Dog (Canis familiaris) – robot interaction

Experimental research on dogs’ socio-communicative behaviour

Doctoral thesis

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**Introduction**

In the past 10 years many robots have been used to investigate social-communicative behaviour in wide-range of animals (e.g. Narins et al 2003, Leaver & Reimchen 2007). This method enhances controllability and reproducibility of experimental techniques, and it allows also the experimental separation of the effects of bodily appearance (embodiment) and behaviour (see Krause et al 2011). Most of these studies examined intraspecific interactions and used life-like ‘conspecific robots’ aimed to mimic the morphology and particular behaviour of the species studied (e.g. Partan et al 2009, Kubinyi et al 2004).

At the same time using unfamiliar artificial agents in a social context may also has the potential to reveal the animals’ ability to recognise some aspects of the other’s behaviour and the quality and quantity of experience needed for such recognition to emerge and/or to get improved. In this way, the effects of behaviour and embodiment can be investigated separately allowing us to identify those external and behavioural features (i.e. key stimulus) of the partner that are important for the animal to engage in social interactions. In this case the embodiment should be as distinct as possible from the range of objects and living animal species with which the subject interacts in a social way under habitual (natural) conditions. In principle this agent can take any form and shape, so we introduce the general term of an unidentified moving object (UMO) which emphasises that at the time of the first encounter the animal subject has no previous experience with that particular artificial agent.

Our studies aimed to provide supporting evidence for the above concept of using UMOs with different embodiments and behaviours. We decided to use dogs as subjects, especially because they are becoming very popular in studying complex social behaviours (for a review see Miklósi & Topál 2013). Dogs may also be favourable subjects for these studies because they have shared a common environment with humans (a heterospecific agent) for a long time, and they live also in human families at present. Thus dogs may be especially skilful at interacting with non-dog-type agents (UMOs) if they can recognise some aspects of the behaviour of those unfamiliar agents. We designed our experiments by adopting recently used methods in human-dog interaction studies to see whether dogs display similar social behaviour toward a human and an UMO.

**Aims and questions**

As a first step in Experiment 1 we investigated whether different behaviour of the UMO has an effect on dogs’ social behaviour in a problem situation, in which the partner helped the dog...
to get the ‘unreachable’ food. We hypothesised that dogs’ would increase their social behaviour toward the ‘social’ UMO, which we endowed with certain social characteristics, compared to the ‘mechanical’ UMO if they recognised some social aspects of the UMO’s behaviour. We also assumed that dogs would utilize similar amount of behaviours toward the ‘mechanical’ UMO and the ‘mechanical’ human partners.

As a next step in Experiment 2 we were curious about whether dogs are able to flexibly adjust their social behaviour to fit their UMO partners’ different capabilities in a similar problem situation. We hypothesised that dogs are able to discriminate between different roles of their inanimate partners and they would prefer the appropriate partner, who is able to help in that particular situation.

In Experiment 3 we focused more on communicative interaction between dogs and different UMO and human partners. Dogs in one group had opportunity to interact socially with the UMO or the human partner in a similar problem situation as in Experiment 1 (Context 1), while dogs in the other group had no interaction with the UMO or the human partner during this phase. After, all of the subjects faced with a two-way choice task in which the partner approached one of the hiding places and then they were allowed to make a choice (Context 2). We hypothesised that after previous social interaction dogs would be able to generalise the social behaviour of the UMO to the test situation i.e. they would consider the UMO’s movement as an indication. We emphasised that results of this experiment might have useful insight on how do communicative signals between dogs and humans achieve their function.

The aim of Experiment 4 was to investigate whether dogs’ behaviour can be influenced by a human or an UMO partner in a food-choice task. We hypothesised that dogs would change their ‘original’ preference for options between small and large amount of food after having witnessed a human’s explicit preference for the other. However they would ‘follow’ an inanimate UMO’s preference exclusively after previous social interaction with it.

In Experiment 5 we focused more on practical applications of dog-robot interaction and designed an experiment in order to provide useful information to the SWARMIX Project. Our questions were whether dogs are able to generalise different acoustic signals to novel contexts. In the present experiment dogs were trained to perform oriented movement (go left/right) in response to different acoustic signals, then they were exposed to novel test situations where they had to rely on the same acoustic signals to solve a series of new spatial tests. We hypothesised that dogs are able to generalise learnt acoustic signals to novel contexts.
Materials and Methods

Experiment 1

In the present study we examined 47 adult pet dogs’ social behaviour in a problem solving task (in which the dog has no access to the food). Subjects were divided into three experimental conditions with three different partners (i.e. helpers), two of which were UMOs (i.e. a remote control car) and the third a human behaving in a robot-like manner. The Mechanical UMO and the Mechanical Human differed only in their embodiment, but showed similar behaviour toward the dog. In contrast, the Social UMO had two eye spots, it was interactive, showed contingent reactivity and goal-directed behaviour and moved along varied routes. Dogs’ behaviour toward the partner (i.e. gazing and touching the partner, gaze alternations between the partner and the food) was recorded and analysed later. We compared dogs’ social behaviour between all three conditions and we also analysed the effect of repeated test trials.

Experiment 2

In a similar problem situation 48 adult pet dogs were presented with a problem box with two lockable holes, one on the front and one on the top. Both holes were small enough to prevent the dog to reach the hidden food. However, front hole was suitable for one of the UMOs (a remote control car), while the top hole was fitted to the other UMO (a remote control crane with a telescopic boom) to help the dogs to obtain the food. Dogs had the opportunity to observe both UMOs actions 5-5 times during the Learning phase. Then in the two test trials both UMOs were presented in the test room while only one of the two holes was open. We analysed dogs’ behaviour later (i.e. approach, look, touch the car or the crane, gaze alternations between the UMOs and the box) during test trials.

Experiment 3

In the third study we presented two different partners in four different conditions to the dogs (N=60) in a between subject design. The Helper UMO and the Non-Helper UMO was a remote control car, in the Helper Human and Non-Helper Human group the partner was a female human. During the familiarization phase only dogs in the Helper UMO and Helper Human group had opportunity to engage in a short social interaction with the partner (we used the same problem situation as in Experiment 1), while partners’ in the Non-helper groups were circling around the room without any interaction with the dogs. After, all of the subjects
faced with a two-way choice task in which after having called the dogs’ attention the partner (UMO or Human) approached one of the hiding places and then they were allowed to make a choice (16 trials). We analysed dogs’ looking behaviour (i.e. look at the partner) through familiarization and test phases and dogs’ choice behaviour during test trials.

**Experiment 4**

In the fourth study dogs (N=62) were divided into three groups: Helper UMO, Non-helper UMO and Human group. All of the dogs first were presented with 6 trials in which two different amounts of food had been offered to them (small=1 piece, large=6 pieces), then dogs were allowed to choose freely between the two food quantities (Phase 1). Next, dogs in the Helper UMO and Human group had opportunity to engage in a short social interaction with the partner (we used the same problem situation as in Experiment 1 and 3), while in the Non-helper UMO group, the partner was circling around the room without any interaction with the dogs (Phase 2). Then in the third phase dogs faced with the same choice situation as in Phase 1 except that the partner (UMO or Human) first approached the plate containing the ‘non-preferred’ quantity of food and then dogs were allowed to choose (Phase 3). We analysed and compared dogs’ choice behaviour in Phase 1 and Phase 3 and their looking behaviour (i.e. look at the partner) during Phase 2.

**Experiment 5**

In our last study dogs (N= 16) first were trained to perform oriented movement (go left/ right) in response to different acoustic signals. After having reached the criterion (10 consecutive correct trials) dogs were participated in an Advanced training where we eliminated the target objects from the training room (No target training, N=8), or we rotated the position of the target objects and the orientation of the dog and the owner by 90° (Rotation training, N=8). After having reached the criterion, subjects participated in five field test sessions that included several novel targets (balls/trees/humans) at different distances (7–18 m) and angular deviations (36°–87°). The test sessions were followed by a control session in the laboratory in order to control for owners’ and experimenter’s influence on dogs’ performance (Clever Hans control). Test conditions were videotaped and analysed later. We scored correct trials with 1 (i.e. dog went to the target on the side indicated by the specific sound), and incorrect trials with 0.
Results and discussion

In Experiment 1 we found that dogs looked longer toward the Mechanical UMO than toward the Mechanical Human, however dogs in the Mechanical Human group displayed more gaze alternations between the partner and the place of food than dogs in the Mechanical UMO group. Then we compared dogs’ behaviour in the first and last trials to examine whether dogs showed more intensive gazing and touching behaviours toward the Social UMO than dogs in the mechanical groups toward the mechanical partners. In the first trial there were no differences among the three groups in any of the measured behaviour variables, however during the last trial all variables differed significantly across the groups: (1) dogs looked longer at the Social UMO than the Mechanical UMO or the Mechanical Human; (2) dogs also altered their gaze more frequently between the Social UMO and the place of food during the last trial compared to the Mechanical UMO; (3) dogs touched the Social UMO and the Mechanical UMO sooner than the Mechanical Human. These results suggest that dogs form expectations about an unfamiliar moving object within a short period of time and they recognise some social aspects of UMOs’ behaviour. This is the first evidence that social behaviour of a robot is important for evoking dogs’ social responsiveness.

Results of the second study showed that dogs direct their social behaviour in accordance with the actions and different capabilities of their inanimate partners in a problem situation, i.e. they first approached, touched and looked at the partner which could help in that particular situation. However, time spent looking at the partners and the frequency of gaze alternations between partners and the place of the hidden food were independent from the type of the partner, i.e. dogs did not show any preference toward one of the partners.

In Experiment 3 we have shown that dogs are able to use directional movement (approach) of a non-living partner (UMO) as effectively as similar human action to locate the hidden food. Previous social interaction with the UMO seemed to be indispensable for dogs to interpret partners’ movement as a significant cue because dogs performed at chance with the Non-helper UMO. We also found evidence that previous interaction with the UMO also enhances learning about the communicative aspects of the action. At the same time dogs utilized human indication efficiently from the beginning and irrespectively of prior experience in the familiarisation phase.

Results of Experiment 4 showed that only 52% of the subjects preferred the larger quantity (in Phase 1), while 21% preferred the smaller amount and 27% showed no explicit preference. In accordance with previous studies (Prato-Previde et al 2008, Marshall-Pescini et al 2012) we
found that the human partners’ preference has the potential to change dogs’ choice behaviour. In contrast, dogs in the Non-helper UMO group did not change their preference after observing the UMO approaching the ‘non-preferred’ food location. At the same time after having witnessed that the Helper UMO favoured the small quantity dogs chose the large quantity of food significantly less than in the free choice situation. This result is in line with our former findings that previous social interaction with the UMO has an effect on dogs’ behaviour (see Experiment 1 and 3).

Results of our last experiment showed that dogs had no difficulty in learning directional responses based on qualitatively different sound signals after a relatively short training. The control testing aimed to exclude human influence (i.e. Clever Hans effect) also supported our findings that the dogs’ performance was based on their attention to the signals. Furthermore, dogs’ performance was significantly above chance level in all test conditions (i.e. novel contexts), thus they approached the correct target matching with the sound command significantly more often than expected. Our results also showed that dogs’ performance was lower if, in the test condition, the angular deviation between the adjacent targets and the dogs’ position was sharper than the angle experienced in the training angle. This is the first evidence that angular deviation influences dogs’ ability to generalise learned directional commands from the training context to a novel context.
Main results of the studies

- In our studies we found evidence that dogs are willing to interact with an Unidentified Moving Object (UMO) resembled neither conspecific nor human. Behavioural elements displayed by the dogs during these encounters were in line with previously observed social behaviour toward human partners.

- In the first study we showed that dogs’ social behaviour toward the UMO increased as a function of the sociality of the inanimate partner. Our results suggested that morphological features of the UMO (i.e. varied movements and the presence of eye-spots) were probably not as effective as the behavioural characteristics (i.e. goal-directedness and interactive behaviour) to elicit dogs’ social behaviour. This might indicate that it is not the embodiment but the behaviour of the artificial partner is crucial for dogs to engage in social interaction.

- In our second study we found that dogs are able to discriminate between different roles of their UMO partners within a short period of time and they used similar behaviours flexibly toward these agents in accordance with their different capabilities.

- Our third study provided evidence that dogs are able to find the hidden food based on the directional movements of an UMO in a two-way choice task after short social interaction. Lesser need for learning about novel signals in this experiment might indicate that dogs’ social skills are flexible enough to generalise from previous experience with humans and give rise to the notion that specific evolutionary (selective) processes might be associated with the emergence of such ‘flexibility’.

- In Experiment 4 we found that dogs have tendency to follow the UMOs’ indication in a food-choice task, even if it is clearly went against their preference. This indicates the possibility that social influencing can emerge between dogs and an UMO and support latter findings that social influencing may often be explained by relatively simple (but powerful) mechanisms in dogs.

- In Experiment 5 we showed that dogs are able to learn directional responses (i.e. go left/right) based on qualitatively different sound signals and they had no difficulties to generalise these sound signals to novel context where they faced with different target objects at different distances. Only the training angle between the target objects and the dog influenced dogs’ performance in the novel context.
Publications

Publications related to the thesis

Gergely, A., Petró, E., Topál, J., & Miklósi, Á. 2013. What are you or who are you? The emergence of social interaction between dog and an Unidentified Moving Object (UMO). PLoS ONE, 8, e72727. doi:10.1371/journal.pone.0072727.


Other publications


References


