

Mindreading in a dog: an adaptation of a primate 'mental attribution' study

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ABSTRACT

In the framework of a longitudinal case study on a male tervueren dog, Philip, the present paper was aimed to get a more sophisticated insight into the cognitive functioning of the dog's mind. Our experiment was designed to study the dog's ability to recognize knowledge or ignorance in others. The procedure used here was identical to that used in an ape-study (Gómez & Teixidor, 1992) and therefore provides the possibility for direct dog-ape comparison regarding their performance. Results show that similarly to the case with this "enculturated" orangutan, after few trials Philip was able to adjust his communicative behaviour to the state of knowledge of his human partner and cooperated successfully in the problem solving task (getting the ball). The exact mechanism underlying this communicative behaviour is still not clear, and both low- and high-level explanations are considered. We suggest that this approach gives a new possibility to conduct comparative studies aimed to understand the evolution of social cognition.

Keywords: social cognition, mind-reading, dog.

RESUMEN

Lectura de la mente en perros. En el marco de un estudio longitudinal de caso único con un perro macho de raza pastor belga tervueren llamado Philip, se realizó el presente estudio a fin de obtener una comprensión más sofisticada del funcionamiento cognitivo de la mente del perro. Nuestro experimento fue diseñado para estudiar la habilidad del perro en reconocer la existencia de conocimiento o ignorancia en otros sujetos. El procedimiento usado aquí fue idéntico al utilizado por Gómez y Teixidor (1992) en un estudio con simios, y, por lo tanto, posibilita la comparación directa perro-simio respecto a su ejecución. Los resultados obtenidos por nosotros muestran una gran similitud con el del orangután "culturrizado". Después de unos pocos ensayos, Philip fue capaz de ajustar su conducta comunicativa al estado de conocimiento de su *partenaire* humano y cooperó eficazmente en la tarea de resolución de problemas (obtener la pelota). El mecanismo exacto que subyace en esta conducta comunicativa no está todavía claro y se discuten diferentes explicaciones tanto de bajo como de alto nivel. Finalmente, se sugiere que esta aproximación abre el camino para realizar investigaciones comparadas encaminadas a entender la evolución de la cognición social.

Palabras clave: cognición social, teoría de la mente, perro.

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In a recent paper Hare et al (2000) state that “It is a focal point of primate cognition what individuals know about each other's psychological processes”. Recently this issue attracted the interest of researchers, which was initiated by Premack and Woodruff (1978) who introduced the concept of “mindreading” in the case of chimpanzees. The hypothesis of theory of mind (e.g. Byrne & Whiten 1988) assumes that individuals are able to represent others' mental state(s) and use this information to modify their own behaviour. Interestingly, the hypothesis of theory of mind was very successful to generate new research questions in developmental psychology (see Perner *et al.*, 1989) but has led to comparatively little progress in non-humans.

One main role of ethology in the study of animals is to emphasize the ultimate causes of behaviour (Tinbergen 1951). The lack of functional analysis can lead to misunderstandings and wrong hypotheses, especially in comparative behavioural studies. In this vein, we need to investigate those circumstances in which “mind reading” could be adaptive for a species. Unfortunately, Humphrey's (1976) argument (i.e. the appearance of the more sophisticated form of social intelligence throughout the evolution can be explained by the complexity of species' social life) is too general for specific hypotheses to be formed. There is a need for more precise observations on the types of interactions between the members of the group and on how much they serve the interest of the individual and that of the group. In this regard Tomasello and Call (1996) do not see any differences in the social life of Old-World monkeys versus anthropoid apes.

In terms of distribution of resources there may be two types of interactions between the members of the group: the competitive and the cooperative. In case of the competitive interactions individuals attempt to exclude others from attaining resources. In cooperative relationships getting or distributing of resources is the result of joint actions.

Two different experimental paradigms illustrate this distinction well. In order to perform in the task designed by Povinelli and his colleagues (1990) chimpanzees had to understand at least two aspects of social interactions. First, they had to understand the cooperative intend of the observer to share the correct information with the subject, second they had to be able to attribute mental states to humans.

In this task the chimpanzees could witness the action of food hiding (into one of three boxes) but they were prevented from observing the actual location of the hidden food. However, they could see that an “observer” was watching the hiding person who was in the position to obtain information about the actual location of the food. After the hider left both a naïve person (not present during the hiding) and the observer pointed at one of the three boxes. The observer pointed always to the correct box, the naïve person pointed always to an empty box. The chimpanzees had only one choice. The results suggested (Povinelli et al 1990) that the chimpanzees did not recognize that the visual information results in a change in the mental state (i.e. “seeing leads to knowing”) and this knowledge could become “visible” in the behaviour.

Although Hare et al's (2000) task had a similar “logical structure” but it was essentially competitive in nature. In this case both a dominant and a submissive chimpanzee witness the hiding of one piece of food, whilst only the submissive one was exposed to the location of the second piece of food. It was assumed that the submissive animal

has some awareness of the knowledge of the dominant (having not seen the second baiting) it should choose the food of which the dominant had no information. Chimpanzees showed a strong preference (85% of total 54 trials) for choosing the food that was hidden when only the submissive chimpanzees are allowed to watch. This suggests that in certain situations chimpanzees are able to take into account what their rivals bear in mind. (Although we should note that this task was less demanding for the chimpanzees -i.e. they did not have to remember who saw what and then to choose between conflicting but equally confident signals.)

The fact that chimpanzees were more successful in competitive situations than in cooperative ones suggests that a particular mental ability (e.g. the recognition of the lack of another individual's knowledge) might control behaviour only in certain situations. It is also possible that representation in relation to the mental state of another individual will only evolve in association with particular circumstances.

The context-dependency of mental representation abilities underlines the importance of an evolutionary-ecological approach. Competition is a key element of the society of adult chimpanzees while in humans adult and child relationships are fundamentally cooperative. The above findings suggest that it might be problematic to model human cooperative interactions (e.g. adult and child) in the chimpanzee. However, the relationship between dogs and humans could offer an alternative opportunity (see Miklósi *et al.*, 2004; Hare & Tomasello, 2005 for reviews). According to our current knowledge this relationship has more cooperative features than competitive ones (Topál *et al.*, 1997; 1998; Naderi *et al.*, 2001). Dogs cooperate in various ways with humans (e.g. guide-dogs and assistant-dogs: Naderi *et al.*, 2002; Topál, Byrne, & Csányi (2006), and possess many sophisticated socio-cognitive skills, for example, understand some visual communicative behaviour in humans (see Miklósi & Soproni 2005, for review). During domestication humans have most likely ousted individuals competing with them, which could have resulted in enhanced cooperative abilities in dogs.

The recognition of another individual's mental state is a sophisticated form of social competence as being manifestation of "distributed cognition" (Johnson 2001). This ability is proved to be evident only in case of humans and can easily be measured by verbal tests (e.g. Chandler *et al.*, 1989). To study mental state attribution in nonhuman animals three basically different non-verbal methods have been recently developed ("Guesser-Knower" e.g. Call *et al.* 2000; "Competitive Conspecific" e.g. Hare *et al.*, 2001; "Ignorant Helper" Gómez, 1998, Whiten 2000). These studies were designed to assess if subjects (mainly primate species) understand the casual connection between past perception and present knowledge and/or whether subjects are able to take their partners' previous experience or perceptual access into account (see also Virányi *et al.*, 2006). Some recent results seem to support the hypothesis that at least chimpanzees understand some psychological states of others (Tomasello *et al.*, 2003).

Here we investigate whether a dog is able to differentiate "knowledgeable" and "ignorant" states of its human partner on the basis of whether human participated in object hiding events or not. Our method is based on the study conducted by Gomez and Teixidor (1992; discussed also in Gómez, 2004) using only one adult orangutan (Dona) housed in a zoo cage. This nonverbal task was developed to assess Dona's ability to

understand knowledge/ignorance of her human partner in a cooperative communicative situation. For the training two big boxes locked with padlocks were placed in front of Dona's cage. The Baiter came in, took the keys from a small box, opened one of the big boxes and hid the food in it. Next he hanged the keys at their usual location and left the room. Dona could get the food only with the help of a second person ("Giver") who entered the room and sat in front of the boxes attending to the orang-utan. If Dona pointed with her extended arm to one of the boxes, the Giver would take the keys, open the selected box and give the food to the orang-utan if that was the baited box. In these "baseline" trials Dona acquired the "requesting" behaviour (pointing at the baited box at the presence of the Giver) without difficulty. This was followed by two types of experimental trials (test trials and control trials; 1-1 daily) were run interspersed with the normal baseline trials. In the test trial, having locked the box the Baiter did not replace the key but hid it somewhere in the room (without the Giver being present) and left whilst in the control trials the Giver herself relocated the keys prior to the trial.

It was hypothesized that if Dona was capable of understanding knowledge and ignorance in human (concerning the whereabouts of the key and the bait) then in the test trials but not in the control trials she should also point to the keys before the Giver started to search for it. In control and baseline trials however Dona was expected to point to the baited box only.

Results showed that Dona failed to show pointing behaviour to the location of the keys in control and baseline trials. Moreover in the first six repetitions of the test trials (when the baiter relocated the keys) Dona did not point to the location of the keys before the Giver tried to find them in the usual place, whilst except for the first trial, she did point after the Giver failed to find the keys. After these six repeated trials, however, she developed relevant signalling behaviour. Authors concluded that pointing to the key was not a reaction to human's ignorance ("mental state") but a result of a fast and efficient insightful learning. It is important to note that when during other occasions an unfamiliar person (a "threatening" stranger) replaced the key in the test trials Dona showed significant improvement in her performance (i.e. she pointed to both the key and the baited box when the Giver entered) (Gómez, 1996). It seems that in line with other studies (see Hare *et al.*, 2001) competitive aspect is a key factor of the situation, which could have facilitated the emergence of mindreading behaviour in Dona (see Gomez, 2004 for a more recent discussion).

Based this study by Gómez (1998) we wanted to investigate whether a dog is able to adjust his "signalling" behaviour to the Giver's actual knowledge/ignorance concerning the whereabouts of the key.

METHOD

Subject

The subject was a castrated male Belgian Tervueren, Philip, who was three years old at the time of the experiment. Philip had been trained to assist his disabled owner

by the trainers of a Hungarian charity (Dogs for Humans) for 6 months when he was one and a half years old. Subsequently, two members of our research team observed the dog over three years, in weekly two-hour visits, testing him on various sociocognitive and communicative tasks (e.g. Soproni *et al.*, 2002; Virányi *et al.* 2004; Topál *et al.*, 2006).

Procedure

We conducted the observations in the living room of the owner's flat (6m x 5m, see Figure 1), which was familiar to Philip. Three boxes (that may be closed by a key) were put on a counter at the height of the dog's eyes at 0.8 m apart from each other. These boxes served to hide the dog's favourite toy (tennis ball). Two persons participated in the experiment: the experimenter (Baiter, J.T.) who hid the reward and the owner (Giver) who helped the dog to get the ball. All visits were recorded on video and the training and test trials were analysed subsequently.

Preliminary training. In the first phase of the experiment the dog was trained to solve a simple requesting task. At the beginning of each training trial the Baiter entered the room and attracted verbally the dog's attention ('Philip, listen!') with a tennis ball in his hand. Then he went to the desk (the standard place of the key) and picked up the key. After this the Baiter slowly approached one of the three boxes, opened it by the key and put in the ball. Having locked the box he placed back the key on the desk and left the room.

Next the owner (Giver) entered the room at a predetermined point looking at the boxes he stopped and waited for Philip to approach one of the boxes and to prickle the box with his muzzle. In this situation the owner was allowed to encourage Philip with the "Show it!" command. If the dog did not choose a box then the command was repeated at five seconds intervals, until Philip approached one of the boxes. When the dog indicated one of the boxes unambiguously the owner went to the desk, picked up the key and opened the box chosen by the dog. If the dog chose the baited box then he received the ball for a short play. If the box was empty the owner was not allowed to open another box. Finally, the Giver relocked the box, placed the key on the desk and left the room.

Preliminary training trials were presented 18 times altogether over the course of four weekly visits (4-5 trials per visit). Baiting locations were randomly determined with the restrictions that the ball was put in each box for the same number of times (6) and never placed more than two times in succession into the same box.

Test trials. Following the preliminary training sessions three experimental conditions were introduced in order to analyse Philip's "requesting/informing" behaviour. Experimental situations were designed so that the Giver's knowledge concerning the whereabouts of the tool (key) and the goal object (ball) were systematically manipulated in three conditions:

Control. The procedure of this condition was identical to the task the dog had to solve in preliminary training trials. These trials included to reveal whether Philip acquired efficient signalling behaviour in the situation where he had to inform the

Giver about the place of the reward only.

Hidden key. The procedure of this condition was identical to the *Control* condition except, when the Baiter had locked the ball in one of the boxes, he did not put back the key to the desk but instead he hid it somewhere in the room. The hidden location of the key was different in each experimental trial. In these trials the Giver had no information about the actual location of the ball and he had no information about the location of the key either.

Relocated key. Prior to the trial both the Baiter and the Giver entered the room and the Baiter picked up the key from the table. He showed it to Philip and then relocated the key to another part of the room. During this the Giver followed the action and movements of the Baiter very closely and care was taken that Philip was clearly attending and following each step of the manipulation. The hiding place of the key was varied from trial to trial (e.g. under the carpet, behind a book on the bookshelves etc.). Then both persons left the room and after some seconds the Baiter re-entered. He attracted verbally the dog's attention ('Philip, listen!') with a tennis ball in his hand and went to the key. Next he slowly approached one of the three boxes, opened it by the key and put the ball in it. Having locked the box he replaced the key to its recent location (to the place where he found it) and left the room. From this point the trial continued in the same way as in *Control* condition.

Behavioural rules for the Giver during the test trials. In order to standardize the Giver's behaviour across conditions, he had to act according to the following instructions: After entering the Giver had to go to the 'starting point' (see Figure 1) where he was waiting for the dog's signalling behaviour.

Once the dog indicated one of the boxes (i.e. he touched one of the boxes or only approached a box within 10 cm-s with his nose and waited there for at least 3 seconds) the Giver had to act differently according to the particular type of trial:

Control. The Giver picked up the key from the desk and opened the box chosen by the dog. If the ball was there he initialised a short fetching game with the dog.

Hidden key. The Giver approached the usual place of the key (desk) and started to look for the key for 5 seconds. Then he turned towards the dog and he was waiting for the dog's further actions. If the dog indicated at any time any particular place in the room (approaching, sniffing, pricking with its muzzle, staring) the Giver went there to take a close look. If he found the key he picked it up and opened the box shown by the dog. If no box was indicated, the Giver went back to the starting point and kept on waiting.

Relocated key. The Giver went to the actual place of the key (to where he put it together with the Baiter) and opened the box selected by the dog. If the ball was there he initialised a short fetching game with the dog. The Giver was allowed to open only one box and if the box selected by the dog was empty or they did not manage to get the ball within 1 minute, the trial was terminated and the Giver left the room.

The test trials were conducted over 11 weekly sessions, each condition was presented once in each session in a randomised order ($3 \times 11 = 33$ trials in total). The box in which the ball was put by the Baiter was also randomised across conditions. Video recordings of 3 sessions were excluded from further analysis because the owner (Giver)

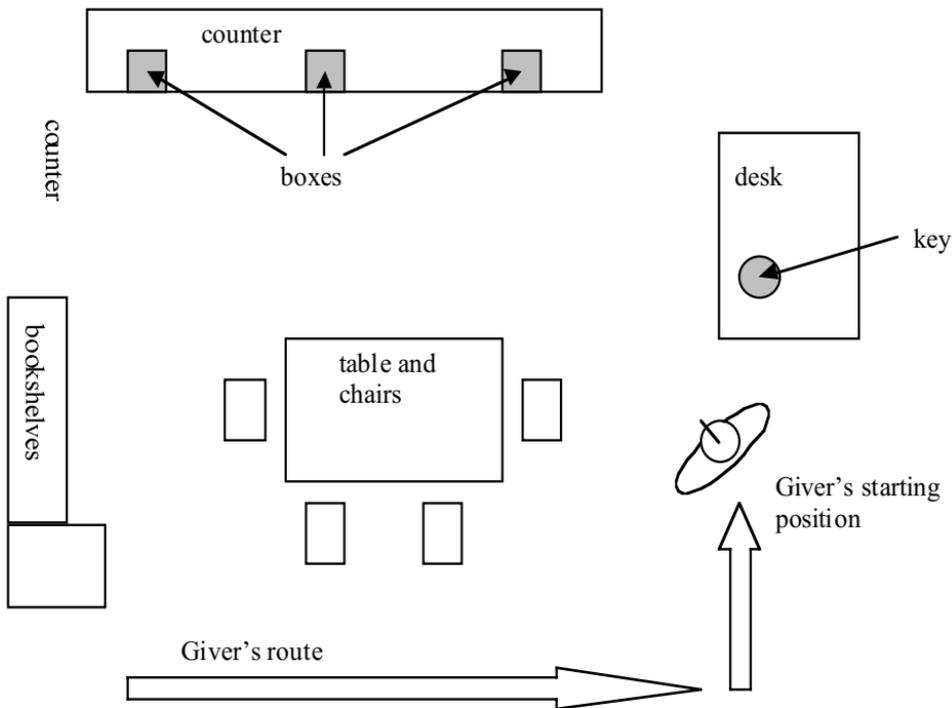


Figure 1. Experimental arrangement in the owner's flat (view from above, not to scale)

violated the behaviour instructions described above.

Behavioural analysis. The behaviour of the dog was observed during the 1 minute long trials and the analysis focused on the dog's 'indicative' behaviours towards the predetermined directions (i.e. baited box, location of the key). These behaviours were as follows:

“Approach”: The dog orients towards one of the predetermined locations (key or bait) and approaches it within 30 cm.

“Touching”: The dog prickles the baited box or the key with his muzzle.

On the basis of head orientation of the dog two behaviour variables were recorded:

“Gaze alternation”: Gazing (head orientation) at the Giver is directly followed (within 2 seconds) by a direct head orientation at the location of the baited box or the key or vice versa. We recorded how many times Philip oriented at the relevant directions (Giver, location of the key, baited box), and how many times he displayed gaze alternation (i.e. back and forth alternation between the

three important directions). (For a more detailed description and justification of this kind of behavioural analysis in dogs see Miklósi *et al.*, 2000; Virányi, Gácsi, Kubinyi, Topál, Belényi, Ujfalussy, & Miklósi, Note 1)

“*Gazing sequence*”: For the analysis of the sequence of head orientations toward the three different directions (Giver, baited box, location of the key) we established their relative rank order by noting the order of the directions to which Philip oriented after the Giver arrived at the starting position.

Reliability of measuring the number of approaches and touches and the direction of gazing were assessed by means of parallel coding of total sample by two observers. The inter-observer agreements (Cohen's kappa) were 0.92 (approach), 1 (touching) and 0.87 in the case of dogs' orientation.

RESULTS

Training for the request task

In the course of the preliminary training trials Philip mastered the *requesting* behaviour very quickly. He showed the Giver the baited box by approaching and touching it within one minute and the human could select the baited box in all but two trials (88% correct choices).

Test trials

In the test trials Philip showed good performance in all conditions. He got quickly the ball in all (8-8) trials of the *Control* and the *Relocated key* conditions (on average within 20 seconds) by utilizing the cooperative behaviour of the Giver. He found the ball in most of the *Hidden key* condition trials (6 out of 8). It is important to note that in this latter condition for the successful problem solving the dog had to *inform* the Giver (and at the same time the Giver had to *read* the dog's behaviour) about both the actually baited box and location of the key. The comparison of problem solving latency (i.e. how quickly the dog got the ball) showed significant differences among experimental conditions. Philip got the ball by the help₂ of the Giver significantly later in the “*Hidden key*” condition (Friedman ANOVA, $\chi^2=11.2$; $df = 2$; $p=0.003$; Figure 2).

We found that Philip indicated the location of the ball by approaching and touching the baited box in all trials of the *Control* and *Relocated key* conditions. In contrast, the dog in these conditions did not approach and touch the key (Table 1). In the *Control* condition he did so in just two cases: during the 1st and 2nd trial Philip picked up the key from the desk (its usual place) and gave it to the Giver before approaching and touching the baited box. In the '*Relocated key*' condition Philip approached and picked up the key before approaching and pricking the baited box only one time out of the 8 trials (during the 2nd trial). Importantly, however, dog's signalling behaviour

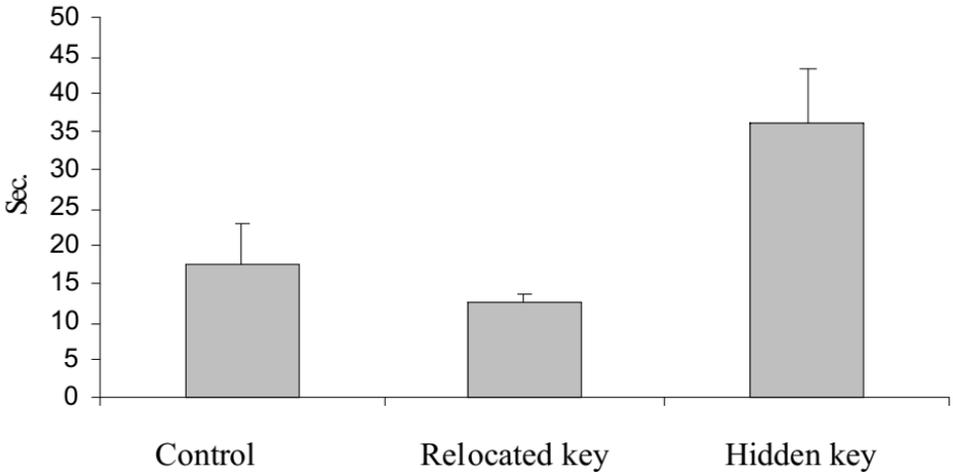


Figure 2. Latency of getting the ball in the different conditions. (The time elapsed from starting the trial until the Giver opened the baited box) (mean + SE).

has changed in the '*Hidden key*' condition. Philip informed the Giver about the location of the key in most of the trials (6/8). In four cases (3rd, 5th, 7th and 8th trials) he approached the key before going to the baited box, that is, while the Giver were still waiting motionless and in the remaining two cases (1st and 6th trial) Philip first approached and touched the baited box and showed the key only when the Giver failed to find it in the usual location (Table 2).

Next we analysed how Philip divided his attention between the three particular directions (the Giver, the baited box, the place of the key) in the different conditions.

In the *Control* condition Philip predominantly looked at the baited box and the Giver (in sum 84.4% of the total time) and spent in average less than 1 second orienting towards the key or at other directions in the room. The pattern of the dog's head

Table 1. Categorization of Philip's indicating behaviour in the three different conditions (8 trials in each).

	Approaching / touching				
	Key only	Key then baited box	Baited box then key	Baited box only	Neither key nor baited box
Control condition	0	2	—	6	0
Relocated key condition	0	1		7	0
Hidden key condition	0	4	2	1	1

Note: Having been shown the baited box, the dog had no possibility to approach the key in the *Control* and *Relocated key* conditions because the Helper picked it up. Therefore the *baited box then key* option is irrelevant in these cases.

orientation was similar in the *Relocated key* condition, in which Philip spent 85.3% of the total time in orienting either towards the Giver or the baited box and he gazed only rarely at other directions (on average less than 1 second). Interestingly however, in those trials in which the Giver was ignorant regarding the whereabouts of the key (*Hidden key* condition), the pattern of Philip's head orientation has changed strikingly. He gazed less at the Giver and the baited box (64.5% of the total time) and at the same time he focused his attention towards the location of the key. (26.2% of the total time vs. 4% shown in Control condition and 7% in Relocated key condition; Friedman ANOVA, $\chi^2 = 6.4$; $df = 2$; $p = 0.039$).

Next we studied the changes in Philip's communicative behaviour as a function of the Giver's knowledge regarding the whereabouts of the key by analysing frequency of gaze-alternations. Results show that Philip turned his head towards the location of the key approximately two times more frequently when the Giver was ignorant about the place of the key (*Hidden key* condition) than in those trials when the key was at its usual location or the Giver was involved in the relocation of the key (Friedman ANOVA, $\chi^2 = 9.5$; $df = 2$; $p = 0.008$). Similarly, compared to other conditions Philip performed significantly more gaze alternations between the location of the key and the Giver in the *Hidden key* condition (Friedman ANOVA, $\chi^2 = 7.05$; $df = 2$; $p = 0.029$). Moreover alternating head-orientations between the baited box and the location of the key were also observed in the '*Hidden key*' condition, but not in case of the other two ones (Friedman ANOVA, $\chi^2 = 10$; $df = 2$; $p = 0.006$).

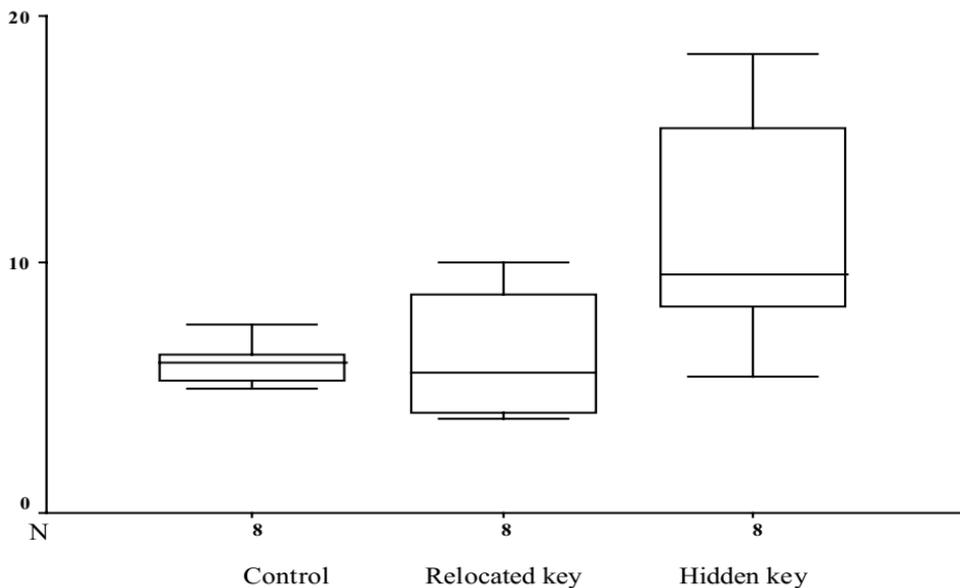


Figure 3. The total number of gaze alternations (per minute) occurring between any two of the three distinctive directions (Giver, baited box, location of the key) in the three different conditions (median, quartiles and extremes).

Figure 3 indicates differences in the total number of per-minute gaze alternations across the three experimental conditions (Friedman ANOVA, $\chi^2 = 7.46$; $df = 2$; $p = 0.023$; in 'Hidden key' condition Philip alternated his gaze more frequently among the three distinctive directions).

The comparison of the 'Relocated key' and 'Hidden key' conditions show characteristic differences in Philip's orienting behaviour (Figure 4). In the 'Relocated key' condition when the Giver was knowledgeable regarding the whereabouts of the key Philip predominantly oriented first toward the baited box, and this was followed by gazing at the Giver and last (if at all) he turned towards the actual location of the key (comparisons of the ranks: $\chi^2 = 10.75$, $df = 2$, $p = 0.0024$). At the beginning of the trial Philip first indicated the baited box in all but one cases (in the third trial he showed first the location of the key). In contrast, when the Giver had no information about the actual location of both the key and the reward ('Hidden key' condition) we did not find such bias in order of head orientations ($\chi^2 = 0.75$, $df = 2$, $p = NS$). In this case the location of the key and the baited box was equally preferred to be gazed at as Philip started with looking towards the key in half of the trials (1st, 4th, 6th and 7th) whilst he indicated first the baited box in the other four cases.

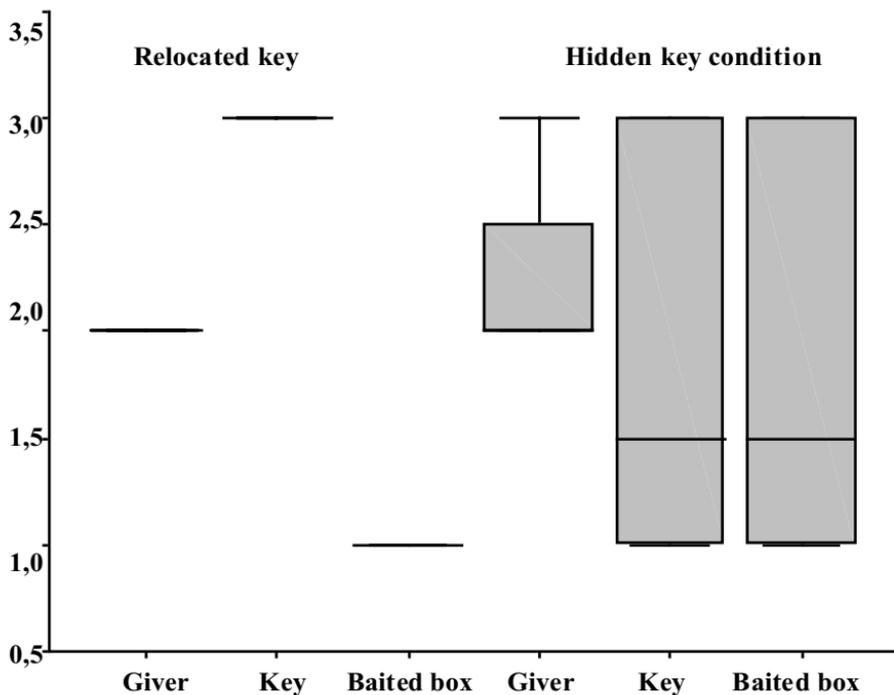


Figure 4. Rank orders of head orientations (first, second or third direction of looking after the beginning of the trial) in either of the three distinctive directions (Giver, Baited box, location of the key). Median, quartiles and extremes are indicated.

DISCUSSION

In the last few years a handful of investigations have argued that in the course of adaptation to the human environment dogs have undergone significant behavioural changes, and these species specific communication skills and social competences can be regarded as functionally analogue behaviours to corresponding human skills (for reviews see Miklósi *et al.*, 2004; Hare and Tomasello, 2005). Dogs show sophisticated skills in understanding state of 'attention' when one is looking at a target (Call *et al.*, 2003; Gácsi *et al.*, 2004; Virányi *et al.*, 2004), and they seem to fulfil some of the basic criteria to recognize intentionality in communication (Soproni *et al.*, 2001; Miklósi & Soproni, 2005). Similarly to human infants and apes, dogs are willing to look at the eyes of their human partner in problem situations and they do this more readily than wolves (Miklósi *et al.*, 2003; Virányi *et al.*, submitted). Eye contact is a way of establishing attention that offers the possibility for mutual intentional communication.

The 'Ignorant Helper' design (Gómez 1996; Whiten 2000) proved to be a useful method for studying the question whether dogs are capable of relying not only on directly observable behavioural cues of mental states as attention or intention, but are sensitive to such 'indirect' attributes of mental states toward human's presence or absence in past relevant events (leading to knowledge or ignorance concerning the test situation).

Results show that similarly to that of reported in the case of the orang-utan, Dona (Gómez & Teixidor, 1992), Philip had no problem with the *request task* and he could show relevant 'pointing' behaviour from the very beginning of the baseline training. Moreover, in spite of the dogs' restricted gesturing abilities Philip modified his behaviour adequately to the different experimental conditions. Philip effectively cooperated with the Giver throughout the tasks because he showed relevant changes in his orienting behaviour and in the frequency of gaze alternations between the target places as a function of Giver's participation in relocating the key. Philip's seemed to have adapted his behaviour to the changes in the Giver's state of knowledge, similarly as observed in the great apes (Gómez 1996; Whiten 2000).

Taking a parsimoniously low-level approach it seems that discrimination learning is a plausible explanation for the observed behaviour. Philip is an extensively socialized and trained domestic dog who has sophisticated abilities for reading subtle cues of human behaviour, and he has extensive experience with different communicative situations. Supposedly, he routinely monitors the state of his owner's attention and is able to use behavioural cues given by humans in order to effectively cooperate in interactive situations. Therefore we assume that a rapid learning process can explain the changes in Philip's behaviour, and as a result he became capable of adjusting his behaviour to the different changed context of the problem situations.

Some observations, however, seem to contradict discrimination learning hypothesis. First, Philip met the test situations very rarely (one trial with each condition per week) and the total number of trials (including preliminary training and all testing conditions) was relatively low (51) compared to the several hundreds of trials in Gómez and Teixidor's (1992) study with Dona. Second, over the three months period of the study we could not observe any trends of the changes in Philip's behaviour (so if he had in

fact learnt behavioural strategies for solving problems it should have been based on very rapid, 'insightful' learning).

Among others Whiten (1997) argued that the manifestation of 'mind reading' skills could be species specific and are displayed as a special kind of "behavioural and situational reading" ability (e.g. Whiten, 1997). Understanding such overt mental states in others can be developed without any insightful recognition of other's subjective mind-states. One possibility is to generalize own past experiences in order to predict other's behaviour (and mental states) in certain situations. Another way of improving social competence is the ability to recognize that a particular sequence of events and/or actions precede certain behaviour response (and specific changes in mental states) in others. In contrast, implicit theory of mind assumes that the animal is able to recognize the relationship between the information observed by the other individual and the action taken by the other individual subsequently.

The traditional comparative approach for studying the evolutionary emergence of human social cognition is based on our homologue evolutionary relationship with apes and monkeys. Recently, however, research has focused on other species that provide analogue models of the evolution of human social cognitive abilities (e.g. Herman *et al.*, 1999). Dogs seem to offer an alternative approach to understand how social competence has emerged and evolved. We assume that the new challenges of the human physical and social environment selected for a canid species that seem possess a certain set of skills which can be regarded as functional analogue behaviours to its human counterparts (Miklósi *et al.*, 2004). Importantly, the cognitive mechanisms underlying such performance in dogs may rest on different processes in comparison to humans; nevertheless we argue that such behavioural skills in humans were the necessary precursors for the emergence of more complex 'mind reading' abilities in our species.

In summary, Philip's performance shows that he was able to develop adequate actions in the presence of a knowledgeable/ignorant human. Although *in situ* learning might have contributed to his performance, the rapid adaptation to the social situation from the beginning suggests that he had already possessed most of the necessary social skills before coming to the experimental situation. This could be explained by his extensive experience with such social situations during his life as an assistant dog but the facilitating role of certain specific skills rooted in the adaptation process of dogs in general could not be ruled out at this stage. Further experiments with large number of dogs are required here to clarify the issue of contribution of dog-specific skills and effects of learning but we know that wolves socialized to similar level to that of dogs, generally trail behind the former in their performance in various simpler social situations (Miklósi *et al.*, 2003).

Notes

1. Virányi, Zs, Gácsi, M, Kubinyi, E, Topál, J, Belényi, B, Ujfalussy, D & Miklósi, Á (submitted manuscript). Comprehension of the human pointing gesture in young socialized wolves and dogs. *Animal Cognition*

REFERENCES

- Byrne RW (1995). *The Thinking Ape*. Oxford Univ. Press. Oxford
- Byrne RW & Whiten A (1988). *Machiavellian intelligence: social expertise and evolution of intellect in monkeys, apes and humans*. Oxford: Clarendon Press
- Call J, Brauer J, Kaminsky J & Tomasello M (2003). Domestic dogs (*Canis familiaris*) are sensitive to attentional state of humans. *Journal of Comparative Psychology*, 117, 257-263.
- Call J, Agnetta B & Tomasello M (2000). Cues that chimpanzees do and do not use to find hidden objects. *Animal Cognition* 3, 23-34.
- Chandler M, Fritz AS & Hala, S (1989). Small-Scale Deceit: Deception as a Marker of Two-, Three- and Four-Year-Olds' Early Theories of Mind. *Child Development*, 60, 1263-1277.
- Gácsi M, Miklósi Á, Varga O, Topál J, Csányi V (2004). Are readers of our face readers of our minds? Dogs (*Canis familiaris*) show situation- dependent recognition of human's attention. *Animal Cognition*, 7, 144-153.
- Gómez JC (2004). *Apes, Monkeys, Children and the Growth of Mind*. Cambridge, Ma.: Harvard University Press.
- Gómez JC (1998). Assessing theory of mind with nonverbal procedures: Problems with training methods and an alternative "key" procedure. *Behavioral and Brain Sciences*, 21, 119-120.
- Gómez JC (1996). Nonhuman primate theories of (nonhuman primate) minds: some issues concerning the origins of mindreading. In Carruthers, P., Smith, P. K. (eds), *Theories of theories of mind* (pp. 330-343). Cambridge University Press, Cambridge
- Gómez JC & Teixidor P (1992). Theory of mind in an orangutan: A nonverbal test of false-belief appreciation? Paper presented at *The XIV Congress of the International Primatological Society*, Strasbourg
- Hare B & Tomasello M (2005). Human-like social skills in dogs? *Trends in Cognitive Sciences*, 9, 439-444.
- Hare B, Call J & Tomasello M (2001). Do chimpanzees know what conspecifics know? *Animal Behaviour*, 61, 139-151.
- Hare B, Call J, Agnetta B & Tomasello M (2000). Chimpanzees know what conspecifics do and do not see. *Animal Behaviour*, 59, 771-785.
- Herman LM, Abichandani SL, Elhajj AN, Herman EYK, Sánchez JL & Pack AA (1999). Dolphins (*Tursiops truncatus*) comprehend the referential character of the human pointing gesture. *Journal of Comparative Psychology*, 113, 347-364.
- Humphrey NK (1976). The social function of intellect. In PPG Bateson, RA Hinde (Eds), *Growing points in ethology* (pp. 303-317). Cambridge University Press, Cambridge
- Johnson CM (2001). Distributed primate cognition: a review. *Animal Cognition*, 4, 167-183.
- Miklósi Á, Kubinyi E, Topál J, Gácsi M, Virányi Zs & Csányi V (2003) A simple reason for a big difference: wolves do not look back at humans but dogs do. *Current Biology*, 13, 763-767.
- Miklósi Á, Polgárdi R, Topál J & Csányi V (2000) Intentional behaviour in dog-human communication: An experimental analysis of 'showing' behaviour in the dog. *Animal Cognition*, 3, 159-166.
- Miklósi Á & Soproni K (2006) *Comprehension of the human pointing gesture in animals: A comparative approach*. *Animal Cognition*, 9, 81-93.
- Miklósi Á, Topál J, Csányi V (2004) Comparative social cognition: What can dogs teach us? *Animal*

Behaviour 67, 995-1004.

- Naderi Sz, Miklósi Á, Dóka A & Csányi V (2001). Cooperative interactions between blind persons and their dog. *Applied Animal Behavior Science*, 74, 59-80.
- Naderi Sz, Miklósi Á, Dóka A, Csányi V (2002). Does dog-human attachment affect their interspecific cooperation? *Acta Biologica Hungarica*, 53, 537-550.
- Perner J, Frith U, Leslie AM & Leekam SR (1989). Exploration of the Autistic Child's Theory of Mind: Knowledge, Belief and Communication. *Child Development*, 60, 689-700.
- Povinelli DJ, Nelson KE & Boysen ST (1990). Inferences about guessing and knowing by chimpanzees (Pan troglodytes). *Journal of Comparative Psychology*, 104, 203-210.
- Premack D & Woodruff G (1978). Does the chimpanzee have a theory of mind? *The Behavioral and Brain Sciences*, 4, 515-526.
- Soproni K, Miklósi Á, Topál J & Csányi V (2001). Comprehension of human communicative signs in pet dogs. *Journal of Comparative Psychology*, 115, 122-126.
- Soproni K, Miklósi Á, Topál J & Csányi V (2002). Dogs' responsiveness to human pointing gestures. *Journal of Comparative Psychology*, 116, 27-34.
- Tinbergen, N (1951). *The study of Instinct*. Oxford University Press, Oxford
- Tomasell M, Call J & Hare B (2003). Chimpanzees understand psychological states -the question is which ones and to what extent. *Trends in Cognitive Sciences*, 4, 153-156.
- Tomasello M & Call J (1996). *Primate Cognition*. Oxford University Press, Oxford
- Topál J, Miklósi Á, Dóka, A, Csányi V (1998). Attachment behaviour in the dogs: a new application of the Ainsworth's Strange Situation Test. *Journal of Comparative Psychology*, 112, 219-229.
- Topál J, Miklósi Á & Csányi, V (1997). Dog-human relationship affects problem solving behaviour in the dog. *Anthrozoös*, 10, 213-223.
- Topál J, Byrne R, Miklósi Á & Csányi V (2006) Reproducing actions and action sequences: Do as I do in a dog. *Animal Cognition*, 9, 355-367.
- Virányi Zs, Topál J, Miklósi Á & Csányi V (2006). A nonverbal test of knowledge attribution: a comparative study on dogs and human infants. *Animal Cognition*, 9, 13-26.
- Virányi Zs, Topál J, Gácsi M, Miklósi Á & Csányi V (2004). Dogs respond appropriately to cues of human's attentional focus. *Behavioral Processes*, 66, 161-172.
- Whiten A (1997). The Machiavellian mindreader. In: A Whiten, RW Byrne (Eds.), *Machiavellian Intelligence II: Extensions and Evaluations* (pp. 144-173). Cambridge University Press, Cambridge
- Whiten A (2000). Chimpanzee cognition and the question of mental re-representation. In D Sperber (Ed.), *Metarepresentation: A Multidisciplinary Perspective* (pp. 139-167). Oxford University Press, Oxford.

Recibido 28 Diciembre, 2005

Aceptado 25 September, 2006