Ethology 109, 809-821 (2003)

ISSN 0179--1613

Successful Application of Video-Projected Human Images for Signalling to Dogs

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Abstract

Dogs were tested (1) in a two-way choice experiment, where the experimenter indicated a baited bowl by pointing; and (2) in a task where the owner was asked to command the dog to execute simple obedience tasks. In expt l dogs (n = 10) were tested at first in the presence of the experimenter (three dimensional condition, 3D), that was followed by a series of pointing trials when the life-sized image of the experimenter was projected onto the wall by the means of a video-projector (two dimensional condition, 2D). Dogs performed correctly more often than expected by chance in both 3D and 2D conditions. In expt 2 the commanding owner was either present in the room (3D), or her/his image was projected on the screen (2D), or only her/his voice was audible for the dog through a speaker (OD). The performance of the dogs (n = 10) decreased to great extent comparing the 3D and OD condition, as the number of different actions the dogs obeyed was significantly less in the OD condition. However, there was no difference in the number of different actions obeyed in the 3D and 2D conditions. Our results show that dogs readily obey life-sized, interactive moving image in various communicative situtations. We suppose that the difference between 2D and 3D conditions can be attributed partially to the lack of some additional communicative signals as sounds (verbal cues) and odours (from the human), and to some changes in the context.

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Introduction

Animals are often confronted with some derivative of a natural stimulus in behavioural experiments (Csányi 1986; Bolhuis et al. 1990; Bovet & Vauclair 2000), e.g. stuffed specimens (e.g. Pongrácz & Altbäcker 2000), or schematic models of conspecifics or predators (e.g. Miklósi et al. 1995). According to the

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theory on sign (`key') stimulus a narrow set of natural releasers give the basis for the effectiveness of more complex stimuli (Tinbergen & Perdeck 1950; Baerends 1985; Curio 1993). The use of photographs, slides or video films is wide-spread in experimental work (for review see D'Eath 1998; Bovet & Vauclair 2000). Usually these investigations have bi-directional aims. First, researchers investigate whether a given species is able to recognize a picture, namely whether its behaviour toward a two dimensional (2D) image presented on a picture resembles its response to the `real' three dimensional (3D) object. Second, the presentation of pictures or videos provides means to a systematic manipulation of the stimulus to investigate separately the significance of different stimulus features (Dawkins 1996; Jitsumori et al. 1999). Naturally, this latter case presumes that the subject is able to recognize conspecfics depicted on picture, photopraphs or videos.

There is a rich collection of convincing experiments that tested the picture recognition ability in many species of a variety of taxons including invertebrates and vertebrates (Bovet & Vauclair 2000). However, the use of 2D images whether stationary (pictures) or dynamic (films, pre-recorded videos, or live on-line displays) presupposes some knowledge of the sensory abilities of the animal under study. In many (if not most) cases the perceived `Umwelt' of an animal differs in many ways from that of humans, and the uncritical application of methods and equipments designed for human `stimulation' could lead to misleading results (D'Eath 1998). For example, in a communicative context pictures and videos might lack one or more important sensory channels that are used in `real' 3D situations (e.g. sounds, smell), therefore the complexity of a communicative situation might present a limit for the use of some types of visual stimulation (Dawkins 1996).

We know only a single case where picture recognition of dogs was reported (Fox 1971). In this study life-sized paintings of conspecifics were presented to the subjects. The dogs showed explorative sniffing at body parts of the painted dog which corresponded to the areas of a `real' 3D conspecific to be sniffed in the case of an encounter. There has been no systematic research on how dogs react to video images, and only a minority of dogs is reported by the owners to `watch' TV.

Human and dog vision differs along several important characteristics (for a review see Miller & Murphy 1995). For example, having only two types of cones (dichromatic vision), dogs cannot distinguish between lights that appear to us as green, yellow-green, yellow or red (Neitz et al. 1989). Regarding the viewing of video images on television one of the most critical differences between human and dog vision lies in the sensitivity to flickering lights. The flicker fusion frequency of humans is in the range between 50 and 60 Hz (Hart 1992), in contrast, dogs are able to detect flickering at 70 or even 80 Hz. This means that video images projected on commercial TV monitors may appear as rapid flickering to dogs (Coile et al. 1989; Miller & Murphy 1995), and to some extent this may also explain why most dogs do not like to watch TV monitors. However, Fleishman & Endler (2000) noted that even an apparent flickering of the video images does not affect seriously the illusion of movement of the presentation. They and also Zeil (2000) place more emphasis on problems caused by the lack of three-dimensionality of video-presentations. Animals almost always judge the size of an object based on its distance, and they may conclude that the video-presented object is on the screen. Other than life-sized presentations may consequently cause serious errors in behavioural tests.

Recent studies on the dog human visual communication found that dogs readily rely on various human pointing gestures (Miklósi et al. 1998; Hare & Tomasello 1999; Soproni et al. 2001, 2002), however other studies suggested that dog-human communication involves many channels of information transfer (Warden & Warner 1928; Pongrácz et al. 2001). Therefore there is a need for a suitable method to investigate communicative interactions by handling the different communicatory channels (e.g. visual, auditory etc.) separately. Life-sized, interactive human video images could provide a useful method for controlling these variables. In this study we show that projecting video images on a large screen can be used to investigate dog-human communication.

General Materials and Methods

Subjects

Owners and their dogs were recruited from various dog-training schools in Budapest, Hungary. Only adult (at least 1.5-yr old) dogs participated.

Experimental Rooms and Apparatus

Two separate rooms served as experimental and acting places (see Fig. 1). The dogs stayed in the larger (3 m wide, 5 m long and 2.5 m high) room (ER: experimental room) for the trials. One of the shorter walls was covered with a white screen for the projected picture. The video-projector (NEC MT-850; NEC Viewtechnology Ltd., Tokyo, Japan) was placed in the opposite end of the room at 1.7 m high at an angle of 85°. The separate speaker unit was hidden behind the screen in middle position at a height of 1.7 m. A 0.6 m high wooden barrier was placed in front of the screen at its entire length, at a 0.8 m distance from it to prevent the dog from getting in contact with the screen. The dog and the persons (owners and the experimenters) involved in the experiments could enter and leave the room through a door situated near to the screen. A video camera (Panasonic W-CS 300/G; Matsushita Electric Ind. Co., Osaka, Japan) was mounted onto the ceiling opposite to the screen at the rear corner. This camera served for recording the experiments and additionally, for the acting person [in the acting room (AR), see below] to watch the dog's behaviour on line.

The AR was a non-adjacent room on the other side of a corridor (2 m wide, 2 m long and 2.5 m high). A beige coloured screen was stretched behind the acting person who was standing 2.5 m in front of a video camera (Panasonic RX20) that transferred the actor's visual and acoustic signals via the video-projector and the speaker onto the screen in the ER. The actor could watch the ongoing events in the ER on a small TV monitor.

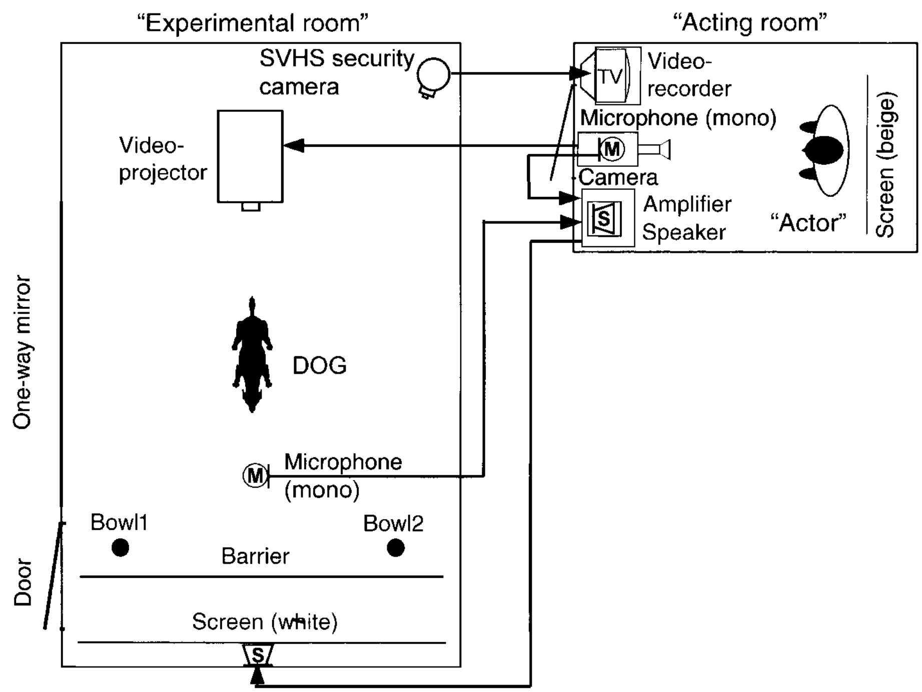

Fig. 1: Drawing of the experimental room and the action room. The drawing shows the actual scale and also the actual position of the rooms in relation to each other. Other observers could watch the tests through the one-way mirrors. S = speaker, TV = monitor, M = microphone

The video-projector in the ER and the camera in the AR were positioned in such a way that a standing person in the AR was projected onto the screen in real size and `standing' on the floor. The exact place for appearing in this position on the screen was marked on the floor of the AR.

Experiment 1

Here we investigated whether human pointing can serve as a signal for the dog when projected onto the screen. Signaling the place of hidden food in a choice task was successfully used in many previous studies (e.g. Miklósi et al. 1998; Soproni et al. 2001, 2002). Ten dogs participated in this experiment [German shepherd (two), golden retriever (two), Tervueren (two), Border collie (one), Hungarian vizsla (one), Irish wolfhound (one), mudi (one)]. Each dog was given at first a 3D series (2+ 10 trials) when the pointing person was present in the ER; and after it a 2D series (10 trials) when the pointing person was signaling in the AR and the dog could watch him via the projector only. We chose this fixed order of conditions, because we hypothesized that the 2D condition would be harder for the dogs and wanted to familiarize them with the experimental situation at first in the simpler 3D session.

Three Dimensional Session

A familiar experimenter pointed in each trial, while the owner was keeping the dog on the starting line (see Fig. 1). The experimenter stood in mid-position, behind the barrier, in front of the screen. Two round brown plastic pots (0.25 m high and 0.2 m in diameter) were placed in front of the barrier on the floor, with 2 m distance between them. A piece of dry dog-chow was hidden permanently between the double bottoms of each pot to prevent the dogs from finding the food via olfactory cues (see also Miklósi et al. 1998). Another small piece of dry dog food was hidden in a pre-determined semi-random manner (the same pot was not baited more than two times in a row) by the experimenter into one of the pots, while the owner covered the eyes of the dog with her/his hands. The dog and the owner stayed at the starting line, 2 m far from the pots. During the experiment, the video-projector was on, projecting the picture of the empty AR onto the screen.

The first two trials served for habituating the dog to the situation. Here, the owner didn't cover the eyes of the dog while experimenter was placing visibly a piece of food into one of the pots. We performed ten trials subsequently, where the owner had to cover the eyes of the dog while the experimenter executed the hiding process. Before each trial the experimenter left the room for a piece of food (opened and closed the door on the left side of the screen), and then he returned within 10 s and hid the food. After the hiding, experimenter told the owner that she/he is allowed to uncover the eyes of the dog. The experimenter waited for catching the dog's gaze (he might have said the dog's name or a phrase like `Watch me!') and pointed with straight arm and pointing finger for 1-2 s toward the pot containing the bait. Pointing was always done with arm near to the baited pot. The owner released the dog just after the experimenter finished the pointing by lowering his arm to the resting position at his body. We considered the dog's choice correct if it approached the indicated pot at first. Dogs that chose correctly were allowed to eat the reward and were praised by both the owner and the experimenter. 1f the dog missed the baited pot, the owner caught it quickly, preventing it from visiting the other pot.

Two Dimensional Session

Having finished the 3D trials, the owner and the dog left the ER for a short period of 5-10 min. During this time the experimenter went to the AR, and the experimental trials have been resumed. The owner positioned him/herself and the dog at the starting line. The video-projector was continuously on. This time an assistant did the baiting, while the owner covered the eyes of the dog during the hiding. After the assistant left the ER, in the AR the experimenter stepped from the left side into the scope of the camera that provided the picture for the projector. The experimenter positioned himself into mid position in relation to the projected picture, and tried to catch the attention of the dog. Owners were asked to help the dog to watch into the right direction if necessary (however this was only necessary in the first few trials). Pointing was done as described above. The corresponding position of the pots in the ER was marked on the floor of the AR. Immediately after the pointing gesture the owner released the dog, allowing it to visit one of the pots. After the dog had chosen one of the pots, the experimenter left the AR disappearing from the screen. Dogs were tested in ten 2D trials.

Both sessions were recorded on video and have been analysed later. The number of correct choices in both the 3D and the 2D sessions was used as indication of the dogs' performance. Additionally, we measured the time elapsed between the pointing gesture and the dog getting to one of the pots (`latency'). For comparison the individual mean latencies were used.

Results and Discussion

The number of correct choices was significantly over the chance level (50%) in six of 10 dogs both in the 3D and 2D conditions (Binomial tests, significance at $p < 0.05$ was attained, if at least nine of 10 choices of a dog were correct). Wilcoxon matched-pairs signed-ranks test did not show a significant difference between the performances of the dogs in the two conditions ($Z = -1.19$; $p = 0.23$). The latencies of reaching the pots did not differ significantly in the two conditions (only latencies of the correct choices were taken into account, because in the case of wrong choices the dog was prevented by the owner's command to reach the pot), paired t-test, $t = 1.18$, $df = 9$, $p = 0.27$.

Dogs did not seem to be disturbed by the change in the procedure. They responded similarly to the projected image of the experimenter pointing to the pots as if he were present in the room. These results showed that dogs trained in the presence of the experimenter performed the learnt task subsequently with similar success when the same instructor was displayed via video projector. We should note, however, that according to our previous results (Miklósi et al. 1998; Soproni et al. 2001) dogs learn very little during simple pointing tests. We examined the dogs' performance at the start and at the end of each condition, (3D and 2D, respectively) by comparing the number of their correct choices in the first and last three trials within a condition. Again, there was no significant difference in any of the conditions (Wilcoxon matched-pairs signed-ranks test: 3D: $Z = -0.38$; $p = 0.71$; 2D: $Z = -0.45$; $p = 0.67$). This suggests that adult pet dogs tend to react correctly to human pointing gestures without previous training. Therefore it is unlikely that our subjects did learn to follow the pointing during the 3D session, however by this initial exposure they became accustomed to the experimental situation and to the presence of the experimenter. In conclusion, we showed that dogs can utilize the video-projected, life-sized image of a pointing human in a simple communicative situation based mainly on visual cues.

Experiment 2

In this experiment we investigated the effect of video-projected humans on executing behavioural actions on commands by the dog. We compared the efficiency of the projected image (`2D condition') with both the efficiency when the owner giving the commands was present in the room (`3D condition') and when the commands were only audible through a speaker without the presence of the owner (`OD condition').

Ten dogs participated in this experiment, which were different to the ones in expt 1 [border collie (four), mudi (two), cocker spaniel (one), German shepherd (one), mixed breed (one), Tervueren (one)]. We have chosen only such animals that have been reported by the owner to perform at least four kinds of different actions on verbal command. The chosen actions were listed on a paper and the owner had to command the dog in this fixed pre-determined order, three times successively. Additionally, we instructed the owners to repeat a given command for a maximum of three times if the dog was not obeying. (The action `Come!' was forbidden because we wanted to avoid the dog getting in contact with the owner's image on the screen.) The sessions of all conditions lasted for about 2-3 min depending on the dog's readiness to respond to the commands. As far as possible the order of the conditions was balanced among the dogs (N in the parentheses): 3D-2D-OD (three dogs); OD-3D-2D (three dogs); 2D-OD-3D (four dogs). There was a 5-10 min short pause between the sessions.

Three Dimensional Condition

Only the owner and the dog were in the ER. The projector was on, projecting the picture of the empty AR onto the screen. The owner was standing behind the barrier, in mid-position, and she/he was asked to encourage the dog to obey the verbal command given in fixed order.

Two Dimensional Condition

This trial started as soon as the owner went across to the AR, and entered the scope of the camera calling upon the dog. At the beginning the owner tried to get the attention of the dog then the owner uttered the commands in the same manner and same order as in the other conditions. At the end of the session the owner returned to the dog.

Zero Dimensional Condition

The owner commanded the dog from the AR, but now the objective of the camera was covered by a translucent lens-cap. Thus the screen was lit, but empty in the ER. The owner could see the actions of the dog via the monitor and the dog heard her/his voice through the speaker. The owner used the same list of commands as in the two other conditions.

All sessions were video recorded, and analysed later. We measured the following variables: the number and the type of the commands given by the owner; the number and type of the actions performed correctly by the dog during the trials. We calculated an obedience score separately for each type of action, dividing the number of perfectly executed actions with the number of commands. The maximum of the obedience score was 1 if all commands were obeyed instantly (i.e. on the first command uttered).

Results and Discussion

Table 1 shows the variety of the commands used by the owners, and the occurrence of the corresponding actions executed by the dogs. For further analysis, we used only the first four commands (and their corresponding actions), which were used by all the 10 owners. Table 2 shows the average numbers of the four most common commands and the elicited actions in the dogs. Owners were asked to command their dogs three consecutive sessions of the same set of commands, and in the case of the dogs' disobedience owners were allowed to repeat the given command three times only, thus the maximum occurrence of a command was nine. From the same reason, a dog could perform a given action three times as maximum. First we analysed whether the type and the order of conditions had any effect on the pooled obedience scores of the four most common actions in the different group of dogs (mixed ANOVA with the type of conditions as repeated factor). The type of condition had a strong significant effect on the obedience scores, $F(1,37) = 24.89$; $p < 0.001$. In contrast neither the

Table 1: The commands that owners used in experiment 2

	No. of dogs where the command was uttered			No. of dogs that obeyed the command at least once		
Command	0D	2D	3D	0D	2D	3D
Sit down!	10	10	10	4	8	10
Bark!	10	10	10	5	9	9
Fetch the ball!	10	10	10	4	10	10
Lay down!	10	10	10	4	9	10
Up!	2	2	0	2	2	0
Release the ball!	1	0	5	1	0	5
Shut up!	0	1	2	0	1	2

Table 2: Average total number of the four most common commands and of elicited actions of the dogs

	0D		2D		3D	
	Command	Action	Command	Action	Command	Action
Sit down!	7.6	0.6	7.5	1.1	5.2	3
Bark!	7.5	1.2	5.3	2.6	4.1	2.7
Fetch the ball!	8.6	0.6	6.9	2.6	4.3	3
Lay down!	7.7	0.5	6.8	1.4	4.2	2.9

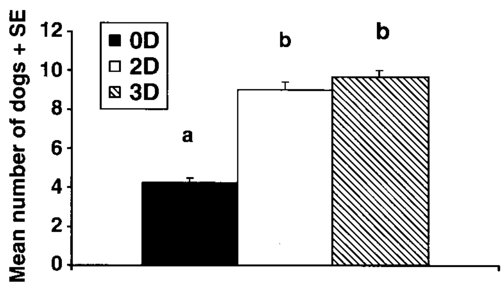

Fig. 2. The mean number (+ SE) of dogs that executed all the four most common commands at least once in the three experimental conditions. Conditions differing significantly are labelled with different letters (Student-Newman-Keuls post hoc test, $p < 0.05$)

order of conditions, $F(2,37) = 0.39$; $p = 0.68$, nor the interaction between the two factors proved to be significant, $F(2,37) = 0.10$; $p = 0.91$.

The experimental conditions affected strongly the number of dogs that obeyed the four most common commands [Table 1, ANOVA for repeated measures, $F(2,6) = 75.35$; $p < 0.001$]. Student-Newman-Keuls post hoc tests showed that significantly more dogs performed all the four actions (at least once) in the 2D and the 3D conditions, than in the OD condition (Table 1 and Fig. 2).

We analysed the overall number of the four commands and the overall number of the corresponding actions in the three conditions. Both variables showed strong effect of conditions [ANOVA for repeated measures: number of commands: $F(2,78) = 24.70$; $p < 0.001$; number of actions: $F(2,78) = 41.74$; $p < 0.001$]. Student Newman-Keuls post hoc tests showed that owners gave significantly more commands in the OD condition than in 2D and 3D, and there were slightly more commands in the 2D condition than in the 3D. Contrary to this, dogs performed the least correct actions in the OD condition, more in 2D, and the highest number of correct actions occurred in the 3D condition (Table 2). Consequently, the pooled obedience scores gave a similar result for the four commands [ANOVA with repeated measures, $F(2,78) = 75.48$; $p < 0.001$]. Dogs were the most obedient in the 3D condition, they obeyed to a lesser extent in 2D condition, whilst dogs disobeyed mostly in the OD condition.

We compared the obedience scores of the four most common actions within different conditions. There was no significant difference in the performance of dogs [ANOVA with repeated measures, OD condition: $F(3,27) = 2.27$; $p = 0.10$; 2D condition: $F(3,27) = 2.37$; $p = 0.09$; 3D condition: $F(3,27) = 0.52$; $p = 0.67$]. In the 2D condition dogs seemed to obey most frequently to the `Bark!' command but this difference did not reach the level of significance.

We also analysed the obedience scores of the four most common actions separately (Fig. 3). The different conditions affected significantly the obedience scores in the case of all commands. [ANOVA with repeated measures: `Sit down!' $F(2,18) = 11.24$; $p < 0.001$; `Lay down!' $F(2,18) = 44.25$; $p < 0.001$; `Bark!' $F(2,18) = 8.92$; $p < 0.01$; `Fetch the ball!' $F(2,18) = 50.23$; $p < 0.001$.]

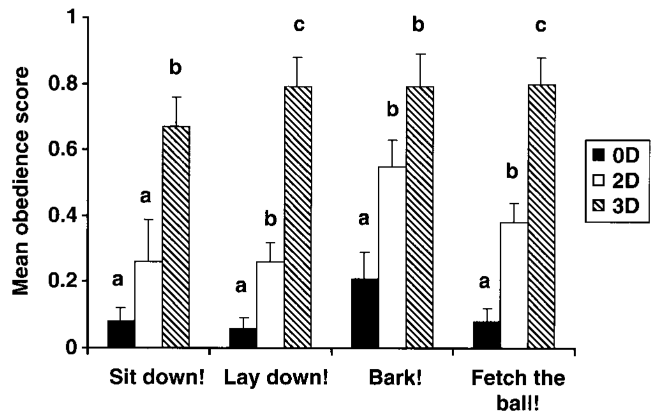

Fig. 3: The mean obedience scores (number of actions of the dogs/number of commands given by the owners; + SE) in the case of the four most common commands. Significantly differing conditions within a given action are labelled with different letters (Student-Newman-Keuls post hoc test, $p < 0.05$)

Student-Newman-Keuls post hoc test showed that obedience scores were the highest in the 3D condition and the lowest in the OD condition. Obedience of the dogs in the 2D condition was between the levels of OD and 3D conditions with the exception of their response to the `Bark!' command, because this command was obeyed with equal frequency in both 2D and 3D conditions, and to the `Sit down!' command that showed no significant difference between 2D and OD conditions.

The results of this experiment showed that although the owners tried to encourage their dogs with more commands in the OD condition, their verbal utterances were less effective than when paired with the projected image or the presence of the owner. There was no significant difference between the number of dogs performing the four most common actions at least once in the 2D and the 3D condition (Table 1), which suggests that life-sized, interactive projected image of the owner, might be a useful tool in situations where the separation of the human and the subject is important. The verbal commands alone (OD condition) elicited poor obedience from the dogs, this may indicate that such a situation is very strange for the dogs, i.e. owners do not use to command their pet-dogs from an invisible place. If we had tested dogs selected or trained for working via acoustic signals (e.g. specific hunting dogs, or rescue dogs), the results in OD condition may have been better.

Nevertheless the general efficiency of commands and the results of the four most common commands showed uniformly that dogs performed with higher reliability in the 3D condition than in the 2D condition. At present we cannot rule out that weaker visibility and the purer voice-quality in the 2D condition contributed to this result. However, there is an alternative hypothesis if we consider the observation that obedience scores for the `Bark!' command remained unchanged in 3D and 2D conditions. Most owners require the dog to perform the actions in a given context with a specific spatial relationship to themselves. The `Bark!' command is probably the only one that does not require a specific posture, and this could be the reason for the higher obedience to for this command in the 2D condition. Further, it has been often reported that many dogs bark in stressful, confusing situations (Lund & Jorgensen 1999; Overall et al. 2001); therefore the strange context of the experimental situation could also facilitate the barking vocalization. Overall, the results showed that verbal commands on their own have little effect on the obedience behaviour of dogs; nevertheless the physical presence of the owner has an additional effect in comparison with the mere video projected picture.

General Discussion

We have found that dogs (1) with previous experience of an instructor's pointing gestures, chose successfully relying on the same signals of a 213, life-sized projected image of the same instructor. (2) Owners could command their dogs to obey simple tasks via the video-projector, and dogs' overall performance was only slightly poorer in this condition, than in the real, 3D situation. (3) Verbal commands without the visual presence of the owner had only a marginal effect on the behaviour of dogs.

An early report (Warden & Warner 1928) on verbal understanding abilities of dogs noted that a wide range of the auditory (including verbal) and visual (and also olfactory) cues present the natural context for a communicative situation between human and the dog. At this stage we can only say that video-projected, interactive image of a commanding human could elicit comparable reaction from a dog as a person present would do, and more work is needed to examine the separate role of the acoustic and the visual (and olfactory) components in such communicative interactions. It is also obvious that the two tasks presented here are different to some extent. In expt 1 dogs were tested in a situation, which had a beneficial outcome for them. The pointing gesture of the human could also be interpreted as a `releasing stimulus' for the dog `restrained' in a choice situation. In contrast, for most dogs it gives `little pleasure' to obey repeatedly the commands of the owner. An additional explanation for the better performance in the 2D condition of expt 1 could be that the `penalty' (not getting the food) experienced by the dogs after incorrect choice contributed to their higher success. 2D and 3D trials do not differ from this aspect in expt 1, but they do somehow in expt 2. All dogs should have had the experience that punishment is most likely if the owner is present or close by. Probably some dogs in the 2D condition of expt 2 have sensed that the owner was actually not present in the room. First, there was no olfactory cue coming from the owner, second we could not control for the quality of the auditory stimulus, thus it is likely that the dogs noticed minor changes in the owners voice. Additionally, dogs could have noticed the change in the owner's `form' (missing the third dimension), and the changes in the relation between the owner's body and the actual environment they were in. These differences might have caused that most dogs performed best, if the owner was there (3D condition), thus `punishment' was most likely.

Dog trainers report often that it is more difficult to command the dog from a greater distance, an observation that might have similar cause. It cannot be excluded that owners also behaved differently in the two situations, although based on our measurements we have found no indication of this. However, given the dog's flexible learning abilities there is no doubt that with little additional training dogs could learn to respond obediently in all three different conditions.

In summary, interactive projected image of a person could be a viable alternative in the experimental work with dogs. In agreement with other reports on the advantages of moving pictures over the still, less natural photographs and slides (D'Eath 1998), life-sized video-projected materials provide us further means to manipulations of the environmental context of communicative situations or other situations of information transfer. Video-projected pictures lack the shortcomings of a TV-screen (small size and uncomfortable placement), but share the advantages of movement, possibility for interaction and almost-natural placement (i.e. one of the walls of the ER). Dogs seemed to be able to perceive inevitably the pictures of a human and follow the signals of her/him. Seemingly, the dogs did not uncover the 'trick, as they did not start to ignore the communicative or signaling attempts of the projected person. In subsequent studies we want to use this technique for investigating the role of direct social interaction in dog-human communication [for further studies on the nature of primary and secondary mental representations in animals see Pepperberg et al. 1999 (in grey parrots, Psittacus erithacus), and Suddendorf & Whiten 2001 (in dogs)).

Acknowledgements

The authors are grateful for the collaboration of the Center for Educational Technology of Eötvös University, Budapest, as well as for István Borbély, Sándor Pribill, Gabriella Scher and the Hungarian Foundation for the Rescue Dogs for their participation in the tests. Katalin Timár-Geng gave her devoted assistance to the experimental work. We are also grateful to Márta Gácsi for her help in designing the tests and comments on earlier versions of the manuscript. The OTKA (T0229709) and Ministry of Education (FKFP-0127/2001) grant this study.

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Received: August 10, 2002

Initial acceptance: April 14, 2003

Final acceptance. June 13, 2003 (M. Taborsky)