behaviour have used this term to indicate a cognitively complex form of social learning that requires some form of cross-modal matching which, in turn, is believed to rely on sophisticated cognitive processes. Imitative learning has been considered a ‘special’ ability (Whiten 1998) that involves some typically human features (Csibra and Gergely 2005). Thorndike (1898, 1911) defined imitation as learning to perform an act by seeing it done and claimed that imitative learning exists only in humans and maybe in other primates. In the past, the comparative psychologists looking for experimental evidence of imitation in non-human animals found it only in a certain number of cases (e.g. Warden and Jackson 1935; Church 1957, Dawson and Foss 1965). Whiten and Ham (1992) defined it as learning some part of the form of a behaviour by observing another animal.
He suggested that the term imitation be used only when an action is copied in another individual. He suggested that this term should be used only in the case of song imitation in birds if the acquired vocalization does not have a big instinctive component and also in the cases in which an otherwise improbable action is performed. More recently Zentall (2006) even proposed an approach that attempts to control for the presence of all the non-imitative factors and considers any matching behaviour that is left as evidence of imitation. This way, imitation is given a negative definition, which does not help the reader's understanding of what a subject learns imitatively (only what is not imitation is actually defined). However, if we consider the various learning processes from the point of view of what is learned by the observer, it would be agreed by most authors that, while in the non-imitative processes of social learning the observer acquires information about the stimuli, the objects, the environment or the events in the environment (e.g. local enhancement and observational conditioning), through imitation the observer learns from the model something about the actions.

Regarding the development of imitative abilities, much research has focused on humans. According to Piaget (1962) the sensory-motor stage of human development produces the ability to imitate. Children learn to coordinate visual inputs with motor outputs so that they can reach for objects that they can see and would be able of transparent imitation (e.g. scratching one's arm). However imitating 'opaque' actions (e.g. scratching one's own head) would require additional processes such as visualising the appearance of one's own head and it is not clear how this would happen (Zentall 2006).

1.2 Dogs' social learning abilities

Dogs represent a particularly interesting species for the study of hetero-specific social learning abilities (Kubinyi et al. 2009) as they have undergone selection for living in human groups through domestication and these changes contributed to form a species with surprisingly complex social skills (Hare et al. 2002; Miklósi et al. 2003; Miklósi et al. 2007; Miklósi and Soproni 2006; Reid 2009;...
According to this view dogs were selected to show reduced human-directed fear and aggression, which in turn lead them to acceptance of humans as social partners. As a consequence, dogs evolved the ability to use intraspecific social skills with humans (Hare and Tomasello 2005).

1.2.1 Social learning in dogs

In the past some controversial findings about social learning from conspecifics in dogs were reported: while Thorndike (1898) found that dogs failed to solve socially some manipulative tasks and Brodgen (1942) did not find evidence of a quicker acquisition of a conditioned response after observation of a similarly conditioned dog, Adler and Adler (1977) and Slabbert and Rasa (1997) found evidence of social learning from conspecifics in dogs, respectively in a string pulling task and in a drug search task. Now there is strong evidence that dogs can learn socially both from conspecific and heterospecific demonstrators and a wide consensus has been reached about their ability and predisposition to benefit from interactions with both conspecifics and humans. Species-typical (e.g. contagion), perceptual (e.g. local and stimulus enhancement) and motivational (social facilitation) factors have been repeatedly shown to produce matching behaviour or to help an observer dog to accomplish a given task. For example dogs can learn by observing humans in detour tests and manipulative tasks (Pongrácz et al. 2001, 2003, 2012; Kubinyi et al. 2003) and are easily influenced by humans in observational learning situations (Kupán et al. 2010). The selection for living in human social groups might therefore have favoured also their general ability to learn socially from humans. Recent results from Range and Virányi (2013) partially support this hypothesis by showing that, in a local enhancement task, in a control condition without food, dogs look longer than wolves towards a human demonstrator who does not carry food but goes to a target location with empty hands, thus showing more 'a priori' interest in humans than wolves.

This is only indirect evidence because looking as a measure of attention is only
one requisite for social learning to occur. Further studies could investigate on the possibility that dogs are more predisposed than wolves to learn socially from humans and eventually in what situations.

1.2.2 Imitation in dogs

Unfortunately there is much less agreement regarding the question whether observational conditioning, emulation and especially imitation are within the range of dogs' cognitive abilities. Some contrasting results can be found in different experiments: in an experiment in which dogs observed a demonstrator pushing a handle to the left or to the right to obtain a ball, Kubinyi et al. (2003) found that dogs in the experimental group touched the handle sooner than controls but did not find a significant direction matching effect. Miller et al. (2009) found that dogs matched the direction of the demonstration when a demonstrator dog pushed a screen more often than when the screen moved independently in presence of a passive dog, while their direction matching did not differ whether the demonstrator was a human or the screen moved independently while a human was present. However, the experimental design of this study may not provide an effective control for other perceptual factors, such as local enhancement. Particularly, simply going to the same side of the screen enables dog to push only to the same direction as the demonstrator.

Range et al. (2011) trained dogs to open a box using two different body parts: head or paw. One group was then rewarded to use the same body action as demonstrated by the owner, while the other group was rewarded for using the different action. This last group, which was required to counter-imitate, was slower than the other. This result is consistent with automatic imitation in humans (Heyes et al. 2005) and budgerigars (Mui et al. 2008), which implies a difficulty to inhibit the tendency to perform the same movement at the same time as demonstrator. Gergely et al. (2002) found that children can understand what is the action to be performed given the constraints of the demonstrator's situation and similar results were found also in dogs (Range et al. 2007). In latter study a model dog was trained to
perform a goal-directed action using a body movement (pull using a paw), which differs from what dogs who learn the task individually do (pull using their mouth). Whether observer dogs imitate the demonstrated body movement or not depends on whether the model’s mouth was free or not at the time of demonstration. Thus dogs were shown to copy the action of the demonstrator selectively, according to the constraints of the demonstrator’s situation, showing the ability to inhibit such automatic imitation described above and to choose instead the most efficient strategy (selective imitation). Accordingly, dogs’ behaviour seems to be goal-directed and they optimize their behaviour on the basis of efficiency (but see also Kaminski et al. 2010).

Topál et al. (2006) were the first to use the Do as I do paradigm with a dog and discovered that dogs are able to match functionally their behaviour to actions shown by a human demonstrator. These results were later replicated and extended by Huber et al. (2009). With the Do as I Do procedure, dogs first learn to match their behaviour to a small set of familiar actions with operant conditioning methods and later are able to generalize the ‘copying rule’ to other actions and demonstrators, thus they can be tested for imitation in various situations. Due to the differences in the behaviour repertoire of humans and dogs, their matching behaviours were described as ‘functional imitation’ because the dog reaches the same goal as the demonstrator taken into account the differences in the behaviour repertoire of the two species when performing similar actions (e.g., if the human demonstrator grabs an object using his hand, the dog grabs it using his mouth).

Tennie et al. (2009) failed to find evidence for imitation of intransitive actions in dogs. Observer dogs were exposed to an interaction between a human and a model dog in which the human rewarded the model dog for performing body movements that were familiar to the observer. Observer dogs were later tested to find evidence of copying the model’s action. In this setup the observer dogs did not outperform controls. One possible explanation for this result is that dogs lack the cognitive ability to copy intransitive actions. In fact, it seems that for many species these actions are more difficult to
IMITATE THAN TRANSITIVE ACTIONS (HUBER 2009). HOWEVER IT IS PROBABLE THAT THIS EXPERIMENTAL PROCEDURE DID NOT ALLOW DOGS TO UNDERSTAND THAT THEY WERE REQUIRED TO ATTEND THE INTERACTION AND TO COPY THE ACTION OF THE DEMONSTRATOR. FOR THIS REASON IT IS PREFERABLE TO USE THE DO AS I DO PROTOCOL IF ONE AIDS AT TESTING IMITATIVE ABILITIES. WITH THIS METHOD IT IS UNQUESTIONABLE THAT THE SUBJECT LEARNS THAT HE IS REQUIRED TO IMITATE, THUS IT IS POSSIBLE TO TEST ITS IMITATIVE ABILITY WITHOUT INCURRING IN OTHER METHODOLOGICAL, ATTENTIONAL AND/OR MOTIVATIONAL CONFOUNDS FACTORS.

1.3 SPECIFYING THE MENTAL MECHANISMS OF IMITATIVE BEHAVIOUR AND METHODOLOGICAL ISSUES

LLOYD MORGAN'S CANON IS USUALLY TAKEN BY RESEARCHERS TO JUSTIFY THAT, WHEN ANIMAL BEHAVIOUR CAN BE EXPLAINED BY TWO DIFFERENT PSYCHOLOGICAL PROCESSES AND THESE PROCESSES VARY IN COMPLEXITY, IT IS LEGITIMATE TO ASSUME THAT THE BEHAVIOUR RELIES ON THE LESS COMPLEX OPTION. ON THE OTHER EXTREME, THERE IS A TENDENCY IN CERTAIN AREAS OF RESEARCH TO ASSUME THAT ANIMALS ENGAGE IN COGNITIVE PROCESSES (E.G., ANIMALS UNDERSTAND PARTICULAR ASPECTS OF THE WORLD, SUCH AS CAUSALITY, INTENTIONS, COOPERATION, ETC.), WHICH IMPLY THAT THEY FORM MENTAL REPRESENTATIONS.

THE PROBLEMATIC ISSUE WITH THIS INTERPRETATION OCCURS IF THESE 'SUPER COGNITIVE' INTERPRETATIONS ARE TAKEN AS THE DEFAULT EXPLANATION OF THE OBSERVED BEHAVIOUR, WITHOUT PROPER CONTROLS FOR OTHER POSSIBLE MECHANISMS. AS STATED BY HEYES (2012) IT IS NECESSARY TO STEER A COURSE BETWEEN THESE TWO EXTREMES BECAUSE, ON THE ONE HAND, EVEN MORGAN FAILED TO GIVE A PROPER JUSTIFICATION FOR HIS CANON AND ALSO SUBSEQUENT ATTEMPTS TO JUSTIFY IT BY EVOLUTIONARY ARGUMENTS WERE FALLACIOUS. THE MAIN PROBLEM OF MORGAN'S ARGUMENT IS THAT IT IMPLIES A RANKING OF COGNITIVE FUNCTIONS THAT IS FAR FROM BEING STRAIGHTFORWARD (HEYES 2012; SOBER 1998). ALSO THE EVOLUTIONARY CONSIDERATION THAT SUPER COGNITIVE PROCESSES ARE MORE COSTLY AND REQUIRE LARGER BRAINS CANNOT BE TAKEN AS A JUSTIFICATION OF THE USE OF MORGAN'S CANON AS A GENERAL PRINCIPLE BECAUSE IT CUTS BOTH WAYS: IN SOME CASES EVOLUTIONARY CONSIDERATIONS WOULD FAVOR COGNITIVE INTERPRETATIONS (E.G. FOR SPECIES THAT EVOLVED IN COMPLEX SOCIAL ENVIRONMENTS).
In contrast, associative learning is widespread among all species, including humans and also some complex psychological mechanisms have been shown to rely on associations (e.g., Kaufam et al. 2012; Moore et al. 2011; Prados et al. 2011). Thus associative learning, as well as all the possible simpler explanations of behaviour, should be considered a contender of the more cognitive ones, but not the default and each study should include the proper controls to exclude (or confirm) the possible alternative hypothesis.

1.3.1 Experimental methods

Also in the domain of social learning, when behavioural similarity between two individuals is observed, it is necessary to exclude other processes (e.g., perceptual factors such as local and stimulus enhancement), before assuming the presence of the ability to imitate. Therefore two-action or multi-action experiments (Dawson and Foss 1965) have become recognised methods (e.g., Akins and Zentall 1996; van de Waal et al. 2012) because they control for other non-imitative processes that may increase the probability of a similar response by the observer, such as local enhancement (Thorpe 1963), stimulus enhancement (Galef 1988) and goal emulation (Wood 1989; Tomasello 1990). If the two-action procedure is used, it is possible to find evidence of imitation or, alternatively, of other non-imitative processes because these are spelled out in sufficient detail to make differential predictions (e.g., if the behavioural similarity relies on a stimulus enhancement process, the subject is expected to match the object used by the demonstrator but not the action, whereas if the behavioural similarity relies on imitation the observer is expected to match also the action in terms of body movement). For example Dawson and Foss (1965) tested imitation in budgerigars allowing observers to watch a conspecific that performed one of three different actions to open a lid of a container of food. The observers matched their behaviour with that of the demonstrator, performing mainly the action that was shown by the demonstrator in each condition.
In order to control for non-imitative processes, some authors (e.g. Heyes and Dawson 1990; Miller et al. 2009) used the so-called bidirectional procedure in which a manipulandum is moved by the model either in one direction or in the opposite one. In this case it is assumed that, if the observer moves the object in the same direction as the demonstration, he is imitating. Miller et al. (2009) also introduced a condition in which the manipulandum is moved remotely, without demonstration, which is a control for goal emulation. While some authors consider the bidirectional procedure as a good control for non-imitative processes, it can be argued that the movement of the object in space, the position of the demonstrator and the part of the object manipulated may have a local enhancement effect and then, the mere fact of contacting that part of the object, due to this effect, provokes the movement in the matching direction. Furthermore, matching the direction is not conceptually equal to matching the action in terms of body movement (e.g., the object could be pushed on the right by using muzzle or paw) and, as discussed above, imitation regards mainly learning socially about actions.

An effective method for studying imitation is the Do as I do paradigm, originally used by Hayes (1952) to test imitative abilities in a home raised chimpanzee. With this method the subject is first trained to match a small set of familiar actions to the demonstration and then is tested on its ability to use this ‘imitation rule’ with various behaviours and situations. The main advantage of this method is that the subject is specifically trained to imitate, thus other confounding factors (e.g., motivation, the possibility to rely on other processes) can be excluded. The Do as I do method has proven efficient as a mean to test imitation, not only in chimpanzees (Custance et al. 1995; Call 2001), but also in some other species: dolphins (Herman 2002), parrots (Moore 1993) and more recently also dogs (Topál et al. 2006).

1.4 Aims of the present research and hypotheses

The present research focuses on two different topics: (1) a cognitive issue regarding dogs' ability of...
deferred imitation and memory of human actions and (2) an applied issue concerning the efficiency of the use of social learning in dog training.

(1) From a cognitive perspective, particularly interesting is the question whether dogs would be able to imitate human actions after a delay (deferred imitation), which would exclude other facilitative processes that may trigger behavioural similarity between model and observer at the same time. The ability of imitating an action after a delay implies that the observer creates a representation of the demonstration, encodes it and recalls it after a delay to use it as the basis to perform a similar action (Study 1). Modifying the conditions of the environment during the recall phase it is also possible to assess what information the observer encodes and retains better among spatial information about the location of demonstration, figurative information about the object used during the demonstration and/or the information about the body movement performed by the model (Study 2).

(2) The dog training methods traditionally rely on the principles of individual associative learning. However, recently the Do as I do method has been introduced in the applied field of dog training (Fugazza 2011). With this method dogs are first trained to match their behaviour to a small set of familiar actions and then their ability to generalize this rule to novel actions is used for training purposes (i.e. teaching them novel behaviours). Study 3 focuses on the assessment of the efficiency of this method that relies on social learning as compared to a method that relies on individual learning to teach dogs specific kinds of novel actions.
Study 1: Deferred imitation in domestic dogs

2.1 Introduction

The ability to encode, retain and retrieve a memory of a demonstration and then to use it as the basis to reproduce the demonstrated action after a delay is defined as deferred imitation (Klein and Meltzoff 1999). Already Piaget (1952) regarded this ability as a hallmark of mental representation of movements because it indicates the emergence of the infant's ability to form a mental representation of the model's actions at the time of demonstration and recall of that image after a retention interval (Barr et al. 1996).

From a cognitive point of view, evidence for deferred imitation rules out alternative hypotheses of the mechanism behind behavioural similarity between individuals in which the demonstration triggers a similar behaviour in the observer at the same time or shortly after it (e.g. contagion). It is generally agreed that an interval of one minute between demonstration and performance is sufficiently long to exclude that the observer performs a similar action because this is primed by the demonstration, like a reflexive response, which is thought to be responsible for behavioural similarity that occurs at the same time as demonstration (e.g., Zentall 2006). Accordingly, imitative behaviour after one minute is considered as deferred imitation.

Recently Topál et al. (2006) used the 'Do as I do' procedure (Hayes and Hayes 1952) and discovered that dogs possess the ability to match functionally their behaviour to a human demonstration. However Huber et al. (2009) found that the dog's matching degree declined when the delay interposed between the demonstration and the 'Do it!' command was increased: the dog that was tested could perform correctly with delays shorter than 5 seconds and only in one occasion she could copy a familiar action after a delay of 35 seconds. Thus dogs may not be able to display deferred imitation. Nevertheless this negative finding could be due to problems with the experimental procedure used. It is likely that through the 'Do as I do' training as applied by Topál et al. (2006) and Huber et al. (2009),
The dog learns that he is required to match the action that has been shown immediately before the 'Do it!' command. In this case dogs trained with this method would not have learned that they were expected to copy the demonstration that was shown before an interval. Thus in this study we investigated whether dogs possess the cognitive ability of deferred imitation and, in order to exclude the possible methodological issues described above, the dogs were first trained by their owners with the 'Do as I do' method and then, before the testing begun, the dogs were trained to wait for short retention intervals (from 5 to 30 seconds) before the owners gave the 'Do it!' command to ask them to copy the observed action. This way we taught dogs that the 'Do it!' command referred to the demonstration that was shown before an interval. In the subsequent testing phase, the dogs participated in a series of tests aimed at investigating (1) their generalisation ability, (2) deferred imitation, (3) emulative learning. We first investigated on dogs' ability to reproduce actions shown by a human demonstrator after intervals of different durations (from 0.40 to 10 minutes). We also included distractions during the delays in order to prevent dogs from keeping their mind active on the demonstration. In fact, by engaging the subjects in a different activity, the ability to encode and recall the demonstrated action can be tested excluding the possibility that their matching behaviour relies on the keeping their mind active on the demonstration for the whole duration of the retention interval.

Barnat et al. (1996) tested the influence of changes in context on deferred imitation in human infants. The subjects were shown demonstrations of object-related actions in a context and were later given the opportunity to imitate in a different context and with objects that had some different features from those used during the demonstration. The results showed that combined changes in context and object features led to a significant decrease in the infants' imitative performances, suggesting that context and object features serve as retrieval cues that help recalling the demonstration. To assess if dogs' imitative abilities are affected by changes in context, in the second part of the testing, we tested them...
In order to control for non-imitative processes that may enhance the probability of behavioural similarity, such as local enhancement (Thorpe 1963), stimulus enhancement (Galef 1988) and goal emulation (Wood 1989; Tomasello 1990) we used the two-action procedure, also because earlier studies on imitation in dogs (Topál et al. 2006, Huber et al. 2009) did not explicitly test for such alternative explanations.

We used two two-action tests that differed in the kind of information provided to the dogs: in the first two-action test, the two actions on the same object did not lead to different outcomes, so that goal emulation could not be used to solve the task. In the second two-action test, the demonstrators achieved two different outcomes on the same object. If dogs were only able to engage in deferred emulation but not in deferred imitation, we expected them to perform correctly only when two different outcomes were presented, but not to succeed when different actions without different outcomes were shown.

Finally, we included a test to control for Clever Hans effect and a test in absence of demonstration.

2.2 Material and methods

2.2.1 Subjects

The subjects in our study consisted of 8 adult pet dogs ranging from 2 to 10 years old and their owners who volunteered to participate in this experiment. The dogs were females of various breeds (4 border collies, 1 Shetland sheepdog, 1 Yorkshire terrier, 1 Czechoslovakian wolfdog, and 1 mixed breed).

Before the study began, all the subjects had previously been trained by their owners with the ‘Do as I do’ method to match their behaviour to demonstrated actions (based on Topál et al. 2006, see below).

2.2.2 Training phase

Preliminary ‘Do as I do’ training (based on Topál et al. 2006):
The training protocol had been previously explained to all the owners by the experimenter (C.F.) before the study began and consisted of two phases:

**Phase 1.** The dogs learned to match their behaviour to 3 demonstrated familiar (i.e., already trained) actions using the 'Do it!' command through operant conditioning techniques. Each owner could decide what actions to use for the training. Once the dogs reached approximately 80% correct performance in at least two sessions in a row, they began the second training phase.

**Phase 2.** The dogs learned to match their behaviour to 6 demonstrated familiar actions using the 'Do it!' command (in the training sessions 3 other familiar actions were added). Both in phase 1 and 2 owners could decide what actions to use for the training, the only requisite being that they had to be already trained actions. The owners typically used both object-related actions and body movements.

The owners were allowed to train the dogs at home and were instructed to reward the dog using food or access to favourite toys only if their behaviour after the 'Do it!' command corresponded to the action that had been demonstrated. The definition of correspondence was based on Topál et al. 2006: the action that the dog performed immediately after the 'Do it!' command was considered as functionally matching the demonstration if it entailed the same goal and, given the species-specific differences in the behaviour repertoire of the two species, was executed in a similar way (figure 1).

The owners were instructed to train their dogs two to three times per week in a single training session lasting no more than 5 minutes. A single training session typically included six to ten trials but owners were not given restrictions about the number of trials. The training of the dogs lasted on average approximately one month, but the duration varied from two to seven weeks according to the time devoted by owners to the training.

Once the dogs reached 80% correct performance with the 6 familiar actions, owners were allowed to train their dogs to perform novel actions using this training technique.
Before the testing began, all subjects went through a training phase aimed at teaching dogs that the ‘Do it!’ command now referred to the action that had been demonstrated after the ‘Stay’ command, even if:

1) an interval elapsed between the demonstration and the ‘Do it!’ command and
2) the demonstrator performed other actions during the interval (i.e. walked in another direction). The procedure was as follows:

Owners made their dog stay in place while facing them and made them pay attention using cues known by the dog. Next the owners demonstrated a familiar object-related action. Then they returned to the starting position in front of their dog and waited for 5 seconds while looking straight ahead, before giving the ‘Do it!’ command. Dogs were rewarded using food or access to favourite toys only if their behaviour after the ‘Do it!’ command corresponded to the action that had been demonstrated. In case of failure the procedure was repeated.

When the dogs were successful with this short delay in at least two trials in a row, owners increased the delay up to 10 seconds, repeating the same procedure. When dogs were successful with this delay in at least two trials in a row, owners were instructed to perform the demonstration and then walk with their dogs during increasingly longer delays, before returning to the starting position and giving the ‘Do it!’ command (Figure 2).

Owners trained the dogs in two different dog schools. They admitted the dog to the following testing procedure once they or the trainer who controlled the training procedure reported that the dogs could functionally match their behaviour to the demonstration of familiar actions in two trials in a row with a delay of 30 seconds.
2.2.3 Testing phase

The testing took place at the same two dog schools where the dogs were trained, in outdoor fenced areas. Before the testing, owners completed a list of all the actions that were already familiar to their dogs (i.e., the dogs were already trained to perform those actions either with traditional training methods or with the Do as I do method). For each subject, we randomly picked five object-related actions from this list to use in those testing conditions where familiar actions were demonstrated. Thus in the Familiar action conditions dogs were randomly shown actions that, either were part of their training repertoire but had never been used in the Do as I do framework, or were used for the Do as I do training.

In each test and for each dog, three object-related actions were randomly chosen out of those five for the Familiar action condition, Distracting condition and Changed context condition and three completely novel object-related actions were presented in the Novel action condition and in the Two-action tests (Table 1). The relative position of the objects on which the demonstration was performed...
(centre, right, left) was also randomized, their distance being 3.5 m from each other. The curtain used to prevent dogs from looking at the target object during the retention interval was placed at a distance of 14 m from the objects (Figure 2). The owners taking part in the tests helped to prepare the setting (i.e., they carried all the objects to the predetermined position). This was done to exclude that dogs could rely on olfactory cues for their performances, as all the objects were previously manipulated by the owners.

At the beginning of each trial, the owner made the dog stay at the same place (using verbal commands and hand gestures known by the dog) and demonstrated a randomly chosen object-related action. After the demonstration, dog and owner walked behind the curtain in order to prevent the dog from looking at the target object. When the predetermined retention interval elapsed, the experimenter told the owner to go back to the starting position and, having reached this position, the owner gave the 'Do it!' command to the dog while looking straight ahead. For the analysis, the length of the delay in each condition was calculated from the demonstration to the 'Do it!' command and could slightly vary (± 30 seconds) according to the walking speed of each owner and dog when they went back from behind the curtain to the starting position.

Dogs were tested in different periods, according to their owners' availability for the testing. For each subject an interval of at least 30 minutes passed between two consecutive tests and the maximum number of tests per day was 4. The maximum interval between two consecutive tests for one dog was 53 days.

Each dog went through the same testing protocol (Table 2) consisting of 19 tests in eight different conditions (one trial per delay) in the following detailed order:

1. **Familiar action:** Eight tests on familiar actions with different retention intervals (durations of retention intervals: 0.40 min; 1 min; 1.5 min; 2 min; 3 min; 4 min; 6 min; 10 min).
2. **Novel action:** Three novel objects were placed in randomized positions and the dogs were tested on a
novel action (enter a wooden box) with a retention interval of 1 min.

Distracting action: In five tests the dogs observed the demonstration of a familiar action and were then distracted during the retention interval, before the 'Do it!' command was given (in 3 tests owners distracted them by giving a different command 'lay down', with retention intervals of 0.50 min; 3 min; 4 min; and in 2 tests owners distracted the dogs by throwing a ball and encouraging them to fetch it, with retention intervals of 1 min and 4 min).

Changed context: Owners demonstrated a familiar action at one location, then walked with their dog to another location where 3 identical objects were placed in similar respective positions and gave the 'Do it!' command (repetition interval: 1 min).

'Clever Hans' control: A single test with the same procedure as the Familiar action condition, except that after the demonstration by the owner, he and the dog walked behind the curtain, where there was a familiar person who had not witnessed the demonstration, thus did not know what action was shown to the dog. After a retention interval of 1.15 minutes, this naive person went with the dog to the predetermined starting position and gave the 'Do it!' command in absence of the owner who stayed behind the curtain.

No demonstration control: Two novel objects (a tube placed in vertical position and an umbrella stand) and the wooden box (already used in the Novel action condition) were placed at randomized positions. The owner commanded the dog to stay in the usual starting position and to pay attention as was done in the other tests. The owner remained still for 5 seconds and then gave the 'Do it!' command to the dog.

After the command the owner was instructed to keep looking straight ahead for the duration of the test. The behaviour of the dog was video recorded for 30 seconds after the 'Do it!' command.

Two-action on box: The setting was the same as in the No demonstration control test. Three dogs were shown an action on the box and the other 5 dogs were shown a different action on the box. The demonstrations were 'Look inside the box' and 'Touch the box with hand' respectively.
actions lead to the same outcome (i.e., the box did not move). If the dog was already familiar with the action of 'Muzzle in the bucket' then we showed 'Touch the box with hand' to him because we suspected that 'Look inside the box' would have been similar to the already familiar action. The retention interval was 1.30 minutes.

Two-action on tube: The setting was the same as in the No demonstration control condition. Half of the dogs were shown an action on the tube and the other half of the dogs were shown a different action on the tube. The actions were 'Walk around the tube from the left side to the right' and 'Knock over the tube' (retention interval: 1.30 min). In this case the dogs demonstrated different actions (the tube stayed in its vertical position when the experimenter walked around or the tube fell to a horizontal position when it was knocked over and was then repositioned by the experimenter while the dog and the owner were behind the curtain). For this test the assignment of the subjects to the groups was randomized.

The testing sessions were recorded by two video cameras placed in two different positions in order to always have a view of the dog and the owner.
positions at a distance of 3.5 m from each other; the curtain used to obstruct the view of the objects during the retention interval is behind the owner at a distance of 14 m from the objects.
<table>
<thead>
<tr>
<th>Behaviour</th>
<th>Owner's Demonstration</th>
<th>Dog's Demonstration</th>
</tr>
</thead>
<tbody>
<tr>
<td>FAMILIAR ACTIONS:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Walk around bucket</td>
<td>The owner walks around a bucket placed on the ground</td>
<td>The dog walks around a bucket placed on the ground</td>
</tr>
<tr>
<td>Muzzle in bucket</td>
<td>The owner puts his face in a bucket placed on the ground</td>
<td>The dog puts her muzzle in a bucket placed on the ground</td>
</tr>
<tr>
<td>Put muzzle in colander</td>
<td>The owner puts his face in a colander placed on the ground</td>
<td>The dog puts her muzzle in a colander placed on the ground</td>
</tr>
<tr>
<td>Climb on chair</td>
<td>The owner climbs with his feet on a chair</td>
<td>The dog climbs with all fours on a chair</td>
</tr>
<tr>
<td>Touch chair</td>
<td>The owner touches the seat of a chair with his hands</td>
<td>The dog touches the seat of the chair with her front paw</td>
</tr>
<tr>
<td>Walk around cone</td>
<td>The owner walks around a cone placed on the ground</td>
<td>The dog walks around a cone placed on the ground</td>
</tr>
<tr>
<td>Touch cone</td>
<td>The owner touches with his hand a plastic cone that is placed on the ground</td>
<td>The dog touches with her front paw a plastic cone that is placed on the ground</td>
</tr>
<tr>
<td>Pull rolling toy</td>
<td>The owner pulls a string attached to a children's toy with wheels using his hand and makes it move on the ground</td>
<td>The dog takes in her mouth a string attached to a children's toy with wheels and pulls it making it move on the ground</td>
</tr>
<tr>
<td>Ring bell</td>
<td>The owner rings a bell that is hanging from a bar</td>
<td>The dog rings a bell that is hanging from a bar</td>
</tr>
<tr>
<td>On table</td>
<td>The owner climbs on an agility table</td>
<td>The dog jumps on an agility table</td>
</tr>
<tr>
<td>Hoop</td>
<td>The owner puts his feet and hands in a hoop placed on the ground</td>
<td>The dog puts her four paws in a hoop placed on the ground</td>
</tr>
<tr>
<td>Open box</td>
<td>The owner removes the lid of a box using his hand</td>
<td>The dog removes the lid of a box using her mouth</td>
</tr>
<tr>
<td>Touch stool</td>
<td>The owner touches a small stool with his hand</td>
<td>The dog touches a small tool with her front paw</td>
</tr>
<tr>
<td>Drop bottle</td>
<td>The owner touches a bottle that is placed on the ground using his hand and makes it fall</td>
<td>The dog touches a bottle that is placed on the ground using her front paw and makes it fall</td>
</tr>
<tr>
<td>Task (nouns)</td>
<td>Description</td>
<td>Expected Dog's Behaviour</td>
</tr>
<tr>
<td>-------------</td>
<td>-------------</td>
<td>-------------------------</td>
</tr>
<tr>
<td>Take object</td>
<td>The owner takes with his hand one of two objects that are placed on a chair.</td>
<td>The dog takes the other object that is placed on the chair with her mouth.</td>
</tr>
<tr>
<td>Jump in high packaging box</td>
<td>The owner steps inside a cartoon packaging box raising his legs to enter in it.</td>
<td>The dog jumps inside the packaging box.</td>
</tr>
<tr>
<td>Roll ball</td>
<td>The owner touches a ball and makes it roll.</td>
<td>The dog touches a ball and makes it roll.</td>
</tr>
<tr>
<td>Swing hanging object</td>
<td>The owner touches with his hand a toy that is hanging from a hurdle.</td>
<td>The dog touches with her front paw a toy that is hanging from a hurdle.</td>
</tr>
<tr>
<td>Touch target</td>
<td>The owner touches with his hand a small pad on the ground.</td>
<td>The dog touches with her front paw a small pad on the ground.</td>
</tr>
<tr>
<td>Jump over hurdle</td>
<td>The owner jumps over a hurdle.</td>
<td>The dog jumps over a hurdle.</td>
</tr>
</tbody>
</table>

**Table 1**

| Behaviours used for the testing, description of the human demonstration and description of the expected dog's behaviour |
2.2.4 Data collection and analysis

The actions of the dogs after the 'Do it!' command were coded by the experimenter as 'match' (the dog performs an action that is functionally similar to the demonstrated task) or 'no match' (the dog performs any other action).

In the conditions where novel actions were demonstrated (Novel action, Two-action on box and Two-action on tube) the behaviour of the dog was scored as matching only if there was a correspondence in both the goal (if a goal was present) and the body movement, taking into account the differences in the body schema of dogs and humans (i.e., a human's hand touch was considered corresponding to a dog's front paw touch). In the conditions where familiar actions were demonstrated, a mere functional correspondence was used as criterion because the expected response of the dog was already known since these were trained actions.

In addition to the main coder (C.F.) an independent observer coded 30% of the videos in order to assess inter-observer reliability. The calculation of the Kappa coefficient yielded K = 1.

The results were analysed using GraphPad software by comparing performances between the different conditions and the No demonstration control test using Fisher's exact test with \( \alpha \) level at 0.05. However, since each testing condition was planned to answer a specific theoretical question, we used the Bonferroni correction taking into account the number of 'Do as I do' tests performed within a specific condition.

2.3 Results and discussion

In the No demonstration control condition no dog performed any action on the objects present in the testing area, all dogs but one did not perform any action at all for at least 5 seconds after the 'Do it!' command, which is matching with the demonstration (the owner did not perform any action for 5 seconds). One dog remained in a sitting position for the duration of the video recording (30 seconds) but slightly raised a paw 2 seconds after the 'Do it!' command was given. Three dogs did not move for...
In the whole duration of the test, one dog did not move for 20 seconds and then stood up, one dog remained in place but barked, one dog moved a little backward while remaining in a sitting position and one dog remained in a sitting position for 5 seconds and then ran away to play and then sniffed the ground.

We compared performances between the different conditions and the No demonstration control using Fisher's exact test. In the Familiar action condition, the subjects were tested with eight different retention intervals and the Bonferroni corrected α level is 0.00625. Comparing the number of correct performances of the demonstrated action after the different delays with the No demonstration condition, we found a statistically significant difference for the tests with delays of 0.40, 1, 1.5, 2, 4 and 10 minutes (Fisher's exact test, respectively: P=0.0014, P=0.0002, P=0.0014, P=0.0002, P=0.0014 and P=0.0002, respectively), while for the tests with 3 and 6 minutes delays the difference was not significant after the Bonferroni correction (P=0.007).

Subjects were tested two times on their memory of novel actions on the box (i.e., all dogs were tested on 'Enter the box' and then some of them were tested on 'Touch the box with hand/front paw' and some of them on 'Look inside the box' in the subsequent Two-action test on box in which all dogs performed the demonstrated action). In this case the Bonferroni corrected α level is 0.025 and there is a significant difference between all the performances and the No demonstration condition ('Enter the box': P=0.0002; 'Touch the box with paw' and 'Look inside the box': P=0.0002). The dogs' performances was also significantly different from the No demonstration condition in the Two-action test on tube (P=0.0014) in which only one dog performed a different action (entered the box) before performing the action that had been demonstrated ('Knock over the tube') and was scored as 'no match'.

In the Distracting action condition, dogs were tested with two different distractions in overall five tests with different delays and the Bonferroni corrected α level is 0.01. All the performances showed
significant difference from the No demonstration condition (Distraction: 'Lay down' with 1 minute delay: \( P=0.0002 \); with 3 and 4 minutes delay: \( P=0.0014 \); Distraction: 'Play with ball' with 1 minute delay: \( P=0.0002 \) and with 4 minutes delay: \( P=0.007 \)).

In the Changed context and Clever Hans conditions the dogs were only tested with one delay, so we did not use the Bonferroni correction for the statistical analysis. We found a significant difference between the dogs' performance in those conditions and the performance in the No demonstration condition (Changed context: \( P=0.0014 \) and Clever Hans: \( P=0.0002 \)).

Fisher's exact test was used to compare each different condition to the Familiar action condition to assess if the matching performance changes with the increased delays, with the introduction of distractions, when changing the context of retrieval or when demonstrating novel actions. First, in order to assess if the increased delay affects the performance, we compared with each other the results obtained after different delay durations in the Familiar action condition (e.g., comparing the performance of dogs with 1 minute delay with their performance with 10 minutes delay) and no comparison reached the level of significance (\( P=0.4667 \) for the comparison of the performance after delays of 3 and 6 minutes compared to the performance after delays of 1, 2 and 10 minutes and \( P=1.000 \) for the comparisons with all the other delay durations) (Figure 3a). Second, we compared the performance of the dogs in the Familiar action condition with their performance in the Distracting condition with respectively similar delays and no comparison reached the level of significance (\( P=1.000 \) for all the comparisons). Then we also compared the performance in the Familiar action condition after one minute delay with that in the Novel action condition and Changed context condition, in which the 'Do it!' command was also given after 1 minute delay and not even in this case we found significant differences (\( P=1.000 \) for both comparisons). The matching performance of the dogs did not even change when they were tested for emulation and imitation in the two Two-action tests, compared to the test in the Familiar action condition with a similar delay (\( P=1.000 \) in both comparisons).
Throughout the testing procedure of 18 trials, 6 dogs made only one error, one dog made two errors, and one dog made 6 errors (for the details see Table 2). Overall 130 (90.28%) trials have been scored as 'match' and 14 as 'no match'.
<table>
<thead>
<tr>
<th>DOG’S NAME - BREED</th>
<th>RANDOMLY CHOSEN FAMILIAR ACTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emma</td>
<td>Rrollo, Mrollo, TCecade, Mrollo, TCecade, Mrollo, TCecade, Orabé, Mrollo, TCecade</td>
</tr>
<tr>
<td>Phoebe</td>
<td>Orabé, Rgbe, Mrollo, Obré, Tcédé, Tcédé, Mrollo, Obré, Tcédé, Tcédé</td>
</tr>
<tr>
<td>Bambù</td>
<td>Cbb, Mbo, Mrollo, Mrollo, Obré, Cbb, Mrollo, Obré, Cbb, Mrollo, Obré</td>
</tr>
<tr>
<td>Lilly</td>
<td>Pbrongg, Otb, Obré, Sgg, ggg, bbré, Jbr, ggg, lbbó, Otb, Obré, Dbró, Pbrongg, Dbró</td>
</tr>
<tr>
<td>Adila</td>
<td>Obré*, Rgbe, Tcédé, Obré, Rgbe, Tcédé, Obré, Tcédé</td>
</tr>
<tr>
<td>Minnie</td>
<td>Mrollo, Mbré, Obré, Obré, Tcédé, Wáa, Mbré, bbré</td>
</tr>
<tr>
<td>Soley</td>
<td>Tcédé, Jbr, ggg, Obré, Mrollo, Mbré, Obré, Obré, Tcédé, Jbr, Obré, *</td>
</tr>
<tr>
<td>India</td>
<td>Jbr, ggg, Tcédé, Tcédé, Dbró, Dbró, Tcédé, Tcédé, Obré</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>NOVEL ACTION</th>
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<table>
<thead>
<tr>
<th>DOG’S NAME</th>
<th>NOVEL ACTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emma, Phoebe, Bambù, Lilly, Adila, Minnie, Soley, India</td>
<td>Enter wooden box</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DOG’S NAME</th>
<th>RANDOMLY CHOSEN FAMILIAR ACTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emma</td>
<td>Hrol, Rbab, Hrol</td>
</tr>
<tr>
<td>Phoebe</td>
<td>Tbré, bbré, Rgbe, Tbré, bbré</td>
</tr>
<tr>
<td>Bambù</td>
<td>Cbb, cbb, Mbo, cbb, Cbb, cbb</td>
</tr>
<tr>
<td>Lilly</td>
<td>Sgg, bgg, bbré, Dbró, Pbrongg</td>
</tr>
<tr>
<td>Adila</td>
<td>Tcédé, Wáa, Mbré, bbré, Obré</td>
</tr>
<tr>
<td>Minnie</td>
<td>Tcédé, Mbré, bbré, Tcédé</td>
</tr>
</tbody>
</table>

* = novel action
<table>
<thead>
<tr>
<th>Dog's Name</th>
<th>Randomly Chosen Familiar Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soley</td>
<td>Touch chair*</td>
</tr>
<tr>
<td>India</td>
<td>Jump over hurdle, Touch chair*</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>DISTRACTING ACTION CONDITION</strong></td>
</tr>
<tr>
<td></td>
<td>(Distraction: play with ball)</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Dog's Name</td>
<td>Randomly Chosen Familiar Action</td>
</tr>
<tr>
<td>Emma</td>
<td>Muzzle in colander, Hoop</td>
</tr>
<tr>
<td>Phoebe</td>
<td>Jump over hurdle, Muzzle in bucket</td>
</tr>
<tr>
<td>Bambù</td>
<td>Muzzle in bucket</td>
</tr>
<tr>
<td>Lilly</td>
<td>Jump in high packaging box, Open box</td>
</tr>
<tr>
<td>Adila</td>
<td>Ring bell, Touch cone</td>
</tr>
<tr>
<td>Minnie</td>
<td>On table, Take object</td>
</tr>
<tr>
<td>Soley</td>
<td>Walk around cone, Touch chair*</td>
</tr>
<tr>
<td>India</td>
<td>Touch chair*</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>CHANGED CONTEXT CONDITION</strong></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Dog's Name</td>
<td>Randomly Chosen Familiar Action</td>
</tr>
<tr>
<td>Emma</td>
<td>Touch target</td>
</tr>
<tr>
<td>Phoebe</td>
<td>Muzzle in bucket</td>
</tr>
<tr>
<td>Bambù</td>
<td>Muzzle in bucket</td>
</tr>
<tr>
<td>Lilly</td>
<td>Drop bottle</td>
</tr>
<tr>
<td>Adila</td>
<td>Touch cone</td>
</tr>
<tr>
<td>Minnie</td>
<td>Take object</td>
</tr>
<tr>
<td>Soley</td>
<td>Walk around cone</td>
</tr>
<tr>
<td>India</td>
<td>Ring bell</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>CLEVER HANS CONTROL CONDITION</strong></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Dog's Name</td>
<td>Randomly Chosen Familiar Action</td>
</tr>
<tr>
<td>Emma</td>
<td>Roll ball</td>
</tr>
<tr>
<td>Phoebe</td>
<td>On table</td>
</tr>
</tbody>
</table>
**DOG'S NAME**

**NOVEL ACTION**

<table>
<thead>
<tr>
<th>Emma, Phoebe, Bambù, Minnie, Soley</th>
<th>Touch box</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lilly, Adìà, India</td>
<td>Look inside box</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Emma, Phoebe, Bambù, Minnie, Soley</th>
<th>Walk around tube</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lilly*, Adìà, Bambù</td>
<td>Knock over tube</td>
</tr>
</tbody>
</table>

**TWO-ACTION ON BOX CONDITION**

<table>
<thead>
<tr>
<th>Emma, Phoebe, Bambù, Minnie, Soley</th>
<th>Touch box</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lilly, Adìà, India</td>
<td>Look inside box</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Emma, Phoebe, Bambù, Minnie, India</th>
<th>Walk around tube</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soley*, Lilly, Adìà, Bambù</td>
<td>Knock over tube</td>
</tr>
</tbody>
</table>

Table 2

Subjects (dog's name and breed) and actions chosen for each subject in the different testing conditions. Wrong performances of the dogs are marked by *.

Actions and conditions are listed in the actual order of testing.
Figure 3 Percentage of dogs' performances scored as 'match' in the different conditions. ** indicate statistically significant difference compared to the No demonstration condition after Bonferroni correction. a. Familiar actions after different delays; b. Familiar actions with distractions during the retention interval; c. Novel action after a delay of 1 minute, familiar action in a different context after a delay of 1 minute and ‘Do it!’ command given by a different ‘naïve’ experimenter after a delay of 1.15 minutes; d. Two-action tests on novel actions after a delay of 1.30 minutes. The figure shows that the matching percentage does not typically change with increased delays from 0.40 to 10 minutes (2a), with the introduction of distractions (2b), when novel actions are demonstrated, changing the context of retrieval and in the Clever Hans control test (2c) and when different novel actions on the same objects are demonstrated (2d).

Dogs were typically able to reproduce familiar and novel actions after a delay, also in a different context and if distracted by their owners who engaged them in different types of activities before recalling the demonstrated action. The robust performance of the dogs in the present study
convincingly supports deferred imitation. The ability to encode and recall the demonstration after a delay implies that facilitative processes cannot exhaustively explain the observed behavioural similarity and that dogs' imitative abilities are rather based on an enduring mental representation of the demonstration.
Study 2: Dogs’ spatial bias affects their imitative performance in a Do as I do task

3.1 Methods

We conducted Study 1 (Fugazza and Miklósi 2013) by asking dogs to imitate a human action. The demonstration phase involved a human actor performing a specific action, such as picking up an object from one location and placing it in another. During the recall phase, the dog was placed in the same location as the human actor and observed the human’s action. The dog was then tested on its ability to reproduce the action. The results showed that dogs were able to successfully imitate the human action.

When in Study 1 (Fugazza and Miklósi 2013) we tested dogs by changing the context between demonstration phase and recall phase, the respective position of the objects that were present during the demonstration remained identical in the recall phase (i.e., when the ‘do it!’ command was given in the different context). Thus it is possible that this respective position – i.e., the spatial position where the owner acted during the demonstration, respective to the starting point where the dog was positioned – might have been an important contextual cue that dogs encoded and later helped them to recall and imitate, even in a different context. Alternatively (or additionally), it is also possible that the features of the objects on which the demonstration was performed helped recall, serving as a figurative cue to help recalling the action. Indeed, dogs may be able to encode information on the physical characteristics of objects, such as colour and size (Pattison et al. 2010; Pattison et al. 2013; Muller et al. 2011). Nonetheless, several studies showed that, when they are forced to choose to rely either on figurative information or on spatial information to solve search tasks, dogs tend to use spatial information (e.g., Doré et al. 1996; Dumas 1998).

The aim of the present study is to disentangle what kind of spatial and/or figurative information dogs recall (or match) preferentially in a deferred imitation task and to find out the role of spatial and/or figurative contextual cues in the recall of the demonstrated action. We tested dogs with a modified version of the Do as I do paradigm by showing them a demonstration of an object-related action and then testing their imitative performance after a 1-minute delay, in conditions in which the object used during the demonstration was displaced to a different position. This way we separated figurative information about the object (On what object to do?) and spatial information about the location of the demonstration (Where to do?). Thus, after the ‘do it!’ command, dogs had to choose matching either.
We used the two-action procedure in order to test if dogs also imitate the action that was shown by the demonstrator (What to do?) and to control for other non-imitative processes (Akins and Zentall 1996). Dogs are known to be particularly perceptive to human ostensive communicative cues and many studies showed that they are skilled in relying on various human gestures (see Bensky et al. 2013 for a recent review). Consistently, we hypothesised that dogs’ success of matching the object-related cues in the ‘Do as I Do’ task (act upon the displaced object rather than going to the location at which the demonstration was seen) could be facilitated by using a human ostensive communicative cue to enhance the attention of the dog towards the displacement of the matching object and/or towards the object itself.

Our results confirm dogs’ ability of deferred imitation with a delay of 1 minute and reveal that, when spatial and figurative information are incongruent at the time when dogs are required to imitate, dogs show a strong spatial bias and a difficulty to spontaneously use figurative information to help recall. To some extent this bias could be reversed by using ostensive cues making the dogs aware about the contextual changes.

3.2 Materials and methods

3.2.1 Subjects

The subjects in this study consisted of 16 adult pet dogs ranging from 3 to 9 years old and their owners who volunteered to participate. The dogs were 12 females and 4 males belonging to various breeds (1 Golden retriever, 3 border collies, 1 galgo, 1 Jack Russell terrier, 1 Shetland sheepdog, 2 poodles, 3 Labradors, 1 Chihuahua and 3 mixed breeds).

Before the study began, all the subjects had already been trained by their owners with a modified version of the ‘Do as I do’ method to match their behaviour to actions that were demonstrated before a...
short interval of approximately 30 seconds elapsed, as described in detail by Fuga and Miklósi (2013).

3.2.2 Testing

The tests were carried out in three different dog schools (Happy Dog School in Como, Italy, Good Boy in Torino, Italy and Ludocan in Barcelona, Spain). All dogs were tested in areas that were familiar to them.

For each test, 1 or 2 objects (depending on the testing condition) randomly chosen out of 4 (see Table 3) were placed at a distance of 2.5 m from each other. The choice between the two possible locations for the objects was semi-randomised with half of the demonstrations being performed at each location. An opaque screen was placed behind the objects and was used in those conditions in which dogs were prevented from looking at the objects during the retention interval (Figure 4). The testing sessions were recorded by two video cameras placed in two different positions in order to always have a view of the dog and the owner.

The object-related actions that the owners were required to demonstrate to their dogs were randomly assigned to each dog for each object, choosing from two possible novel (not previously trained) actions so that, for each object, dogs were divided in two groups regarding the action they were shown, according to the two-action procedure. The actions are described in detail in Table 3.

In each trial the owner demonstrated a different object-related action, so that all 4 objects were used once in each condition.

In each trial the owner entered the testing area with his dog on leash and asked him to stay in a predetermined position at a distance of 3 m from both objects, using cues known by the dog, while s/he performed the demonstration of an object-related action. The owner then returned to the starting position, picked up the leash that was let loose on the ground during the demonstration, and either stayed there still with his/her dog on leash or walked with him/her behind a screen, depending on the condition.
testing condition (see detailed description below). After a retention interval of 1 minute elapsed, during which the setup was experimentally modified according to the various testing conditions described below, the participant returned to the starting position (if he was behind the screen), released the dog and gave the ‘Do it!’ command at a distant point in the middle of the two objects (Figure 4). Dogs were tested in 8 conditions, consisting of 4 trials each.

The subjects were randomly divided in two groups regarding the order of administration of Conditions 2, 3, 4 and 5 in order to control for possible learning effects. The Visible First group started with Conditions 2 to 5, and the Invisible First group started with Conditions 5 to 2.

Condition 1: Two-object visible no displacement (baseline)
All dogs were first tested in a baseline condition in which two objects were present at two different locations. The owner demonstrated one of two possible object-related actions, then walked with the dog behind the screen and stayed there for the whole duration of the retention interval (1 minute). In the baseline condition the position of the objects at the moment of the ‘Do it!’ command was the same as it was during the demonstration (i.e., they were not displaced after the demonstration).

Condition 2: Single object visible displacement
Before the test began one object was positioned at one of the two locations that were used for the objects in the baseline condition. After the owner’s demonstration of an action on the object, this was displaced by the experimenter to the position where the other object would have been in the baseline condition (that is the object was shifted 2.5 m from its original position). The displacement took place while the owner kept the dog on leash in the starting position, thus dogs had full view of the object movement.

Condition 3: Single object invisible displacement
The same as Condition 2 above, but the owner and the dog walked behind the screen after the demonstration and remained there for the whole duration of the retention interval (1 minute), thus the dog was prevented from seeing the displacement.

**Condition 4:** Two objects visible displacement

Before the test began, two objects were positioned by the owner in the two predetermined locations as in the baseline condition. After the owner's demonstration of an action on one object, the position of the two objects was reversed by two experimenters simultaneously. When carrying the objects, the two experimenters crossed their path by keeping right and did not talk to or look at the dog ostensively. The displacement of the objects took place while the owner kept the dog on leash in the starting position, thus the dog had full view of the objects and their movements. After the displacement the experimenters turned their back to the dog and went away from the testing area to a position that was in line with a virtual point in the middle of the two objects, and looked down to the ground.

**Condition 5:** Two objects invisible displacement

The same as Condition 4 above, but the owner and the dog walked behind the screen after the demonstration and remained there for the whole duration of the retention interval, thus the dog was prevented from seeing the displacement.

**Condition 6:** Ostensive cuing during two objects visible displacement

The same as Condition 4 above, but the experimenter who displaced the object on which the owner demonstrated the action attracted the dog's attention towards the displacement (or towards the object) by ostensive cues (i.e., called the dog's name, smacked his/her lips and alternated his/her gaze between the dog and the object) during the displacement. A female and a male experimenter alternated in this role. If the dog was looking in his/her direction during the displacement, the dog's name was called only once at the beginning of the displacement; if the dog looked in a different direction, the experimenter used again the described ostensive cues to direct the attention of the dog back towards...
The experimenter who displaced the object on which no action was demonstrated behaved as in Condition 4. After the visible displacement, the two experimenters left the objects as they did in the two objects visible displacement condition.

**Condition 7:** Pointing after two objects invisible displacement

The same as Condition 5 above but, while the owner performed the demonstration, an experimenter stood in the middle of the 2 objects looking at the ground. After the demonstration the owner and the dog went behind the screen for the duration of the retention interval and returned to the starting position for the 'Do it!', as in Condition 5. Before the 'Do it!' command was given, the experimenter attracted the dog's attention and pointed with her arm towards the object on which the demonstration was performed (her finger reached approximately a distance of 90 cm from the object) and looked at it. The pointing lasted approximately 2 seconds. After the experimenter resumed his original neutral position looking at the ground, the owner released the dog and gave the 'Do it!' command.

Conditions 6 and 7 were administered to all subjects in the same order. As this may have caused order effects, in Condition 8 we repeated the same testing procedure as in Condition 4 for half of the subjects (N=8), to compare their performances to those obtained in Condition 4, thus controlling for possible order effects.

### 3.2.3 Data collection and analysis

We analysed the behaviour of the dogs after the 'Do it!' command in order to assess if they matched the demonstrated action as well as if they matched the position where the demonstration was performed or the object on which it was performed, which in all conditions but the baseline were mutually exclusive. Given the specie-specific differences between humans and dogs the action of the dog was scored as matching only if he used the corresponding body part for performing a similar body...
movement (see Table 3 for more details).

First we compared with Fisher's exact test the number of matching the action, the position and the object in the same conditions between the two groups that participated in the tests in counterbalanced order. Then, we compared the number of matching the action, the position and the object in Conditions from 2 to 5 to the number obtained in the baseline condition. We also used Fisher's exact test to compare the number of matching the action, the position and the object in Ostensive cuing during two objects visible displacement condition to the same number in the Two objects visible displacement condition, because these conditions differed in the social cues provided (or not) by the experimenter during the displacement. The same statistical analysis was done to compare the results of the Pointing after two objects invisible displacement condition with those of the Two objects invisible displacement condition, because they only differed in the presence (or absence) of the experimenter performing the pointing gesture. Finally, as the Ostensive cuing during two objects visible displacement and Pointing conditions were administered to all subjects in the same order, we compared the number of matching the action, the position and the object in the control for order effect condition with the two objects visible displacement, to control for possible order effects.
Table 3: Objects used for the testing, description of the two actions used as human demonstrations (two-action procedure) and description of the expected dog's behaviour.

<table>
<thead>
<tr>
<th>OBJECT</th>
<th>Description of the object</th>
<th>ACTION A</th>
<th>ACTION B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lid: a plastic lid hanging at the height of the dog's shoulder from a string attached to a horizontal pole</td>
<td>The owner swings the lid using his hand</td>
<td>The owner swings the lid using his nose</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The dog swings the lid using his front paw</td>
<td>The dog swings the lid using his nose</td>
<td></td>
</tr>
<tr>
<td>Helmet: a motorcycle helmet placed on the ground</td>
<td>The owner walks around the helmet</td>
<td>The owner touches the helmet with his hand</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The dog walks around the helmet</td>
<td>The dog touches the helmet with his front paw</td>
<td></td>
</tr>
<tr>
<td>Tube: a cartoon tube placed horizontally on the ground</td>
<td>The owner touches the tube with his hand</td>
<td>The owner jumps over the tube</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The dog touches the tube with his front paw</td>
<td>The dog jumps over the tube</td>
<td></td>
</tr>
<tr>
<td>Box: a plastic box placed with the empty end facing the ground</td>
<td>The owner climbs on top of the box with his feet</td>
<td>The owner puts both hands on the box</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The dog climbs on top of the box with all four paws</td>
<td>The dog puts both front paws on the box</td>
<td></td>
</tr>
</tbody>
</table>

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Figure 4: Experimental setting: 1 or 2 objects (depending on the testing condition) are placed at a distance of 2.5 m from each other. The owner and the dog are facing the objects. An opaque screen is behind the objects and is used in those conditions in which dogs are prevented from looking at the objects during the retention interval. The arrows indicate the displacement of the objects: Single object visible displacement (a), Single object invisible displacement (b), Two objects visible displacement (c), and Two objects invisible displacement (d).
3.3 Results and discussion

In the Baseline condition dogs matched the demonstration in 84.4% of the trials.

Comparing the number of matching action, position and object between the Visible First group (N=8) and Non-visible First group (N=8) we did not find any significant difference (Fisher's exact test yielded the following values, respectively for matching action, matching position and matching object: in the Single object visible condition respectively P =1; P=0.6128 and P=1; in the Single object invisible displacement condition P=0.585; P=0.0816; P=0.3649; in the Two objects visible displacement condition P=1; P=0.585; P=0.585; in the Two objects invisible displacement condition P=0.0787; P=0.4302; P=0.2869). Also the number of matching action, position and object in the control for order condition did not differ from the number of matching in the Two objects visible displacement (Fisher's exact test respectively P=0.5124; P=0.8102; P=0.8102) thus we excluded that the order of administration of the various conditions had any effect on the compared variables and we analysed the data of the two groups together.

In the Single object visible displacement condition the dogs matched the action in 85.9%, the position in 6.2% and the object in 89% of the trials. In the Single object invisible displacement condition they matched the action in 70.3%, the position in 15.6% and the object in 78.1% of the trials. In the Two objects visible displacement condition they matched the action in 42.2%, the position in 70.3% and the object in 29.7% of the trials. In the Two objects invisible displacement condition they matched the action in 46.9%, the position in 65.6% and the object in 32.8% of the trials. In the Oste nsive cuing during two objects visible displacement condition they matched the action in 62.5%, the position in 43.75% and the object in 54.7% of the trials. In the Pointing after two objects invisible displacement condition they matched the action in 68.8%, the position in 37.5% and the object in 62.5% of the trials.
First, we compared the number of matching action, position and object in those conditions where only one object was present and displaced after the demonstration (Single object visible and Single object invisible displacement conditions) to the number of matching in the baseline (Figure 5). We observed a significant difference in the action if the object was visible (Fisher's exact test P=0.0001) and the object and the baseline (Fisher's exact test P=0.6036; Single object invisible displacement: action matching P=0.0901; object matching P=0.4975). This indicates that, if only one object is present, even if it is displaced after the demonstration, dogs match the action and the object, as they do in the baseline condition, and they do not match the position, at which there is no object present at the time of the 'Do it!' command.

However, interestingly, in some trials (4 out of 64 in the Single object visible displacement condition and 10 out of 64 in the Single object invisible displacement condition) dogs matched the position where the object was during the demonstration (they approached the former location of the object). One dog also replicated the demonstrated action without object being at the location where the object was at the time of demonstration.

Second, we compared the number of matching between the conditions in which two objects were present and displaced after the demonstration (Two object visible or invisible displacement) to the number of matching in the baseline and we did not find a significant difference in the matching of the position in the Two objects visible displacement (Fisher's exact test P=0.0901) while all the other comparisons yielded significant values for both conditions (Fisher's exact test: action and object matching P=0.0001 in both conditions; position matching P=0.0238 in the Two objects invisible condition) (Figure 5). However, comparing the number of matching positions with the number of matching object within condition, in both the Two objects visible and invisible displacement conditions, dogs matched more often the position rather than the object (Two objects visible...
and the matching of the position was above chance level as assessed by the Sign test (Two objects visible and invisible displacement condition, Sign test one tail P=0.0008 and P=0.0084, respectively).

Third, we compared the number of matching in the Ostensive cuing during two objects visible displacement condition to the number of matching in the Two objects visible displacement condition (Figure 6). We found that they differed significantly in all three variables: dogs matched more the action and the object in the Ostensive cuing during two objects visible displacement condition whereas they matched the position in the Two objects visible displacement (Fisher’s exact test respectively P=0.0333; P=0.007 and P=0.0041). Similarly, the number of matching in the Pointing after two objects invisible displacement condition differed significantly from the number of matching in the Two objects invisible displacement condition (Fisher’s exact test P=0.0196; P=0.0014 and P=0.0025). This indicates that social cues provided in the Ostensive cuing during two objects visible displacement and Pointing conditions counterbalanced the dogs’ preferences for choosing the demonstrated location in the Two objects visible and invisible conditions. However, the number of matching object in the Ostensive cuing during two objects visible displacement condition was below chance level (Sign test one tail P=0.2662), whereas it was above chance level in the Pointing after two objects invisible displacement condition (Sign test one tail P=0.03).

The number of action matching was above chance in the baseline, Single object visible displacement (Sign test one tail P<0.0001 in both conditions) and also in the Single object invisible displacement condition (Sign test one tail P=0.0016). The number of action matching in the Two objects visible and invisible displacement conditions was below chance level (respectively one tail P=0.1302 and one-tail P=0.354), whereas it was above chance level in the Baseline condition.
objects visible displacement condition and in the Pointing after two objects invisible displacement condition, it was above chance (Sign test respectively P=0.03 and P=0.0018).

This study confirms dogs’ ability of deferred imitation after a delay of 1 minute. However dogs show a strong spatial bias that hinders their imitative performances when the position of the object on which the demonstration was performed is interchanged with the position of a different object during the delay. Dogs’ predisposition to follow human’s communicative gestures can outweigh their spatial bias.

![Graph showing matching action, position and object](image)

**Figure 5** Number of matching action, position and object in the Baseline condition and in the Single object visible, Single object invisible, Two objects visible and Two objects invisible conditions.

* Indicates significant difference compared to the baseline condition (Fisher’s exact test P<0.05).
Figure 6 Number of matching action, position and object in the Ostensive cuing during two objects visible displacement condition compared to the Two objects visible displacement and in the Pointing after two objects invisible displacement condition compared to the Two objects invisible displacement. * Indicates significant difference (Fisher’s exact test P<0.05).
Study 3: The efficiency of the Do as I do method compared to shaping/clicker training to train dogs

4.1 Introduction

There is a quite big popular literature on the practical application of dog training methods (e.g. Lindsay 2000); nevertheless this field has not received much attention from scientists. In fact most of the training methods have not received a validation by a scientific approach and the scientific knowledge on whether one method would be superior to others with regard to a given behavioural situation or goal to be achieved is basically non-existing (Miklósi 2007). The approaches to dog training have been categorized by Mills (2005) according to the two main behavioural models used in behavioural sciences: the associative approach, as described by the behaviouristic learning theory (Watson 1913) and the cognitive approach, as theorized by the psychologists (Tolman 1948). According to Mills, associative training approaches – which are those on which most dog training rely (Mills 2005) - concentrate on exposing the dog to the relation between two events (unconditioned and conditioned stimuli) and/or on the association between a discriminative stimulus and an operant behaviour. On the other hand, the role of attention and the knowledge of the learner are more considered in the cognitive oriented approaches.

Shaping (SHA) is one of the most widespread and popular techniques to train dogs (e.g. Pryor 1999). In shaping procedures the dog’s spontaneous behaviour is gradually adjusted by means of strategically timed reinforcements as typically prescribed by operant conditioning rules (Skinner 1951). Shaping involves breaking down the training goal to be reached or target behaviour into simpler parts so that otherwise complex behaviours can be trained by carefully arranging these simpler parts of the target behaviour according to a plan or program of instrumental contingencies (Lindsay 2000). Practically, a sound producing device (“the clicker”) is typically used as (1) a secondary reinforcer (2) a marker...
clicker training), which serves to distinguish for the animal a particular behaviour as the event that has earned the primary reinforcer and/or as a bridging stimulus which fills the temporal gap between the behaviour and the primary reinforcer (usually food) (Pryor 1999, 2005, Williams 1994). Effective classical conditioning of this bridging stimulus is crucial to the shaping process. According to Lindsay (2000), before the trainer can use shaping as a training method, the dog is required to learn that (1) the link of the bridging stimulus with a remote but forthcoming reinforcer and (2) the contingency of this with the emission of a particular behaviour. In shaping procedures, once the dog has learnt the association between the sound produced by the clicker and the primary reinforcement, the clicker is activated by the trainer with a strategic timing so that it produces the 'click' noise precisely when the spontaneous behaviour of the dog approximates the action to be trained. This way, by rewarding successive approximations, the spontaneous behaviour of the dog is gradually shaped to reach the final desired response. Thus the trainer has the main role of delivering the secondary reinforcement ('click') and primary reinforcement ('food') at the right moment. With this method the dog gradually learns individually by trial and error what actions are rewarded and what are not. As mentioned earlier, recent studies have provided robust evidence that dogs are adept to learn socially both from conspecifics (Kubinyi et al. 2009 for review) and following a specific training, dogs are also able to match their behaviour to actions shown by a human experimenter (Topál et al. 2006, Huber et al. 2009). However, little use of this mechanism has been made in formal dog training. It is also surprising that only very few studies (Slabbert and Rasa 1997; McKinley and Young 2003) focused on the use of social learning in the applied field of dog training. McKinley and Young (2003) utilized the 'model-rival' technique (Todt 1975; Pepperberg, 1999) to train dogs for a retrieval selection task. The model-rival method has been extensively used in experiments investigating the cognitive abilities of parrots (e.g., Pepperberg 1994). With this method social stimuli are used to create in the
subject an interest in an object without the use of food. According to Cracknell et al. (2008) this method relies on social processes (stimulus enhancement) to direct the animals’ attention to the specific object to be retrieved. McKinley and Young (2005) found that dogs trained with this method can perform as well as dogs trained with traditional associative training techniques to retrieve a named object. The other study on the use of social learning in dog training (Slabbert & Rasa 1997) concentrates on the training for detection of narcotics. The authors found that pups that were exposed to the training of their mother between the age of six and 12 weeks outperformed the non-exposed pups, when tested at the age of six months on the same task. The use of the Do as I do method (DAID) in dog training, however, was not investigated in previous studies. The aim of Study 3 was to compare the efficiency of the DAID with that of the SHA method to train experienced dogs on novel object-related actions. Some authors (e.g. Thorpe 1963) claim that, for imitation to occur, non-typical actions should be involved. Thus we chose to use object-related actions (e.g. ‘open a drawer’, ‘close a door’ or ‘pick up an item and put it in a basket’) because those are complex behaviours that are not in the typical spontaneous behaviour repertoire of a pet dog. Nevertheless, these kinds of actions are usually required in training dogs that assist disabled owners, therefore it is useful to assess with what method they can be more efficiently trained. Furthermore this kind of actions can be systematically varied in terms of complexity. Another reason why we chose to use object-related actions in our tests is that some authors (Huber et al. 2009) claim that dogs—as well as other animals—have difficulty of replicating body-oriented actions compared with object-oriented ones.

In the theoretical framework of cultural evolution it is predicted that individuals tend to rely on social learning with increased difficulty of the task (Laland and Brown 2011), as experimentally confirmed with regard to humans by McElreath et al. (2005). Consistently, we expected that, in particular, difficult actions would be more easily learned by dogs socially than individually and that, especially...
When difficult tasks are involved, dog training could benefit from the use of social learning with the DAID. Thus we compared the efficiency of the DAID with the efficiency of SHA when teaching dogs actions of different degrees of difficulty: simple actions, complex actions and action sequences and we hypothesised that complex actions would be more efficiently trained with the DAID method, compared to SHA, whereas such difference would be less evident when the subjects are tested on simple actions.

Several factors may influence the success of different training paradigms that may go beyond the aim of this study. Thus we do not aim for claiming an absolute superiority of one training method over the other, but aim to provide useful insights on the use of social learning in addition to the traditional training methods that rely on individual learning, when dogs are trained to learn object-related tasks.

4.2 Material and methods

4.2.1 Subjects

A total of 30 dog-owner dyads were recruited for this study. All the owners had experience with training and had passed a dog-training exam with their dog, either for shaping / clicker training (SHA Group N=15) or for Do as I do (DAID Group N=15) as described in detail in section 2.2. As all subjects passed an advanced level training exam, it is possible to consider all the dyads as experienced in training. Owners were informed about the aim of the study.

Dogs belonged to various breeds and the two groups were balanced for breed-groups and age as much as possible: in the SHA Group there were an Irish terrier, four Hungarian vizslas, a golden retriever, five border collies, a flat coated retriever, a border terrier, a Labrador and a terrier cross breed. In the DAID Group there were: a Yorkshire terrier, a Cavalier King Charles spaniel, six border collies, a beagle, a poodle, a Shetland shepherd, two mixed breeds, a Czechoslovakian wolf-dog and a Jack Russell terrier. The age of the dogs in the SHA Group ranged from 2 to 11 years (mean age 5.9 years; SD±2.82) and in the DAID Group from 3 to 10 years (mean age 5.6 years; SD±2.03).
4.2.2 Training exams

The exam for shaping / clicker training is the so-called CAP and is divided into four levels (Kay Lawrence http://www.learningaboutdogs.com/html/cap_assessment_.html). Only dog-owner dyads that passed at least level 2 or 3 were recruited for this study because we thought these advanced levels are comparable with the Do as I do exam (see below). CAP level 2 assessing the trainer's ability to secure a solid foundation in achieving a consistent quality and reliability to cue and develop more complex behaviors in free shaping. In CAP level 3, the assessor looks for different collections of compound behaviors, advanced shaping and evidence of data collection and analysis (http://www.learningaboutdogs.com/html/cap_criteria.html).

One of us (C.F.) recently developed an exam in order to assess the level of training in dogs that are trained to copy human actions on command (see Topál et al. 2006 for details of the method). To pass the exam for Do as I do, the owner is required to demonstrate that her/his dog can display at least six familiar actions (i.e. actions already trained with other techniques) on the 'Do it!' command with a novel demonstrator. The preliminary training protocol necessary to pass the exam requires that dogs learn through operant conditioning techniques to match their behavior to three demonstrated familiar actions on command 'Do it!' and then generalize this command to other three familiar actions, before the 'Do it!' command can be used as a training rule, following the demonstration of novel tasks to be learned (see Topál et al. 2006 and Fugazza and Miklósi 2013 for details on the training protocol). The definition of behavioral correspondence is based on Topál et al. 2006: the first action that the dog performs after the 'Do it!' command is considered as functionally matching the demonstration if it entails the same goal and, given the species-specific differences in the behavior repertoire of the two species.
4.2.3 Testing

Each dog-owner dyad was tested in three subsequent tests in which the owner was instructed to teach his dog three new object-related actions (one per test) using only the training method s/he was certified for (i.e. clicker training / shaping in the SHA Group and Do as I do in the DAID Group).

An inter-test interval of at least 30 minutes occurred between two subsequent tests for each subject. The maximum inter-test interval was 1 day.

The timeline for a test was 15 minutes. If the owner did not reach the predetermined goal within this time (i.e. the dog did not perform the predetermined action), the test ended and the result was considered as a failure (i.e., the owner did not manage to teach the particular action within 15 minutes).

In the SHA Group, dog owners sat on a chair 1 m from the target object and used food as a reward for their dogs. The spontaneous behaviour of the dog was shaped by the means of strategically timed reinforcements with a clicker as a marker, followed by a treat, until the first occurrence of the predetermined action by the dog. Owners were instructed not to lure the dog's behaviour. After the 'click', the dog could take the treat from the owner's hand or the owner could toss it to a strategic location that could increase the probability that the subject interacted again with the target object (e.g., the owner could toss the treat over the target object, so that the dog, after having eaten the food, had the object between himself and the owner).

In the DAID Group owners were not allowed to give food to their dogs during the tests but could give it after the test was finished, in order to keep the dog motivated in the next testing session. During the tests owners asked their dogs to stay and pay attention, then they demonstrated the action they wanted the dog to perform and gave the 'Do it!' command. If the dog did not perform the correct action after the first demonstration, owners demonstrated the behaviour again and gave the 'Do it!' command.
again, until they reached the predetermined result. If the action provoked a modification in the object (e.g., the drawer was opened), the experimenter repositioned the object in the original situation (e.g., closed the drawer) after the owner's demonstration but before the 'Do it!' command.

In both groups the owners could decide to take as many breaks as they thought were necessary for a successful training. When taking a break, owners in the SHA Group went away from the testing area with their dogs and did not give them treats for the whole duration of the break. Owners in the DAID Group stopped and behaved with them as they usually did at the end of a training session. The break could last from 5 minutes to 4 hours, according to the owner's decision and availability for the tests.

Owners were informed that, for the analysis of results on learning latencies, the time of the breaks was not considered as part of the test. For both groups all tests were run in the presence of an experienced dog trainer who could give suggestions to the owners regarding the training strategy. They were two experts respectively in shaping / clicker training or Do as I do and also assessors for the training exams and gave suggestions only to the owners of the group using the method they were expert on. The suggestions that were given regarded the training strategy (e.g., where to toss the food in the SHA Group, how to demonstrate the action in the DAID group and when to take a break in both groups).

The actions were selected randomly from a predetermined list of 12 actions (see Table 4 for details), discarding only those that were eventually already familiar for a particular dog (Before the testing, each owner had filled a complete list of the actions already taught to his dog, so that those actions were not used in the tests).

All the actions chosen for this study were object-related actions—which are particularly useful, for example, for assistance dogs helping humans with disability. They differed in difficulty: simple actions,
complex actions and action sequences. The simple actions involved getting in contact or interaction (e.g., touch) with specific objects (e.g., knock over a bottle, ring a bell); the complex actions necessitated more elaborate manipulation of objects and consisted of tasks which are usually required for an assistance dog (e.g., open a drawer, close a locker etc.) and deviate from the natural behavioral tendencies of dogs; action sequences consisted of two actions (e.g., climb on a chair and ring a bell).

The required actions, as well as the number of subjects tested on each single action, are described in detail in Table 4.

Each dog-owner dyad was tested on only one action in all conditions representing different levels of difficulty, thus each owner was required to train his dog on a simple action, on a complex one and on a sequence during three different testing sessions. In order to control for the eventual difference in the difficulty of the tasks within a category, each subject in the SHA Group was matched with a subject in the DAID Group with regard to the three actions they were required to train during the tests. Two subjects (one from the SHA Group and one from the DAID Group) were tested on two simple actions and one sequence (another simple action instead of the complex one) because all the complex actions of our list were already familiar for them.

The order of the tests (simple action, complex action and action sequence) was randomized for each matched pair of dogs learning the same actions, with the order being the same for the subjects of the same pair. The testing sessions were recorded by two video cameras placed in two different positions in order to always have a view of the dog and the owner.
<table>
<thead>
<tr>
<th>Action</th>
<th>Description</th>
<th>N. of failures within 15 min. in the SHA Group</th>
<th>N. of failures within 15 min. in the DAID Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIMPLE ACTIONS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ring a doorbell</td>
<td>A doorbell with a button on top is placed on the ground. If the button is pushed the doorbell rings. The dog is required to ring the doorbell so that a sound is emitted.</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Ring bell</td>
<td>A metallic bell hangs from a hurdle at ca. the same height as the dog's withers. The dog is required to ring the bell by touching it with any part of his body. A sound has to be emitted from the bell when the dog touches it.</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Paws in hoop</td>
<td>A plastic hoop is placed on the ground. The dog is required to enter the hoop with all fours.</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Knock over bottle</td>
<td>A plastic bottle is placed vertically on the ground. The dog is required to knock it over.</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>COMPLEX ACTIONS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open drawer</td>
<td>A string is attached to the handle of the drawer of a small cabinet with a drawer and a locker. The dog is required to open the drawer for at least 10 cm.</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Close drawer</td>
<td>The drawer of a small cabinet with a drawer and a locker is opened (15 cm). The dog is required to close the drawer.</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Open locker</td>
<td>A string is attached to the handle of the locker of a small cabinet with a drawer and a locker. The dog is required to open the locker for at least 10 cm.</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Close locker</td>
<td>The locker of a small cabinet with a drawer and a locker is opened (30 cm). The dog is required to close the locker.</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>SEQUENCES</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Object in basket</td>
<td>A basket (ca. 40 x 30 x 8 cm) is placed on the ground. A small purse is placed 50 cm from the basket. The dog is required to pick up the purse and put it in the basket.</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>On chair ring bell</td>
<td>A metallic bell is hanging in a high position over a chair. The dog can reach the bell only if it climbs on the chair. The dog is required to climb on the chair and ring the bell. A sound has to be emitted from the bell when the dog touches it.</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>On chair doorbell</td>
<td>A doorbell is placed on a cabinet. The dog can reach the doorbell only if it climbs on the chair.</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Action</td>
<td>Description</td>
<td>Group SHA</td>
<td>Group DAID</td>
</tr>
<tr>
<td>--------</td>
<td>-------------</td>
<td>-----------</td>
<td>------------</td>
</tr>
<tr>
<td>Doorbell</td>
<td>A small dog is required to climb on a chair and ring the doorbell. A sound must be emitted from the doorbell.</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Open locker</td>
<td>A small purse is placed in the locker. The dog is required to open the locker and take the purse out of it.</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

### 4.2.4 Data collection and analysis

From the videos obtained we determined:

1. The number of dyads who completed the predetermined task within 15 minutes in the two groups.
2. The time from the beginning of the training session to the first correct occurrence of the selected action (latency). In the case of SHA Group the beginning of the session was either marked by the first 'click' or by the owner tossing a treat on the floor as these were the routines typically used by the owners to start the training. In the case of DAID Group, the training session started when the owner made the dog stay and pay attention to the demonstration.
3. We also calculated the number of owners that took breaks for their dogs in each group and the number of breaks.

The difference between SHA and DAID groups in the test outcome (i.e., the number of dogs that succeeded or failed within 15 minutes in the two groups) was statistically analysed by using Fisher's exact test.

In a conservative statistical analysis of the learning latencies we considered the data only from those dogs that actually completed the task within 15 minutes. Normality of the data on the latencies of those successful dogs was assessed with a Shapiro-Wilk test.
dyads that completed the task before the timeline was checked with the Anderson-Darling Normality test and latency values were compared between DAID and SHA dogs by unpaired t-tests if they followed the normal distribution, and by Mann-Whitney U test if they did not follow the normal distribution.

In order to assess if the efficiency of the two training methods increases with increased complexity of the tasks, we compared the relative difference of the learning latencies when training complex and simple actions with the two methods by unpaired t-tests.

The number of owners who took breaks for their dogs during the tests was compared between the two groups in each condition by Fisher’s exact test $P=0.018$ and the number of breaks in each condition was compared between the two groups by Mann-Whitney U test.

We used GraphPad software for the statistical analysis of the results.

4.3 Results and discussion

Simple actions

When tested on simple actions all dogs in both groups were able to perform the predetermined action within 15 minutes (Table 2). We did not find a significant difference in learning latency between the two groups ($t=1.47$; $df=29$; $P=0.152$) (Figure 7).

When training the simple actions no trainer decided to take a break for his/her dog during the tests.

Complex actions

All 14 dogs tested in the DAID Group succeeded with the complex actions and in the SHA Group 11 dogs out of 14 succeeded within 15 minutes. Accordingly, both training methods seemed to be equally successful (Fisher’s exact test $P=0.22$).

However, subjects in the DAID Group outperformed those in the SHA Group by obtaining significantly shorter latencies to display the target complex action ($t$ test: $t=3.62$; $df=22$; $P=0.0015$).
Significantly more owners (9 out of 14) in the SHA Group had breaks for their dogs during the training of complex actions than owners in the DAID Group (2 out of 14) (Fisher's exact test P=0.018) and the number of breaks in the DAID Group was significantly smaller than the number of breaks in the SHA Group (Mann-Whitney U test: U=44; df=27; P=0.013).

Action sequences
In this test, 13 dogs out of 15 in the DAID group and only 7 dogs out of 15 in the SHA group succeeded after 15 minutes. Thus the training method affected the success of dogs, that is, significantly more dogs were successful in the DAID group (Fisher's exact test P=0.05).

In the conservative statistical analysis on learning latencies (see above) we did not find a significant difference between the two groups (Mann-Whitney U test: U=24; df=19; P=0.09).

Upon training action sequences significantly more owners (13 out of 15) in the SHA Group took breaks for their dogs during the tests than owners in the DAID Group (5 out of 15) (Fisher's exact test P=0.0078) and the number of breaks in the DAID Group was significantly smaller than the number of breaks in the SHA Group (Mann-Whitney U test: U=49.5; df=29; P=0.009).

In the DAID group, all owners used the so-called 'back-chaining' strategy, that is they trained the last action of the sequence first and then the first action, before training the dog to perform the whole sequence in the proper order. Owners in the DAID Group trained the sequence in the given order since the first trial, demonstrating the first action followed by the second one since the very first demonstration of the training session.

Relative difference in learning latencies
The relative difference of the learning latencies when training complex and simple actions with the SHA method is significantly larger compared to the difference of the learning latencies when training complex and simple actions with the DAID method (t-test: t=3.43; df=21; P=0.0025). Thus dogs in the DAID group show a smaller increase in the latency if they have to perform a complex action.
While we did not find a significant difference between the two training methods with regard to simple actions, we found that subjects using the Do as I do method outperformed those using shaping/clicker training in the case of complex actions and sequences of two actions. This study is the first to formalize a method based on the Do as I do protocol for training dogs and to assess its efficiency by comparing it with shaping/clicker training. Consistently with the social learning strategy theory, the DAID method, which is based on social learning, is particularly useful for teaching difficult object-related actions.

From a cognitive perspective, the efficiency of the DAID method relies on dogs' ability to flexibly use various sources of social information such as local enhancement, goal emulation and functional imitation.

### Table 5

<table>
<thead>
<tr>
<th>Condition</th>
<th>Subjects that succeeded within 15 min</th>
<th>Mean latency</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple Tasks</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Do as I do</strong></td>
<td>15</td>
<td>27.18</td>
<td>26.72</td>
</tr>
<tr>
<td><strong>Shaping</strong></td>
<td>15</td>
<td>45.25</td>
<td>49.11</td>
</tr>
<tr>
<td>Complex Tasks</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Do as I do</strong></td>
<td>14</td>
<td>55.71</td>
<td>59.23</td>
</tr>
<tr>
<td><strong>Shaping</strong></td>
<td>11</td>
<td>356.18</td>
<td>322.66</td>
</tr>
<tr>
<td>Sequences</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Do as I do</strong></td>
<td>13</td>
<td>192.07</td>
<td>243.45</td>
</tr>
<tr>
<td><strong>Shaping</strong></td>
<td>7</td>
<td>318.14</td>
<td>234.29</td>
</tr>
</tbody>
</table>
Figure 7 Mean latency (+ SD) of the first occurrence of the predetermined action in the Do as I do group (DAID) and in the Shaping group (SHA) (** indicate statistically significant difference; unpaired t test, P=0.05)
The study of imitation is particularly interesting from the cognitive perspective because it gives the possibility to investigate how dogs represent the actions of others, their memory of events and what social cognitive abilities they use when they interact and learn socially from humans. This adds important information to our understanding of dog behaviour and cognition.

5.1 Deferred imitation in domestic dogs

In study 1 dogs showed robust imitative performance that convincingly supports deferred imitation. They typically reproduced familiar and novel actions after different delays, also in a different context and after their owners distracted them with different kinds of activities before asking them to recall and imitate the action that was demonstrated. In the tests where familiar object-related actions were shown it cannot be ruled out that dogs relied on (deferred) stimulus enhancement (Galef 1988) and matched the object that was manipulated by the demonstrator and that they matched also the action just because this was the most probable action for a dog on that object. However, the results of the Two-action tests reveal that dogs were able to imitate after a delay because they not only acted on the same object that was manipulated by the demonstrator, but also copied the different novel actions that were performed on that object. In the test in which the two different actions led to different outcomes dogs may have used goal emulation, but they were also able to match their body movement to the demonstration in the test in which the two different actions led to the same outcome. This result can be explained only by their ability of deferred imitation.

We also added a condition in which the 'Do it!' command was given by an unknowledgeable ('naive') experimenter after a delay of 1.15 minutes to control for Clever Hans effect. This effect may arise when the owner is aware of the goal of the experiment, as in the case of Study 1, and he/she may voluntarily display cues to the dog that increase its performance (Pfungst 1911). Although Hegedűs et
al. (2013) did not find a Clever Hans effect in a two-way object choice test on dogs, other authors (Horowitz et al. 2013, Prato Previde et al. 2008) emphasised that ostensive communication has a significant influence on dogs' performances in different behavioural situations and Clever Hans effect can occur in different tasks (Lit et al. 2011, Szetei et al. 2003). In our control condition for such effect all dogs were able to reproduce the demonstrated action, which allowed us to exclude any effect of involuntary cues given by the demonstrator or the owner on the dog's performance. It is thus probable that dogs trained with the Do as I do method learn to rely only on the demonstration of the action and do not rely on other cues to solve the task.

In the condition in which the owner did not demonstrate any action before the 'Do it!' command (No demonstration control condition), dogs did not perform any action on the objects used for the tests and tended to stay still. This result is consistent with the findings from Topál et al. (2006) and also excludes that the mere presence of the objects and the human could elicit the target behaviours (social facilitation).

All dogs except one imitated the demonstration in the Novel action condition. Nevertheless, also the dog that was scored as 'no match' entered the box, but she did so only using her front paws, leaving the hind legs outside. Thus she approximated her behaviour to the demonstration showing that she was able to at least partially encode and recall the demonstration. As argued by Whiten and Custance (1996) novelty is a relative concept that can refer to various aspects of the behaviour (e.g., the object involved, the body movement, the context etc.). We considered the behaviour to be a match if a dog entered the box only using her front paws, leaving the hind legs outside, showing that she was able to at least partially encode and recall the demonstration. For this dog, that action was new only with regard to the target object.
We could exclude that only one action was possible for a dog on the object used for the novel actions because we showed overall three different actions on the box in the Novel action condition and in the Two-action test: 'Enter the box', 'Look in the box' and 'Touch the box with paw'. The ability of the dogs to match their behaviour to the various actions that were demonstrated demonstrates that at least three different actions were conceivable for a dog on that object: thus we can exclude that 'Enter the box' was the only achievable or probable action for a dog who could just match the object after a delay (delayed matching), or that the increased attention toward the stimulus alone can explain the observed behavioural similarity (stimulus enhancement).

In the condition in which the owners demonstrated two different actions leading to two different outcomes (i.e. 'Knock over a tube' and 'Walk around the tube') the dogs may have solved the task using goal emulation instead of imitation, because they not only reached the same goal (i.e. caused the same movement of the object, making it fall or not) but also used the same body action. In particular, in the case of the 'Knock over the tube' demonstration, the affordance of the object – the tube passed from a vertical to a horizontal position – might have helped them to retrieve the goal to be reached. However, in the Two-action test on the box (or Multi-action test, if also the 'Enter the box' action is considered) dogs were not provided with information on the object's affordance and goal, because no modification in the object was possible. In this condition dogs were still able to match the three actions that were demonstrated on the object, thus showing strong imitative abilities that perfectly fit the definition of deferred imitation.

While the Two-action procedure usually involves two different groups of subjects that are tested on two different actions (e.g., Akins et al. 1996; Dorrance and Zentall 2001; Van de Waal et al. 2012), in Study 1 all dogs were exposed to the demonstration of 'Enter the box' in the Novel action condition and later, in the Two-action condition two other different actions on the same box were demonstrated ('Touch the box' was demonstrated to five subjects and 'Look in the box' to the other three). Thus the same
subjects were exposed to two different actions on the same objects and were able to match their behaviour to the actions shown. The present results reveal that dogs are able to change their behaviour according to what they have observed in two different tests where two different actions with same outcomes are demonstrated to the same subject on the same object. When we tested dogs giving the 'Do it!' command in a different location from that of demonstration after a retention interval of 1 minute, their performance was not affected by context change, which further supports the deferred nature of dogs' imitative abilities and is also consistent with findings on human infants (Barnat et al. 1996; Klein and Meltzoff 1999). More importantly, this result provides compelling evidence that local enhancement (i.e., increased attention toward the location of the demonstration) cannot exhaustively explain the observed behavioural similarity.

5.2 Spatial memory, figurative memory and memory of human actions

The results we obtained in the baseline condition of Study 2, in which dogs were required to reproduce one of two possible object-related actions after a retention interval of 1 minute, confirm dog's ability of deferred imitation as assessed in Study 1 (Fugazza and Miklósi 2013). In our experimental conditions in which the object/s were displaced after the demonstration, dogs were able to match their behaviour to the demonstration when only one object was present, even if it was displaced to a different location after the demonstration. Thus, in the case of functional imitation, dogs are able to generalize across contexts to a certain extent. Nonetheless, when two different objects were present during the demonstration phase and their respective position was interchanged thereafter, dogs tended to match mainly the location of demonstration rather than the object and also their action matching performance dropped dramatically. Very likely in those conditions where only one object was present, the fact that the location of demonstration was empty at the time of recall facilitated dogs to approach the object in the new location. As a consequence, the object itself may have functioned as a retrieval cue that
enhanced dogs' memory of the demonstrated action (Learmonth et al. 2004; Barnat et al. 1996; Bjorklund et al. 2002).

The performance of our dogs in both two object visible and invisible displacement conditions is consistent with other reports on dogs' strong spatial bias (e.g., Plourde and Fiset 2013) and difficulty to rely on figurative cues (e.g., Dumas 1998). Our subjects' predisposition to match the location rather than the object was so strong that in some trials of the conditions in which only one object was present and displaced after the demonstration, some dogs went to the location where the demonstration was performed, even if, at the time of recall, this location was empty. In one occasion a dog even performed an action that matched the demonstration in the empty location (i.e., without the target object), which suggests that, at least for some individuals, imitative abilities in terms of body movements can be quite precise and also 'blind', considering that the action was performed by the dog as a 'vacuum action' that did not make sense without the target object.

Our dogs' imitative performances differed significantly from the baseline and also dropped below chance level (as assessed by the Sign test) in those conditions in which the position of the two objects was interchanged and they tended to match the location rather than the object, as opposed to the conditions in which they tended to match the object. These results confirm that dogs indeed encode some information on the features of the object (e.g., Callahan et al. 2000), which they use as a figurative cue to enhance recall of the action that was performed on it by the demonstrator according to the two-action procedure and it is possible that the fact of finding in the matching location a different object hindered dogs' recall of the demonstrated action.

Miller et al. (2009b) found that dogs search accurately in an invisible displacement task when their search immediately follows the displacement and Fiset et al. (2003) discovered that they could solve a visible displacement task after delays up to 4 minutes. However, Miller et al. (2009c) report that dogs' performances were not accurate when a barrier prevented their view of the objects during the delay.
Such disruptive effects in our experimental protocol, in which two experimenters moved the objects simultaneously, may have also affected dog's imitative performance. However, our dogs' performance in the visible and the invisible displacement conditions differed similarly from the baseline condition in which they went behind a curtain after the demonstration. Thus in a Do as I do task, dogs can match the demonstration after one minute even if their view of the objects is obscured (see Study 1 and the baseline condition of Study 2) and after much longer delays, up to 24 hours (Fugazza and Miklósi in preparation). However, in contrast to their performance in visible displacement tasks (Fiset 2003), in a Do as I do task dogs are not able to match the demonstration after a short delay if two objects are displaced, irrespectively of whether they observe the displacement or not. It is possible that a deferred imitation task is more cognitively demanding for dogs than an object search task, thus their performance is more hindered by changes in context and objects, similarly to what was found for human 14-month-old infants (e.g. Barnat et al. 1996; Learmonth et al. 2004).

We also did not find any effect of the order of administration of the various conditions. This indicates that the subjects that were allowed to observe first the displacement and later were tested in invisible conditions were also not able to overcome their spatial bias by relying on the previously obtained information about the position switching of the two objects. Dogs are particularly susceptible to the human presence and human communicative cues. The impact of human communicative cues on dogs' behaviour is so strong that they can be misled to perform non-functional actions, if these are indicated by the human partner (Topál et al. 2009), even if they previously received information about the correct solution (Szetei et al. 2003; Erdőhegyi 2007; Prato-Previde et al. 2008). Kupán et al. (2011) found that dogs' preference for a baited container can be outweighed by human's ostensive communicative signals indicating a different empty container. Dogs' preference for searching at the location where they saw the target object disappear, can also be modified by human communicative cues (Plourde and Fiset 2013).
A- not-B error is reduced if the B location is ostensively enhanced by a human (Kis et al. 2012). Consistently, our results also confirm that dogs' tendencies can be outweighed by human ostensive communication directing the dog's attention to the act of the displacement or to the object itself. Indeed, in the conditions (5 and 6) in which a human produced ostensive cues, dogs displayed a higher tendency for matching, compared to the respective non-social conditions (Two objects visible and invisible displacement). As human infants' imitative performance improves if they are tested on the same object used in the demonstration phase, compared to a different one (e.g., Barnat et al. 1996), we also hypothesised that, if dogs could follow the human indications to the matching object, the object itself would serve as a retrieval cue to help recalling the demonstrated action and, consequently, we expected enhanced imitative performances in this condition. However, while the number of object matching was above chance level as assessed by the Sign test in the Pointing after two objects invisible displacement condition, it was below chance level in the Ostensive cueing during two objects visible displacement condition. These results confirm that dogs have a strong tendency to follow the pointing gesture (e.g., Reid 2009; Soproni et al. 2002), but also raise the question of why dogs did not rely on the ostensive cues. Analysing in more detail the cues provided by the experimenter—given that, if the dog was looking in the direction of the matching object during the displacement, the dog's name was called only once at the beginning of the displacement—it is possible that the fact that the experimenter attracted the dogs' attention more at the beginning of the displacement procedure, enhanced also the dogs' attention towards the initial location of the object instead of towards the displacement or the object itself, which would be similar to what happens in the case of the A-not-B error (e.g., Topál et al. 2008), thus reinforcing (instead of outweighing) the spatial bias. Alternatively, it is also possible that some dogs focused their attention on the human more than on the object he was carrying (Mongillo et al. 2010).
However, the ostensive cues provided by the experimenter before the owner gave the 'Do it!' command were enough to overcome the spatial bias and to raise the imitative performance (i.e., action matching) of dogs above chance level as assessed by the Sign test, which may suggest that dogs' imitative abilities are enhanced by the ostensive cues provided, guiding them towards the correct object.
In this study we have demonstrated the efficiency of the Do as I do (DAID) method in dog training. In particular, actions that are usually required from an assistance dog, such as sequences and complex object-related actions are more efficiently trained with the DAID method compared to the SHA method. With regard to the simple object-related actions, we did not find any significant difference between the two methods, neither concerning the number of dogs that succeeded within 15 minutes, nor with regard to the time needed by the trainer to obtain the first correct occurrence of the behaviour. Nevertheless, concerning complex actions, the DAID method proved more efficient than the shaping method for teaching complex actions and sequences, respectively considering the learning latency and the number of dogs succeeding within 15 minutes. In fact, when the dog-owner dyads were tested on complex behaviours, the time needed to obtain the first correct performance was dramatically shorter in the DAID Group compared to the Shaping Group. As we hypothesised, the relative difference in the learning latencies between the two methods increased with increased complexity of the actions to be taught, which is consistent with the social learning strategy theory (Laland & Brown 2011). With the action sequences, we found a significant difference with regard to the number of dyads that succeeded within 15 minutes (more dyads succeeded in the DAID Group compared to the SHA Group) although we did not find a significant difference when we compared the time needed by the owners to obtain the first correct performance of the behaviour. We analysed the latency of the first performance of the predetermined action in a conservative way that only uses for comparison the latencies of those subjects that succeeded within 15 minutes because after this arbitrary deadline we stopped the tests. For the sequences, in the SHA Group only 7 dogs succeeded before the cut off time in comparison with 13 dogs from the DAID Group. Thus the low sample size may be the cause of the absence of significant difference in latencies. We also found a significant difference in the number of breaks taken by owners in the two groups: in the SHA Group owners decided to take more breaks...
compared to the owners in the DAID Group. This could be due to the increased length of the training sessions. Furthermore, experienced owners using a training method with which the complex actions are usually obtained in longer times may have expected longer testing sessions since the beginning and therefore would have been more likely to take breaks, splitting the expectedly long training session into shorter bouts in order to prevent the dog from being tired or stressed later in the training session. Thus, the expectations that the owners form about the duration of the training session may have influenced their decision to take more breaks.

Dog training is often aimed at teaching dogs a sequence of arbitrary behaviours, which is structured so that they occur in a specific order (Lindsay 2000). The order of occurrence is based on a predetermined continuity in which one action must always precede the next in a set sequence. The training strategy for training sequences in our experiment differed between the two groups: in the SHA Group all owners used an operant technique described by Lindsay (2000) as 'connecting the final response with the terminal reinforcer and then adding on successive behaviours up to the origin of the chain' (so-called backward chaining). Differently, owners in the DAID Group demonstrated the predetermined sequence beginning with the first action and demonstrating the second action next, so that the whole sequence was shown to the dogs in the correct order since the first trial and we did not find a recency effect. Apparently this is in contrast with the recency effect found by Huber et al. (2009) as they tested a dog trained with the Do as I do protocol on her ability to reproduce sequences. A possible explanation for this discrepancy is the different kind of tasks used for the tests: in our sequences the first action of the sequence was always necessary to reach the final goal and/or to enable the second action to be performed (e.g., open a locker and pick up an object that is placed inside of it or pick up an object from the floor and put it in a basket), while the sequences used by Huber et al. (2009) were constituted by arbitrary actions that could be performed in a different order. Thus, in our experiment, as opposed to Huber et al. (2009), dogs could not perform the last action without having previously performed the...
The goal of these kind of sequences is an information that would probably require a lot of time to be acquired individually by trial and error, as it is the case with shaping. Whereas it is possible that the owner's demonstration of the goal to be reached, together with the demonstration of the correct sequence of actions that were required to reach it, helped the dogs in the DAID Group to acquire the proper sequence either by goal emulation, (Wood 1989; Tomasel 1990) or by functional imitation, where also some aspects of the action are socially acquired (Topál et al. 2006) or also by imitation of the sequential organization (Whiten 1998).

Some preliminary training is necessary for the successful use of the shaping/clicker training method both in order to establish the association between the 'click' and the primary reinforcement (Murphree 1974; Lindsay 2000) and also for the dog to become skilled with this form of trial and error learning so that he will be more confident in spontaneously showing different behaviours that the trainer can choose to reward in the training process (Pryor 2009). Also in order to use the DAID method to teach dogs novel actions, a preliminary training is necessary for the dog to learn the imitation rule (see Topál et al. 2006). The amount of time needed for this preliminary training with the two methods was not considered in the present study (i.e., only already experienced subjects were tested) and it is possible that it varies between the two techniques, therefore making one technique more laborious than the other for the trainers and owners.

Furthermore, although in Study 3 we enrolled only dog-owner dyads that achieved a training certificate for the training method they were tested on, we cannot completely rule out the possibility that there were some differences in their skilfulness and this could have slightly affected the results. Moreover we are aware that the comparison of learning rates is a very difficult issue because several factors, such as individual experience of each subject, may influence the results.

Importantly, the results of this study do not claim for an absolute superiority of one training method over the other. Instead, we suggest the usefulness of the DAID method in addition to the already widespread techniques that rely on individual associative learning, such as shaping/clicker training,
particularly to teach dogs complex object-related tasks. This is the first study on the practical application of the DAID method and we only assessed its efficiency with regard to object-related actions to be trained. Therefore, it is possible that different kinds of actions can be more easily taught with shaping or other traditional methods that rely on individual associative learning. For example, it is known that different species—i.e., chimpanzees (Myowa-Yamakoshi and Matsuzwa 1999), orangutans (Call 2001), and dogs too (Huber et al. 2009)—show a higher difficulty in copying body movements, compared to object-related actions. Therefore, the results of the present study should not be automatically extended to tasks that are different from those actually tested and, in particular, should not be extended to the training of body movements. Furthermore, our measure of training success for Study 3 was the latency to the first correct performance of the action, which, in certain cases, might also occur by chance, particularly with shaping, where the dog learns by trial and error.
5.4 General discussion

From the methodological point of view, the Do as I do paradigm has proven an effective method to study imitation in dogs. Dealing with behavioural similarity between two different species (humans and dogs) we used the definition of functional imitation (Topál et al. 2006) to adjust the coding of the performance as 'match' or 'no match' to the differences in the behaviour repertoire and body schemas of humans and dogs. The novel actions in Study 1 and 2 were considered a 'match' if the body part used by the dog for performing the particular action was corresponding (e.g., the human's hand touch was considered corresponding to the dog's front paw touch). This is also a more stringent criterion for imitation than the one used by Miller et al. (2009) where a human demonstrator pulled a screen with hand and the dog's performance was considered imitation even if the dog used his muzzle.

In fact, as discussed above, the bidirectional procedure does not control for local enhancement, while the Do as I do paradigm, combined with the two-action procedure, is an effective and powerful test for imitation because it controls for all the other non-imitative learning processes and enables the researcher to investigate similarity of actions also in terms of body movements. This method allowed us to discover that dogs are able to match their body movements to the action that was shown by the demonstrator, as it is required in imitation. Furthermore, assuming that dogs (as well as other species) can flexibly engage in different social learning processes according to the constraints of situation and the information provided (see Horner and Whiten 2005 and Range et al. 2007), without a specific training for imitation in which dogs learn that they are required to imitate, it is difficult to interpret negative results. For example it is impossible to exclude the possibility that, instead of lacking the cognitive ability to imitate, the subjects do not imitate because they rely on a different process and/or do not learn that they are required to imitate (see for example the negative results obtained by Tennie et al. 2009 in which, as discussed above, it is probable that the subjects did not know they were required to imitate).
In Study 1 we were able to show that dogs possess the ability of deferred imitation after intervals ranging from 0.40 to 10 minutes. From a cognitive perspective, this finding excludes that other mechanisms, which may trigger a similar behaviour in the observer at the same time as demonstration (e.g., facilitative processes, contagion), can be an exhaustive explanation of dogs' ability to match their behaviour to human actions. Instead, our results suggest the existence of the capacity to form a mental representation of the demonstration and to recall it after a delay, to use it as the basis for performing a matching action. Thus the Do as I do method could be also used to study how dogs represent the actions of others.

A possible field of further investigation includes dog's representation of other's goals and intentions and of intransitive actions (i.e., actions performed without interacting with an object). Huber et al. (2009) suggested that a dog who faced a vacuum demonstration (i.e., a demonstration of an object-related action performed by the demonstrator on nothing) 'tried to make sense' of it by reproducing a functionally similar goal-directed action using a proper target object, which was not used by the demonstrator. In Study 2 in some tests in which the demonstrator showed an action on an object, after the displacement, some dogs reproduced the body movement that was shown in the location where it was shown, thus on nothing (there was no object there). These results suggest that there might be some individual variation in how dogs represent functional and vacuum actions and more research would be needed to shed light on how dogs represent others' goal-directed actions (see also Range et al. 2007; Kaminski et al. 2011) and intransitive actions.

Dogs' ability of deferred imitation seems to be unaffected by changes in context to a certain extent: in Study 1 they were able to imitate after a delay of 1.5 minute in a different context when the objects were placed there in the same respective positions, and in Study 2 dogs were able to imitate after a delay of 1 minute if the only object that was present during the demonstration phase was displaced to a different location. However, dogs' imitative abilities dropped dramatically when the object used during demonstration was replaced with a completely different one. In fact, in the conditions in which the...
The position of two objects was shifted, dogs tended to approach the location where the demonstration was performed, rather than act on the object on which it was performed. These results are also consistent with many previous findings on dogs' spatial bias. It is thus possible that, during memory retrieval, context and object features serve as cues that help recall, especially in certain conditions, such as with longer retention intervals that challenge dogs' memory.

Several studies (e.g., Doré et al. 1996) suggest that dogs generally show difficulties to rely on figurative information to search for hidden objects. Dumas (1998) tested dogs in a delayed matching-to-sample paradigm, in which either spatial or figurative information was relevant to solve the task. Dogs' performance was above chance only when spatial information could be used, but not when figurative cues were the clue to solve the task. Also, rats (Cheng and Gallistel 1984) and pre-verbal human infants (Hermer and Spelke 1994) were shown to ignore figurative information and to favor geometric information instead. However, research on human infants' development of object permanence generally suggests that figurative information can to some extent guide search behaviour for hidden objects (Butterworth 1982). Meltzoff and Moore (1998) propose that children's copying accuracy in delayed imitation tasks relies on an 'object-organized' representational system. Accordingly, it is the objects' representation that allows access to the action and infants do not represent the observed actions as separated mental entities. Indeed when dogs (Fugazza and Miklósi 2013) and human infants (Meltzoff 1985, 1988) are provided the object manipulated by the demonstrator, they are able to reproduce observed actions after a delay without motor-practicing on them and the matching action is typically the first thing they perform on the object, thus the role of experience through individual learning can be excluded (note however that the two-action procedure is usually not included when testing imitation in human children, while it was included for dogs in Study 1 - Fugazza and Miklósi 2013).

Our subjects did not decrease their imitative performances with increased delay up to 10 minutes and...
we later conducted further experimental work to investigate dogs' memory of human actions after longer delays (Fugazza and Miklósi in preparation).

For this study we used a similar method but we increased the delays to assess if dogs possess long-term memory of imitative actions. The dogs (N=12) were tested after delays of different durations: 1 hour, 2 hours, 12 hours (overnight) and 24 hours and their imitative performance after those delays does not differ significantly from the performance of a control group (N=12). It is thus possible that dogs possess long-term memory of imitative actions. However we expect that dogs' memory of human actions decreases with longer delays.

Indeed, it is known that the length of the delay affects performance in the case of human pre-verbal infants (e.g., Klein and Meltzoff 1999; Óturai et al. 2012). Very long retention intervals, such as one week or four weeks, affect imitative behaviour and it has been hypothesized that this forgetting pattern might be due to the transfer of the acquired information to 'very-long-term memory' (Klein and Meltzoff 1999).

Imitation after some delay has been claimed to indicate representational abilities in human infants (e.g., Carpenter et al. 1998b; Meltzoff 1995). Particularly, evidence for the capacity to imitate a novel action after a delay without previous motor practice of that action has also been used to provide a measure of declarative (non-verbal) memory (Barnat et al. 1996; Klein and Meltzoff 1999). For example Klein and Meltzoff (1999) assessed deferred imitation in 12-month-old using a procedure that did not allow subjects to motor practice on the tasks before the delay was imposed, therefore excluding that memory could be based on re-accessing a motor habit. The ability shown by human infants to recall the behaviour after a delay suggests presence of declarative (non-procedural) memory. Similarly, in Study 1 and 2 we used a procedure in which dogs were not allowed to interact with the object before the 'Do it!' command was given (so called 'observation-only procedure' Klein and Meltzoff 1999). Furthermore the subjects' view of the object was prevented, so that they could not keep their mind active on the demonstration by constantly looking at the target object. Thus dogs recalled the actions in...
The absence of any direct or indirect cue that, during the retention interval, could have functioned as a perceptual trigger. In study 1, dogs imitated the actions after a delay also in those conditions in which novel actions were shown, without any previous practice of these particular actions, so that their memory and recall could not have been based on re-accessing a motor habit, because none was previously formed. Therefore, dogs did not simply recognize and choose after a delay the object that was used during the demonstration, but also retrieved and reproduced an action they had not performed on this object before, without the possibility to base their recall on the aid of previous motor practice.

Taken together, these results suggest the presence of some form of declarative memory for imitative actions in dogs and also claim for further investigation on this issue. In fact, the Do as I do paradigm has not only proven successful to test imitative abilities but could be also an effective and innovative method for testing some forms of memory for events in dogs, like their ability to mentally travel back in time, representing the past (Suddendorf and Corballis 2010). In order to test such kind of memory in non-human animals researchers need to train the subjects to 'answer questions' about past events by giving behavioural responses (see Zentall 2013), and the modified version of the Do as I do method that we used to test dogs' deferred imitation could be adapted to this purpose, because dogs are asked to 'report' about a past event (i.e., reproduce it). Moreover, with this method it may be possible to investigate an unexplored kind of episodic-like memory in animals, because in this case the subjects are asked to recall an event (the actions shown by the demonstrator) that they observed, but in which they did not act, so that re-accessing a motor practice habit can be completely excluded.

Our results are also important from the applied perspective. In fact, as shown in Study 3, the introduction of the use of social learning with the Do as I do method may be efficient in dog training, particularly for training dogs to perform complex object-related actions such as those typically required from dogs trained to assist disabled owners. We therefore think that the applied field of dog training will benefit from the knowledge of dogs' social learning abilities and that our research has also
contributed to make a little step forward towards a training approach that takes into account the ethology of dogs.

Furthermore, dogs' ability to flexibly use different social learning processes could be of particular benefit for the field of dog training because it is very likely that, when trained with the Do as I Do method for training purposes, dogs learn about the tasks by flexibly relying on different types of social learning processes, such as goal emulation, functional imitation, local and stimulus enhancement.

Indeed, social learning processes are utilized flexibly also by other species, and the information gained socially may depend on the particular situation or task to be learned. For example, Horner and Whiten (2005) found that chimpanzees' tendency to use emulation or imitation to solve a tool-using task depends on the availability of causal information that is provided during demonstration. Thus, chimpanzees are able to flexibly use the learning process that is more efficient to reach the goal, given the environmental constraints of the situation. Dogs may also be able to engage in different social learning processes, according to the task and the situation (e.g., Miller et al. 2009, Kubinyi et al. 2009, Huber et al. 2009). In Study 1, we showed that dogs are able to match not only the goal of the human demonstrated action, as could be explained by goal emulation, but also the action, even if this action is not goal-directed. This ability can be explained only by functional imitation.

5.5 General conclusion

Across the dissertation, we have shed light on different issues regarding dogs' imitative abilities. Our results, consistent with previous studies on dogs' social cognitive abilities, suggest that dogs are able to learn socially from both humans and conspecifics engaging in different kinds of social learning processes, including imitation.

(1) We discovered that they possess the ability of deferred imitation, which implies the ability to form a mental representation of the demonstration and to recall it later time. This cognitive skill may play a functional role in acquiring information socially from humans. It is likely that...
This ability is not restricted to dogs and other canids may also possess it. Further investigation could reveal more precisely what functional role this skill might have both in dogs and in wild living canids.

(2) We discovered that dogs' imitative abilities can be generalized across contexts to a certain extent. However, dogs' spatial bias (i.e., their tendency to act in the location of demonstration) affects their imitative performance when they find a different object in the place where the demonstration was performed.

(3) The ability of dogs to learn socially from humans can also be effectively exploited in dog training to make the learning process of some tasks more efficient compared to traditional methods that rely on individual learning.
Aknowledgements

There are no words to express my deep gratitude to my supervisor Adam Miklósi who gave me the possibility to learn and discover so much, who supported and shaped my enthusiasm, who was patient and curious enough to listen to my ideas, to discuss them and to give me useful suggestions. Without him I would not have walked so far along the path of scientific research.

I am also sincerely grateful to all the colleagues who helped me by reading and revising my manuscripts, who discussed with me my ideas and provided useful advice. I also feel really lucky to have had the possibility to be part of the Family Dog Project.

I am grateful to my companion, who was there for me, even when I was too busy to remember to have lunch and who patiently waited for me during all my traveling for this research.

Least but not least, this research would have been impossible to complete without the enthusiastic collaboration of all the dog owners and their dogs who participated in the training and testing phases. I am really grateful for their cooperation.

The research was supported by the Hungarian Scholarship Board, by OTKA (109337) and the Hungarian Academy of Sciences (MTA 01 031).


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