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Co-operative interactions between blind persons and their dogs

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Abstract

In two studies, we have investigated the co-operative behaviour between dogs and their owners. We supposed that co-operative behaviour is an inherited trait in dogs, and is a major contributing factor in the development of successful guide dog performance. According to our view, leading a blind person involves complex behaviour where success depends on the ability of the participants to synchronise their actions. In Study I, we observed both British and Hungarian blind owners taking a half-hour walk in their neighbourhood. In Study II, both guide dogs with their blind and pet dogs with their blind-folded owners had to master an obstacle course. Measuring the frequency of initiations of various actions during leading their owners, dogs did not keep the role of the initiator to themselves. However, both dogs and humans were found to initiate more often in some types of actions, for example, guide dogs initialised avoidance or stepping up more often than their owners. Further, the role of the initiator was kept only for short durations, longer sequences of initialising were rare.

Despite many differences among groups studied, we observed some qualitative similarities in the co-operative behaviour of dogs. We assume that during domestication, dogs have been selected for the ability to change to-and-fro the role of the initiator that seems to be fundamental in this type of co-operation. In the case of leading the blind, information should not only be provided but also accepted by both parties in the course of the joint actions, therefore, the leadership (the role of the initiator) may vary form one action to the next. © 2001 Elsevier Science B.V. All rights reserved.

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1. Introduction

The study of co-operation in animals has taken an interesting course in recent years. With the rise of behavioural ecology, co-operation has been viewed mainly as a means of

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gaining either short- or long-term benefits for interacting individuals. In a recent review, Dugatkin (1997) gives a detailed account of many such co-operative interactions ranging from intraspecific cleaning in fishes to co-operative hunting in lions and alloparental helping in birds. The invention of game theoretical and other mathematical models have also promoted the understanding of the function of co-operation at the population level.

In recent years there is a renewed interest in investigating the behaviour mechanisms that enable or inhibit the manifestation of co-operative actions between individuals (e.g. Schuster et al., 1993; Chalmeau, 1994; Tebbich et al., 1996). Boesch and Boesch (1989) defined co-operation "as individuals acting together to achieve a common goal". This aspect of animal co-operation has received much less attention since both field and laboratory studies are difficult to carry out.

In 1989, Boesch and Boesch introduced four dimensions for analysing co-operation. According to the similarity or dissimilarity of actions of individuals, and their orientation and relation in space and time, the authors categorised co-operative actions of group hunting chimpanzees (*Pan troglodytes*). Later, this scheme was also used by Chalmeau and Gallo (1996) to categorise co-operative interactions observed in laboratory experiments. However, both accounts seem to be too narrow to be applied to diverse species, and the theoretical perspective of co-operation has to be broadened. Incorporating some categories invented and defined originally by Boesch and Boesch (1989) and Chalmeau and Gallo (1996), we propose that co-operative interactions should be categorised along three independent dimensions: similarity of the behaviour actions performed (congruence: 1), the timing (synchrony: 2), and the spatial relationship of the co-acting animals (spatial co-ordination: 3).

Congruence in co-operation can be defined as the interactants performing similar or dissimilar behaviours in their joint action. Synchrony describes whether the two actions are performed in parallel, or sequentially (are non-simultaneous), i.e. the two individuals act at the same time or the action by one individual is followed by an action of the other (see also Chalmeau and Gallo, 1996). Whether the co-operative actions are co-ordinated in space and/or are performed independently is also a useful indicator. By definition, co-ordinated actions might be executed while being in close spatial proximity (i.e. within the individuals range; (homospheric) or when individuals move off from each other (heterospheric). Using these parameters, co-operative actions in various species can be easily classified and compared to each other. It should be noted that this descriptive categorisation does not refer to or explain any involvement of intention and/or communication that are often regarded as important components of co-operative actions. (e.g. see Chalmeau and Gallo, 1996). Those factors should be given consideration separately, and if necessary their existence or absence should be proved by independent measures, observations or other evidence. For example, consider the fire making activity of humans that consists of a series of actions which can be also performed in co-operating dyads. Whilst one is collecting dry wood in the woods and at the same time the other is clearing up the ground for the place of the fire. This co-operation can be described as non-congruent (dissimilar actions aiming at the same final goal), simultaneous (executed in parallel) and heterospheric (performed in different parts of space). Some co-operative hunts in wolves (*Canis lupus*) involve part of the pack to chase the prey (i.e. reindeer, *Rangifer tarandus*) while others break away in order to overtake the prey and try to block its escape route (Mech, 1970). In similar vein, this co-operative action can be characterised as being non-congruent, simultaneous and heterospheric. Other accounts on wolf hunt report that pack member alternately chase the prey which would be described as consisting of congruent, sequential and homospheric actions (see also Sharp, 1978).

According to Boesch and Boesch (1989), co-acting individuals should achieve a common goal. We should, however, distinguish whether their action is aimed at their goal directly (chasing the prey, or pushing a handle, etc.) or whether they act indirectly, for example, by manipulating their social companions. There are many reports that in laboratory setting dominant animals enforce co-operation of submissives by aggression towards them. This also raises the question to what extent the aggressive behaviour of the dominant and the enforced behaviour on the part of the submissive can be regarded as co-operative. For example, Tebbich et al. (1996) showed that pairs of keas (*Nestor notabilis*) can learn to manipulate a seesaw by one individual sitting on the handle whilst the other (mainly the dominant) obtains the food. Dominant keas might have learnt that a kea on the handle "means" they can get food, and their aggressive behaviour toward their companion was aimed at forcing them to sit on the handle. The submissive kea might have learnt that the handle is a safe place from the attacks of their dominant companions, etc. and this explanation leaves little room for an interpretation as being a complex co-operative interaction.

Strong dominance hierarchy can inhibit the emergence of co-operative actions. For example, in the Tonkean macaques (*Macaca tonkeana*) researchers observed more co-operative actions than in the Rhesus macaques (*M. mulatta*), and this difference seemed to be related to the hierarchical structures of these species (Petit et al., 1992). Tonkean macaques have a more relaxed dominance structure and animals show higher levels of interindividual tolerance which is necessary for co-operation that involve 'homospheric' actions (see above), for example, lifting a heavy stone by two individuals (Petit et al., 1992, see also Schuster et al., 1993). These and other similar observations (see Chalmeau and Gallo, 1996) underline that many forms of co-operation can only emerge if there is a flexible dominance hierarchy and/or there is some form of attachment between individuals in the group.

Although laboratory settings offer a good opportunity for making detailed observations, demonstration of co-operation in these circumstances has many constrains. We sought a different system where the co-operative interaction between individuals can be observed under more natural circumstances.

Co-operative interaction between humans and their dogs have been taken for granted among both dog owners and the layman, and many still believe that dogs were originally domesticated to assist our ancestors in their hunting ventures. Although this turned out not to be the case (see Vilá et al., 1997), today many dog breeds display complex co-operative actions while helping their human companions in herding or hunting, and dogs proved to be extremely useful in assisting people who lost their sight or are disabled (e.g. Pfaffenberger et al., 1979). Johnston (1990) notes that leading a blind person is "perhaps the most demanding work the human being asks of any animal" (p. 1).

In our view, dogs present an obvious choice for investigating co-operation since their wolf ancestors are also credited with many co-operative behaviours (see Mech, 1970; Peters and Mech, 1975), but dogs have also a long history of domestication in course of which an unconscious selection for animals with enhanced co-operative abilities can be assumed (Ginsburg and Hiestand, 1991). It is also widely assumed that the dogs' ability to co-operate is closely related to their affiliative (e.g. Topál et al., 1998) and communicative (e.g. Miklósi et al., 1998) behaviours toward humans. Interestingly, however, there are no recent studies that have investigated co-operative abilities in dogs, and to our knowledge this study is the first which gives a detailed description on how dogs guide their blind owners.

2. Study I

In this study, we have observed how well-trained dogs with different training history lead their blind owners. The guide dog training is a long process during which dogs are generally being trained (among others) to (1) walk in a straight line in the centre of the pavement unless there is an obstacle, (2) not to turn corners unless told to do so, (3) stop at kerbs and wait for a command to cross the road, or turn left or right, (3) to judge height and width so that the owner does not bump his/her head, (4) how to deal with traffic (for details see Johnston, 1990).

Guide dogs for the blind are trained throughout the world but there are many differences in the training methods applied, obedience requirements, puppy raising, choice of breed, etc. In this study, we wanted to see whether these differences affect the co-operative behaviour that is necessary for successful performance. British (trained by the Guide Dogs for the Blind Association, GDBA) and Hungarian (trained by the Hungarian Guide Dog School, HGDS) guide dogs for the blind are trained in a very different manner (see Table 1). (There are many historical and economical reasons for this that are not the subject of this study.) As it can be seen there are many dissimilarities not only in the technical details of the training program itself but also how the behaviour of the dogs is shaped. The present study presents data of dogs and their owners of the British and Hungarian training school. Anyone can notice that on program-level, the behaviour of the two groups chosen for observation differs considerably. The aim of this study was to investigate whether there is influence of these differences on the behaviour pattern of the guide dog dyads in the action-level. We tried to answer the question, how the co-operation between the participants of the guide dog dyads works by observing which member of the dyad initialises the actions.

2.1. Methods

2.1.1. Subjects

Twenty British blind persons, 8 males (mean age: 53.9 years; range: 37–75 years) and 12 females (mean age: 52.1 years; range: 30–72 years) took part in this study voluntarily. The behaviour of the dyad was observed on a day when they were visited on a regular aftercare visit by an instructor of the GDBA accompanied by Sz. Naderi. There were no preconditions for taking part in this experiment but the blind person had to own his/her dog for at least 1 year.

Guide dogs for the blind were retrievers (labrador ($n = 7$), yellow labrador ($n = 3$), golden retrievers ($n = 3$)) or cross between labrador retriever and golden retrievers ($n = 4$), furthermore, one blind person owned a cross between a collie and a retriever,

Table 1
Important differences between the training programs for guide dogs in Britain and Hungary

	Britain	Hungary
Number of training centres	>15	1
Number of trained dogs per year (approximately)	750	20
Number of breeding bitches	250	6
Breeds	Labrador, labrador retriever cross (95%)	Labrador retriever (45%)
Puppy walking period	6 weeks–1 year	10 weeks–1 year
Technical		
Stick	Not used with dogs	Are used with dogs
Harness	Rigid metal	Soft leader
Training		
Number of instructors per dog	>1	1
Place of training	On the streets and some exercises with obstacles	Specially designed obstacle course followed by practice on the streets
Training equipment	No	Cart that replaces the blind at the beginning of the training
Indication of kerb	Sitting	Stopping/standing
Turning	Only rightward turns (1/4 or 3/4)	Both leftward and rightward turns
Signalling by the owner	Verbal and visual (hand and leg) signals	Only verbal signals
Recipient class	4 weeks	2 weeks
Aftercare	At least once per year	Only if needed

another a cross between a poodle and a retriever. There was one German shepherd in the group. The mean age of the dogs was 67.1 months (S.E. = 8.3), range 24–120 months. There were 10 male and 10 female dogs in the sample.

Fourteen Hungarian guide dog owners living in the capital city, seven males (mean age: 44 years; range: 23–70 years); and seven females (mean age: 29.8 years; range: 19–45 years), were observed. They were chosen randomly from the list provided by the HGDS. Nine Hungarian blind persons owned a German shepherd, four labrador retrievers and one Airedale terrier was also included in this sample. The mean age of the 3 male and 11 female dogs was 69.2 months (S.E. = 9.5), range 30–120 months.

The level of blindness was assessed via a questionnaire. Three categories were used: (1) limited peripheral or central vision; (2) some ability to discern light and/or shape; (3) totally blind. Only one blind person with peripheral or central vision was in each sample. Six totally blind persons were observed in the British sample, the remaining 13 persons reported to have the ability to discern some light. All persons but one were was totally blind in the Hungarian sample.

2.1.2. Study sites and dates

The blind persons were asked to take a walk on a familiar route near to their home. British blind persons were tested in suburban areas of their towns of residence (Blackburn, Barrow-In-Furness, Ulverston, Blackpool, Bolton, Colne, Burney, Caldbeck, Morecambe, Grimsargh, Cheltenham, Redruth, Camborene) between September and October 1996.

All observations on the Hungarian sample took place in Budapest. The Hungarian dyads were observed between May 1994 and June 1995.

2.1.3. Procedure

All observations were done by Sz. Naderi who visited the prospective participants. The guide dog owner was asked to take an approximately 30–60 min long walk on a familiar route. The observer and a cameraman (in Hungary) and an instructor and the observer (in Britain) followed the blind person. The walk was recorded on video. The blind persons were aware of being observed. No other observers were present, and any interaction with the blind person or the dog had been avoided during the time of recording. The video recordings were analysed later.

The main aim of our analysis was to determine whether the dog or the owner was initiating a joint action (see below for the definitions of actions), and for this reason the video record of the walks was analysed frame by frame. Blind persons initiated actions by movement or talking (e.g. verbal commands), dogs initiated always by movements. The party who first performed the action was considered the initiator. The analysis was performed in two steps. First, by viewing the tape at normal speed it was determined what kind of actions had been taken by the dyad, then a frame by frame analysis determined which of the parties was the first to initiate the action.

After many hours of preliminary observations on how blind persons walk with their dogs, the following categories of actions had been determined and used in the present analysis. These categories were chosen on the basis that they are relatively easy to observe and they occur at a relatively high frequency during the walks.

Starting: Any locomotion in any direction from a standing position.

Stopping: Attainment of firm motionlessness that lasts for at least 2 s.

Avoidance: Change of less than 90° in direction of locomotion that is followed by a similar change in the opposite direction. The manoeuvre should be executed to avert the collision with objects or persons.

Turning: Change of approximately 90° in walking direction that results in prolonged change of the walking.

Stepping down: Locomotion resulting in the continuation of the walk on a lower level (at least 5 cm), e.g. at stairs or at kerbs.

Stepping up: Locomotion that resulting in the continuation of the walk on a higher level (at least 5 cm), e.g. at stairs or at kerbs.

Slowing down: Visible decrease in the speed of walking.

2.1.4. Definition of errors

Errors were noted if the joint action fell apart because (1) the dog did not obey a command, (2) the partners moved in opposite directions, so they were pulling each other, the owner (3) stumbled over or (4) hit an obstacle that was not signalled by the dog.

2.1.5. Data analysis

For statistical analysis, the relative frequencies of initiations for each category of behaviour actions were calculated. Since most of the data could not be fitted on a normal distribution, non-parametrical statistical tests were applied. The comparison of guide dogs and their respective blind owners was achieved by the Wilcoxon matched pair test (W). For each group the relative frequency of actions was compared by the non-parametric Friedman ANOVA that was combined with a post hoc Dunn's test calculating significant differences among groups ($P < 0.05$).

The relative contribution by one member of the dyad to the initialisations in a given type of action was calculated by an "initialisation index" (INI): index = ((number of initialisation by the owner) − (number of initialisation by the dog))/total number of actions. Negative values of INI suggest that dogs initiated that given action on more occasions than the human, whilst positive values show the reverse tendency. The significant deviation from the hypothesised 100% of actions initiated by the dog (i.e. INI $= -1$) was tested by one sample *t*-tests.

The length of sequences of actions in which the same party was the initiator was also noted. "Sequences" of one unit length indicated that the role of the initiator changed after one action. Sequences of two units indicated that the same party initiated two subsequent actions (which might have been actions of the same category or different category) that was followed by an action initiated by the other member of the dyad. According to their length, sequences were divided in six categories; sequences of six or more initiations were pulled together forming one category.

Three dyads of the Hungarian sample were also coded by another observer. Index of concordance was calculated for each behavioural category (see Table 2).

2.1.6. Results

We could not design two matched samples for this study for objective reasons, so our subjects at the two training centres differed in many aspects regarding dog breed, sex, age, etc. Thus, we avoided direct statistical comparisons between the English and Hungarian guide dogs and their owners, and restricted ourselves to a descriptive analysis in both cases. The results of the two observers are given in Table 2, showing high level of agreement. For the statistical analysis observations by Sz. Naderi were used.

There were significant differences among the various action frequencies (Friedman ANOVA: $\chi^2 = 111.88$; $P < 0.01$) performed by British owners. The initialisation of starting, stopping and turning were most frequent in comparison to avoiding, stepping up and down, and slowing down. To some extent, dogs displayed a reverse order of

Table 2
Index of concordance between two observers for describing the behaviour of three Hungarian dyads in Study I

Starting	0.66
Stopping	0.97
Avoiding	0.89
Turning	0.85
Stepping down	1.00
Stepping up	1.00
Slowing down	0.85
Total	0.87
Initialisations by the dog	0.89
Initialisations by the owner	0.87

differences in their initialisation frequencies ($\chi^2 = 74.35$, $P < 0.01$). In dogs stopping and stepping up and down dominated, but their also performed avoiding and turning, however, starting and slowing down was however, observed infrequently (Figs. 1 and 2).

A similar pattern emerged with the Hungarian owners ($\chi^2 = 62.21$, $P < 0.01$). They performed initialisation of starting, stopping and turning most often, followed by stepping down, whilst avoiding, stepping up and slowing down was relatively rare.

Dogs in the Hungarian group also differed in the initialisation frequencies of various actions ($\chi^2 = 31.71$, $P < 0.01$). Stopping and turning were most frequent, avoidance, stepping up, and slowing down showed lower levels, starting and slowing down was observed infrequently.

Both groups committed errors with similar frequencies (British group: 0.16 ± 0.04; Hungarian group 0.19 ± 0.03).

Next, we determined whether there was a bias within the samples in the frequency of initiations for a given category of actions. Fig. 2 shows the data for individual dyads of the Hungarian group as well as the means for both the British and Hungarian groups. The individual data have indicated that there were no extreme differences, and combining all actions the amount of initialisation by the dogs varied between 40 and 80%.

Analysing the different actions (Fig. 3), we found that in both groups starting was initialised more often by the blind persons than expected (British sample: $t = 192.1$, $P < 0.01$; Hungarian sample: $t = 16.1$, $P < 0.01$). Similarly, in both groups stopping was initialised often by the owners (British sample: $t = 5.76$, $P < 0.01$; Hungarian sample: $t = 8.02$, $P < 0.01$).

Avoidance was initialised almost exclusively by the dogs that was true for both groups (British sample: $t = 2.4$, ns; Hungarian sample: $t = 2.1$, ns). Blind persons initiated turning over the expected level (British sample: $t = 15.2$, $P < 0.01$; Hungarian sample: $t = 8.3$, $P < 0.01$). Stepping down was initiated relatively often by owners in the British sample ($t = 4.8$, $P < 0.01$) but not in the Hungarian sample ($t = 1.9$, ns). Dogs initiated almost all stepping up actions in the British sample ($t = 1.8$, ns), however, owners contributed to these actions over the expected level in the Hungarian group ($t = 3.3$, $P < 0.01$). Slowing down was also initiated regularly by the owners (British sample: $t = -4.7$, $P < 0.01$; Hungarian sample: $t = 3.2$, $P < 0.01$). Taking all actions into account blind owners initiated a significant amount of actions (British sample: $t = 21.4$, $P < 0.01$; Hungarian sample: $t = 11.4$, $P < 0.01$).

There was a significant variation in the length of sequences where one party performed a series of initiations one after the other for all groups analysed separately (British blind persons: $\chi^2 = 83.8$; British guide dogs: $\chi^2 = 53.1$; Hungarian blind persons: $\chi^2 = 55.8$; Hungarian guide dogs: $\chi^2 = 42.2$; $P < 0.01$ in all cases). Similarly, as it can be seen from Fig. 4 in all four groups subjects initialised one or two actions in a row, longer series of initialisations became rare as the length of the initialisation series increased.

2.1.7. Discussion

In this study, we observed the co-operative behaviour of trained guide dogs and their owners. The analysis was done in parallel on two samples that differed in many respects. Breed of the dog, the training history of both the dog and the owner and many other variables could not be controlled for. Nevertheless, on a qualitative level there were marked

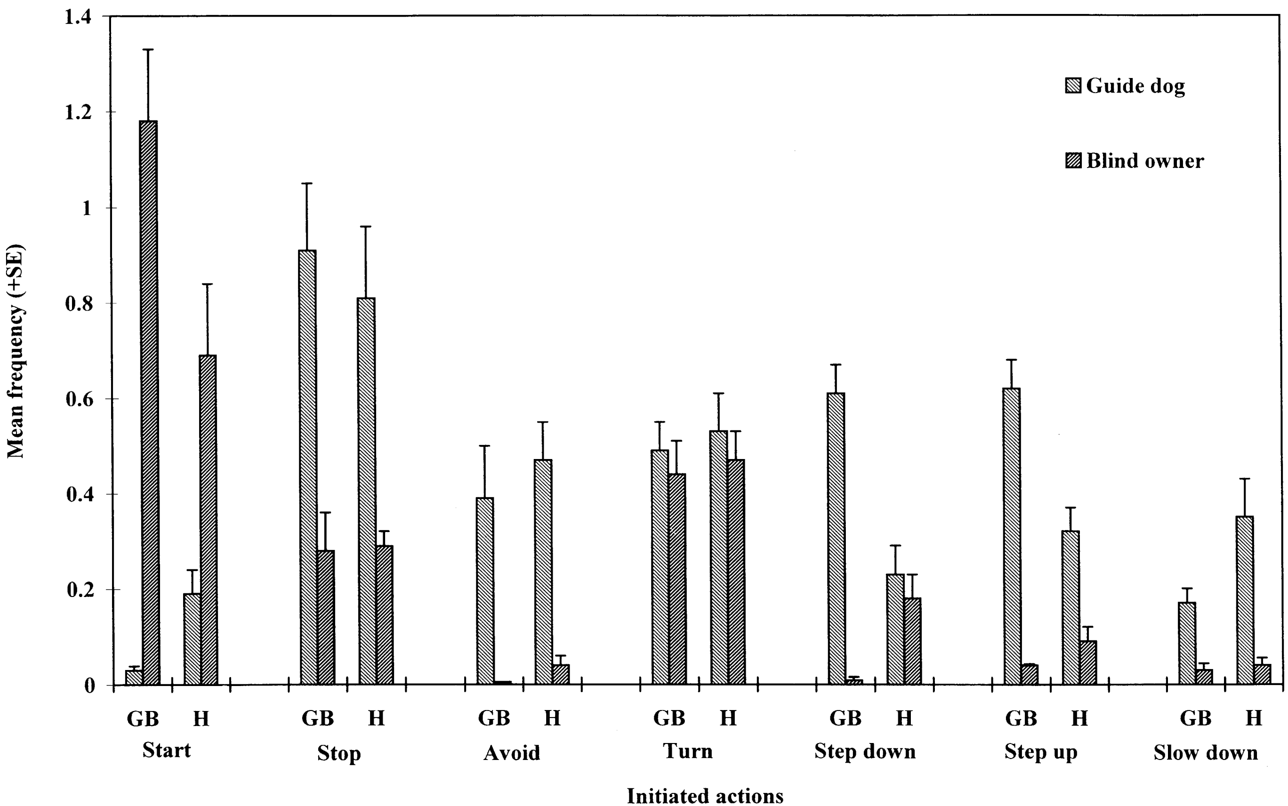

Fig. 1. Mean frequency (±S.E.) of actions initiated by either the guide dog or the owner during walks (GB = British; H = Hungarian).

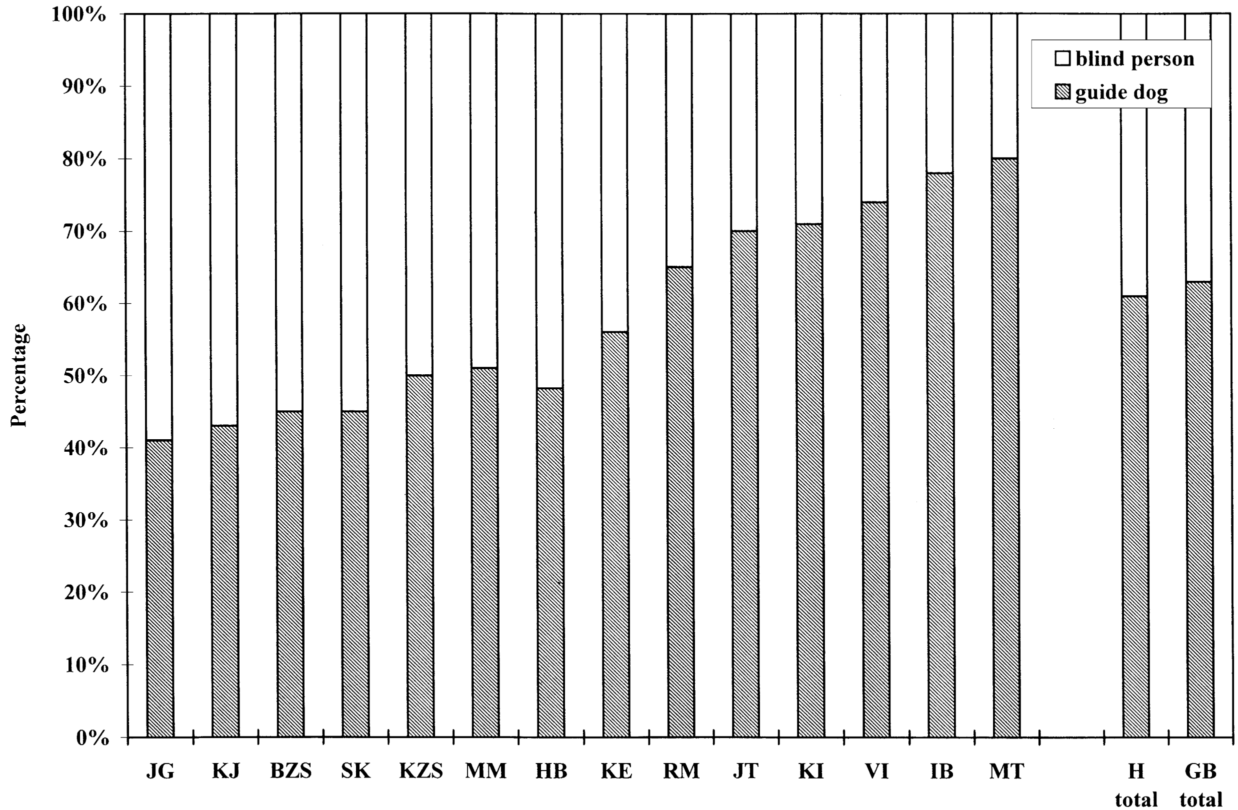

Fig. 2. Distribution of the percentage of initialisations in individual dyads for the Hungarian sample, and the group average for both groups (GB = British; H = Hungarian).

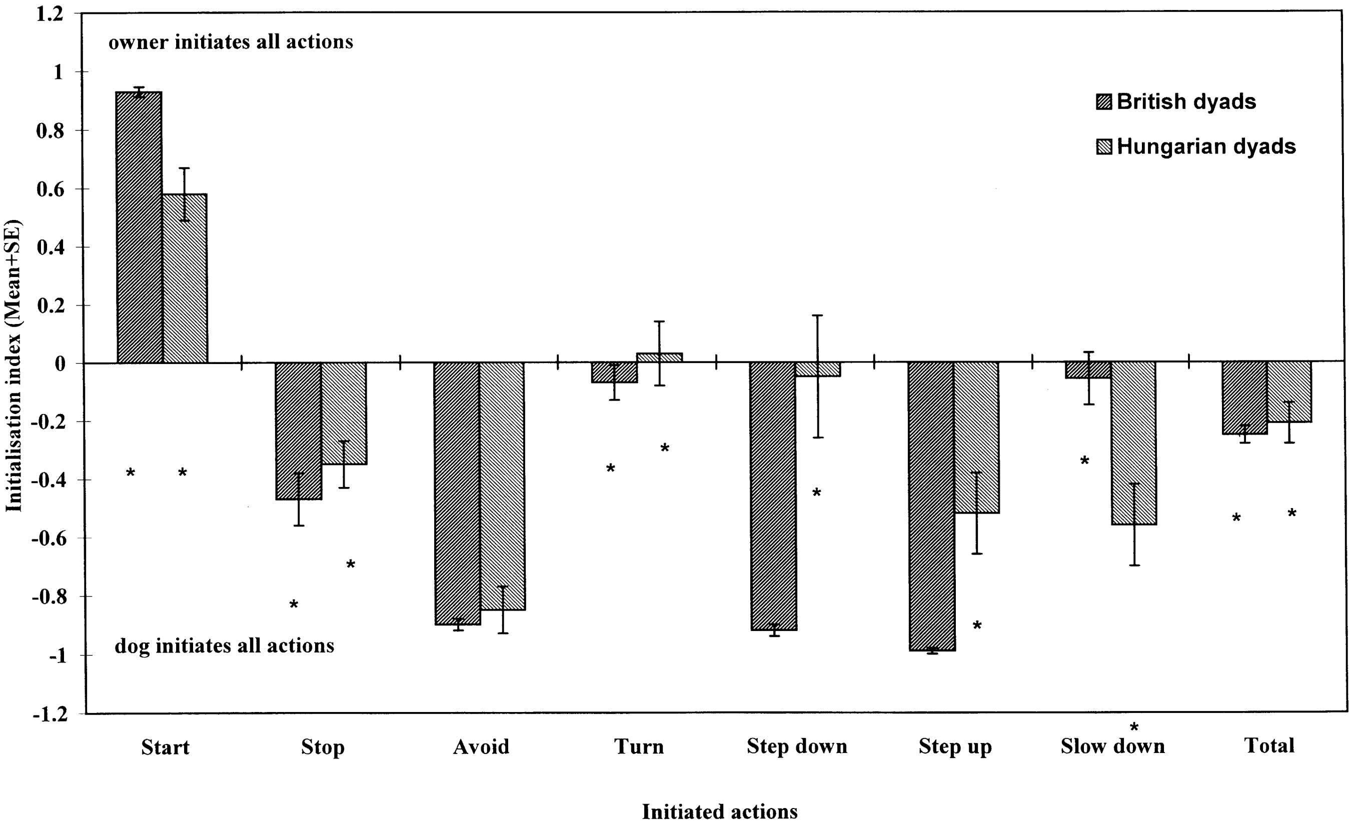

Fig. 3. Initiation index (INI, mean ± S.E.) during walks for guide dog dyads. Asterisk (*) indicates significant ($P < 0.01$) departure from the expected level of initiation (all actions are initiated by the guide dog).

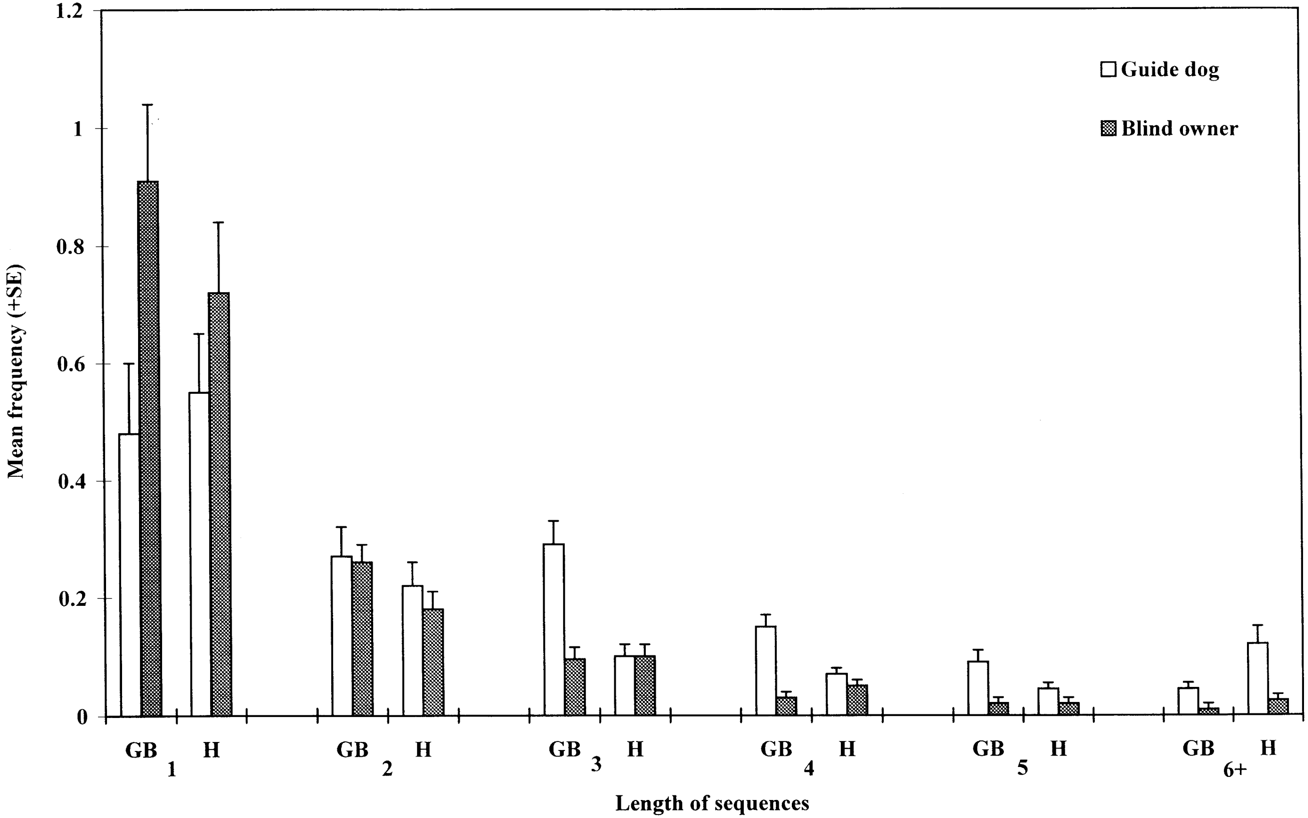

Fig. 4. Mean frequency (±S.E.) of initialisation sequence length (1, 2, 3, 4, 5, or ≥6) for guide dogs and their owner during walks (GB = British; H = Hungarian).

similarities between the two groups. From our point of view, the most interesting finding is that the initiation indices seem to be independent of the influence of environmental factors. Contrary to expectations that dogs would initiate all actions, blind persons tended to initiate a significant amount of starting, stopping, turning and slowing down actions. The dogs seemed to have full control only in the case of avoidance. This general pattern was true for both the British and Hungarian group.

Since the very same actions were initiated at a considerable frequency by the blind person, the co-operation can be described as a sequence of actions in which the members of the dyads take their turn in the initiation of the same or different actions. More than a half of these sequences were only one or two units long, so for most of the time the role of the initiator was changed very frequently between the members of the dyads. Interestingly, blind persons took more often the initiative in short sequences, and it was more common with dogs that they initiated three, four or more subsequent actions. It could be said that longer sequences of initiations by the dogs were ‘‘interrupted’’ by actions initiated by the blind owner.

3. Study II

The main aim of this experiment was to investigate whether naive (pet) dogs are able to assist their blindfolded owner to surmount an obstacle course. If dogs have the ability to co-operate with humans then we should find some similarities in the pattern of initiations of the naive pet dog group and the guide dog group that was used here as a form of control.

3.1. Methods

3.1.1. Subjects

Eighteen Hungarian guide dog owners participated voluntarily in this experiment (7 men — mean age: 52.3 years; range: 38–72 years and 11 women — mean age: 25.1 years; range: 17–39 years). Six guide dog owners reported to have limited peripheral or central vision, four were able to discern some light or shape and the other eight were totally blind. The blind persons were guided by labrador retrievers ($n = 9$), German shepherds ($n = 5$), golden retrievers ($n = 3$) and one rotweiler. The mean age of the 8 male and 10 female dogs was 14.4 months (range: 18–36 months).

The pet group was formed by 13 volunteer pet dog owners (2 men and 11 women: mean age 29.9 years; range: 15–53 years) and their dogs (9 Tervueren; 2 Groenandael; 1 Malinois; 1 boxer). The mean age of the eight male and five female dogs was 35.5 months (range: 12–96 months).

3.1.2. Procedure

Based on preliminary observations of testing trials for the guide dogs, we have built a special, portable obstacle course (Fig. 5). Eight different obstacles were constructed from light wood and green plastic sheets that fell over easily in case subjects ran against them. The order of the obstacles was fixed for all trials: (1) ‘‘pit’’ (distance from start: 13.5 m); (2) ‘‘gate’’ (19 m); (3) ‘‘screen’’ (26 m); (4) ‘‘grid’’ (30 m); (5) ‘‘slalom’’

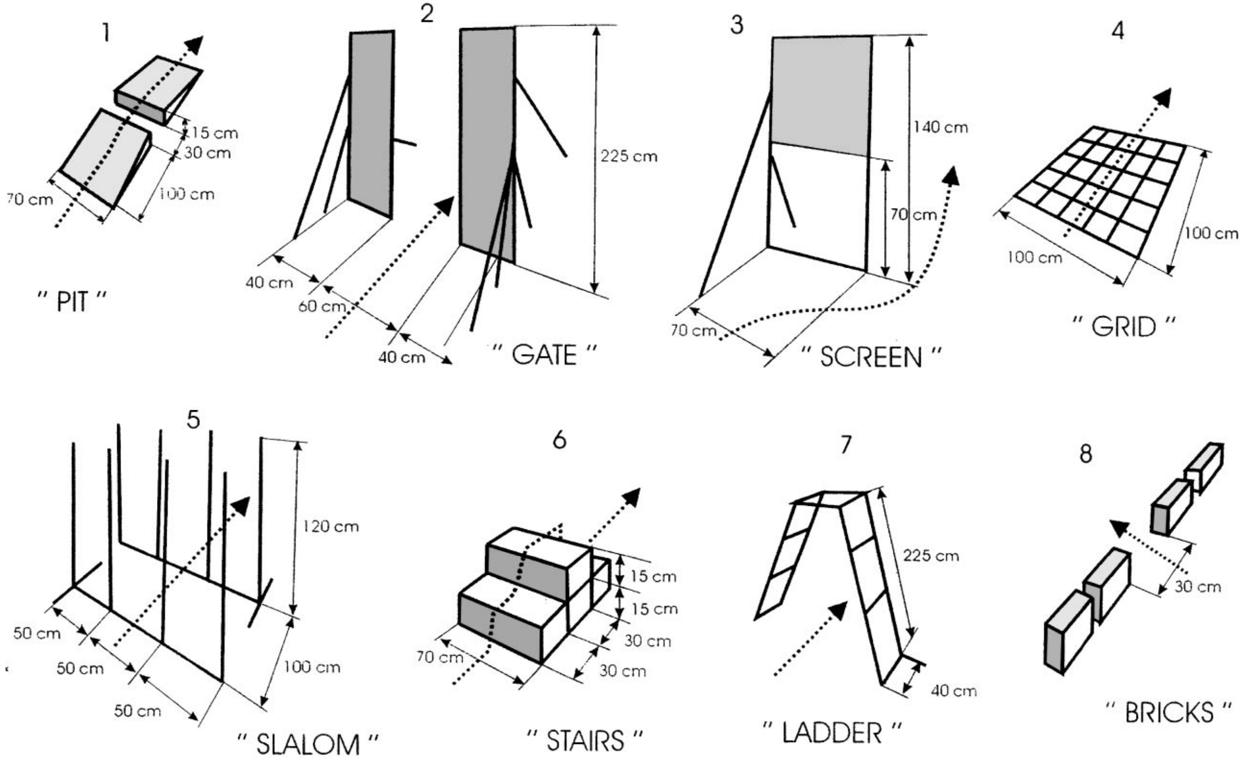

Fig. 5. Schematic drawing of the units of the obstacle course used for testing both pet and guide dogs with blindfolded owners.

(34.5 m); (6) "stairs" (39 m); (7 m) "ladder" (42 m); (8) brick row (48 m). The course was 50 m long, and a white rope (0.8 cm in diameter) was loosely spanned along both sides.

Five minutes before the start of the trial owners had been blindfolded (including the blind persons), to prevent sighted subjects from observing the obstacle course. Only after blindfold had been fixed were they allowed to the vicinity of the obstacle course. Both the owners and their dogs were familiarised with the obstacle course. This was done in two steps. First, an assistant helped the blindfolded owners to walk along the obstacle course. Second, after the dog had been seated at the start of the course and the owner had been positioned at the half point of the course, the owners were told to call in their dogs. The same procedure was repeated with the owner standing at the end of the course and the dog sitting at the middle.

At the beginning of the trial, the owners were equipped with a dictaphone to record their speech during the observation. Their task was to walk from the start to the far end and back in the obstacle course. A cameraman followed the walking dyad from the side keeping at least a 5 m distance between himself and the subjects. The assistant also escorted the subjects to offer help in case the blindfolded person ran against an obstacle. Otherwise they never interfered with the dog or the owner during the walks. At the far end of the obstacle course, the helper gently re-oriented the dyad toward the start.

The videotape was analysed in a similar manner to that described in Study I, and the same behavioural categories were used for the evaluation. Obstacle time was calculated as the sum of durations of passing all the obstacles. Total time was defined as the duration needed for the dyad to walk along the obstacle course from the start to the end (obstacle time plus time spent walking between obstacles). If any member of a dyad ran against an obstacle (it fell over, or moved) or they tried to leave the course an error was recorded.

3.1.3. Results

Friedman analysis of variance detected significant variations in the frequency of actions initiated by both the pet owners ($\chi^2 = 62.7$, $P < 0.01$) and their dogs ($\chi^2 = 63.7$, $P < 0.01$). Owners initiated starting and stopping most often, while turning, stepping up and down, and slowing down was less frequent. In dogs, the initialisation of stopping, avoiding and stepping down most observed most often, and they showed lower frequencies of starting, turning and slowing down (Fig. 6).

A similar picture emerged in analysing the initiating actions of the blind owners ($\chi^2 = 75.1, P < 0.01$), and their dogs ($\chi^2 = 84.7, P < 0.01$). Guide dog owners initialised starting and stopping most often, the frequency of initialisation of avoiding, turning, stepping up and down, and slowing down was significantly lower. The behaviour of guide dogs was characterised by initialising starting and stopping whilst avoidance, turning and stepping up and down, slowing down was initialised to a lesser degree (Fig. 7).

Considering the indices for initiations (Fig. 7), we found that in both groups owners initiated more starting actions ($t = 192.1$, $P < 0.01$; $t = 16.1$, $P < 0.01$). Stopping also deviated from the expected indicating the owner's strong influence in both groups (guide dog dyads: $t = -7.9$, $P < 0.01$; pet dog dyads: $t = -7.8$, $P < 0.01$). In both groups, humans initiated more turning actions than expected (guide dog dyads: $t = -13.2$, $P < 0.01$; pet dog dyads: $t = -9.3$, $P < 0.01$). The initiations of avoidance were

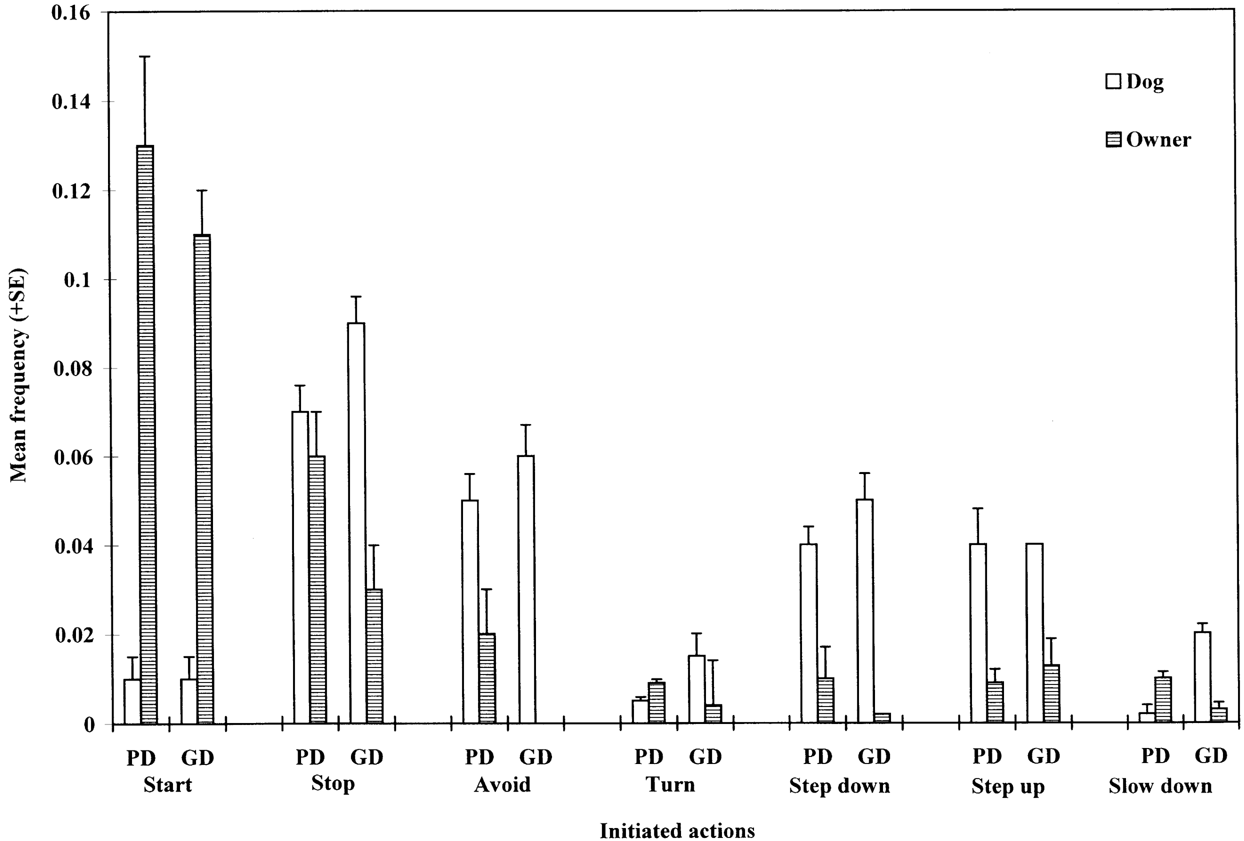

Fig. 6. Mean frequency (±S.E.) of actions initiated by members of the 'pet dyads' (PD) or the 'guide dyads' (GD) during their walk in the obstacle course.

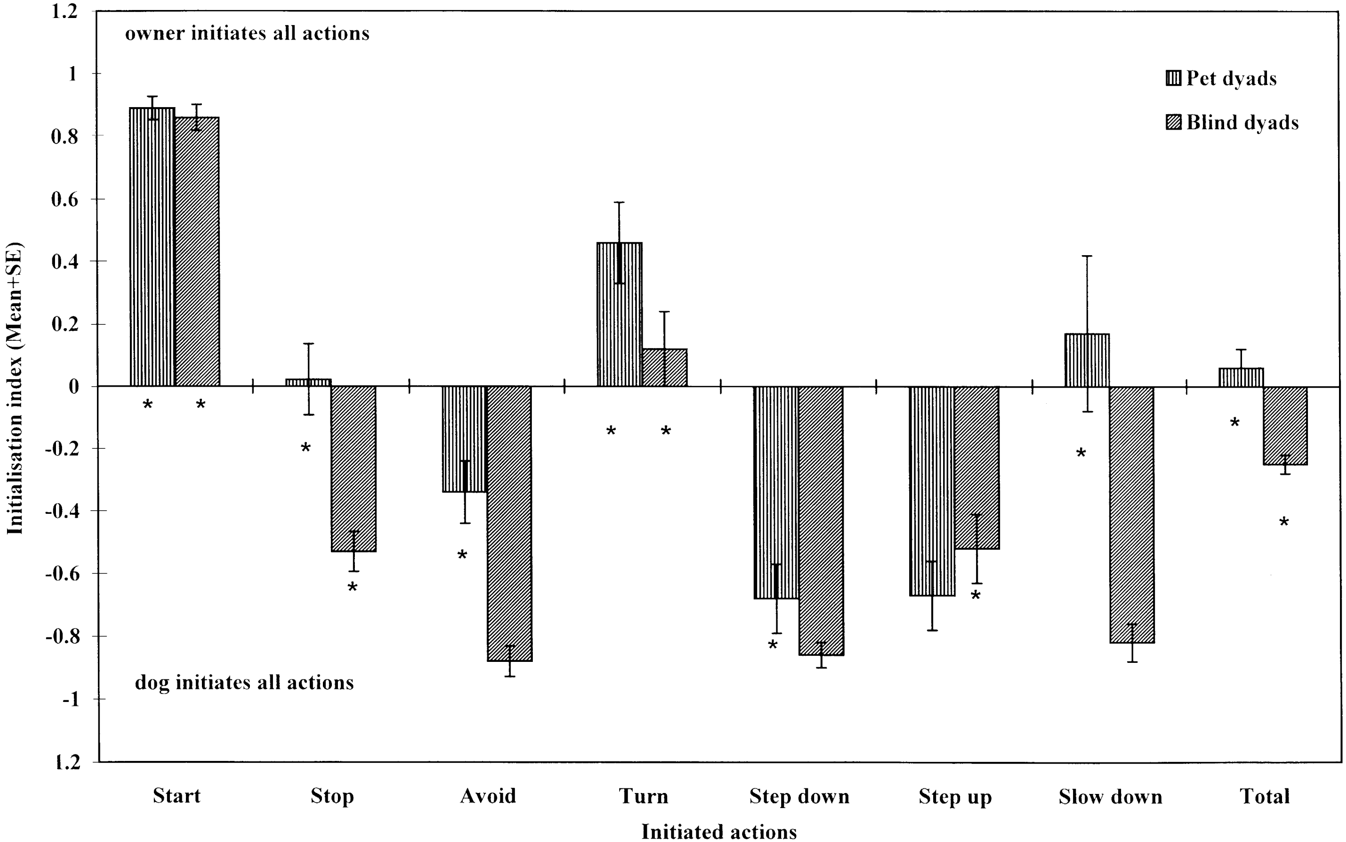

Fig. 7. Initiation index (INI, mean ± S.E.) for 'pet dyads' or the 'guide dyads' in the obstacle course. Asterisk (*) indicates significant ($P < 0.01$) departure from the expected level of initiation (all actions are initiated by the pet/guide dog).

performed at the expected level by guide dogs (most actions were initiated by the dogs: $t = -2.5$, ns) but pet dog owners initiated more avoiding actions ($t = -6.4$, $P < 0.01$). Dogs initiated most of stepping down actions in the guide dog group whilst the performance of pet dogs differed significantly from the expected ($t = -3.5$, $P < 0.01$). Stepping up was initiated less often by the guide dogs ($t = -4.3$, $P < 0.01$). Initiation of slowing down was performed by both pet and guide dogs at lower than the expected level ($t = -3.6, P < 0.01$; $t = 3.3, P < 0.01$, respectively). Considering all actions together, we found that in both cases dogs initiated less actions than expected ($t = 18.8$, $P < 0.01$; $t = -25.3$, $P < 0.01$, respectively).

There was significant variation in all four groups of subjects in the length of sequences (pet dog owners: $\chi^2 = 40.2$; pet dogs: $\chi^2 = 47.7$; guide dog owners: $\chi^2 = 67.6$; guide dogs: $\chi^2 = 46.7, P < 0.01$ in all cases). As it can be judged on Fig. 8. the majority of initialisation sequences were short, consisting only of one or two actions. The frequency of longer sequences was in general lower.

3.1.4. Discussion

Although on the whole guide dogs and their owners showed a more professional performance on the obstacle course, in general, the difference to the pet dog group is smaller than expected. The dyads consisting of the blind person and the guide dog, made less errors during their walk through the obstacle course, and they were also faster in overcoming the individual obstacles.

As in the previous study, qualitative comparison of the two groups points to many similarities and dissimilarities. The order for initialisation frequencies for different actions is similar for both the dogs and their owners, respectively. The differences in initiation sequences show that guide dog owners were more willing to give up initiations for longer durations, or in other words, guide dogs could solve some problems (obstacles) without the necessary interference from the owner. This kind of interchange does not seem to operate in the pet dog dyads, where owners keep the initiative for longer sequences.

3.1.5. General discussion

In two observational studies, we have investigated how co-operative interactions between humans and their dogs are organised. Due to technical reasons, there were many differences among the experimental groups that prevented a direct statistical comparison. Nevertheless, on a qualitative level we found many similarities, that should offer a basis for further, more detailed studies in the future. We should also note that although different dog breeds have been used by these groups the behavioural variables measured seemed to be not affected by this. Due to high individual variation, only a large scale study could in principle discern the effect of breeds on these aspects of leading a blind person.

For long it has been assumed that the most important and exclusive role of the guide dogs is to lead their blind owner. Dogs have been regarded as stimulus response devices that should be able to perform certain actions in given situations. From the practical side, this approach seemed to be justified since the easiest way seemed to be to transfer all decisions and executions to the dog in order to compensate for the restricted abilities of its blind owners. Therefore, dog training was reduced to simple or complex forms of operant conditioning that assured perfect performance. Although this method does not take in full

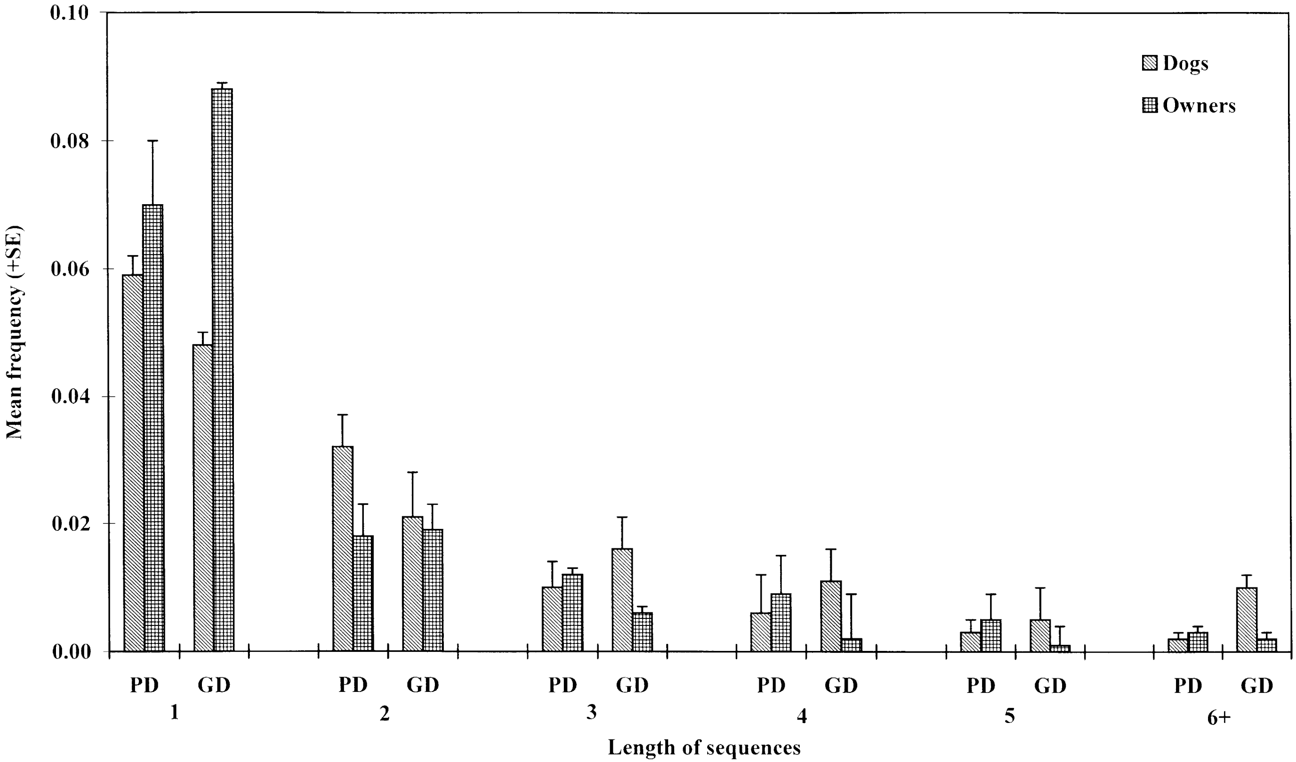

Fig. 8. Mean frequency (±S.E.) of initialisation sequence length (1, 2, 3, 4, 5, or ≥6) for ‘pet dyads’ (PD) or ‘guide dyads’ (GD) during their walk in the obstacle course.

account, the biological abilities of the dog, nevertheless dog trainers have been able to train valuable dogs for many generations.

However, the task of an ethologist is to look for the mechanisms that determine the organisation of a behaviour. This series of observations showed that leading a blind person is a fundamentally co-operative task where both participants have important roles to play. Three critical observations seem to support this assumption that will be discussed in detail below.

First, we found that the rates of initiations were different among dyads. In some dyads, most actions were initiated by the dog, in others the situation was the reverse. However, total leadership (most actions initialised by the same party) exceeding 80% of actions initiated was never recorded.

Second, both British and Hungarian dyads showed that remarkable differences in training still lead to many qualitative similarities in the co-operative behaviour. Our observations also suggest that as the blind person and the guide dog is becoming accustomed to each other, many minute changes take place in their co-operative behaviour. Some elements of the trained behaviour change, others vanish or get modified.

Third, our results show that the basic ability to co-operate in such a situation has an inherited basis in the dog since naive pet dogs showed also some evidence of leading. Wolves have been observed often displaying co-operative behaviours in various contexts (Mech, 1970, see also Section 1, for example), which ability has been certainly utilised and built upon by humans during domestication.

In our view, the most important role of the guide dog training is to teach the dog to observe and use arbitrary cues in the environment for guiding its actions, i.e. when moving around objects they should take into account the physical parameters of the blind persons as well. The training of the guide dog should not be imagined as consisting of teaching only a series of conditional discrimination tasks to the dog (for a similar argument see Johnston, 1990) but that these learned actions get incorporated into a list of co-operative behaviours. In other words, we suggest that the success of guide dog training is built to a great extent on the innate co-operative ability of the dog. It seems that the innate ability for co-operation and the attainment of the need to observe the human's behaviour (see also Kubinyi et al., 2000; Pongrácz et al., 2001), gives a firm basis for co-operation in guiding the blind person. This also means that the dyad can invent new types of joint actions, or they can modify learned ones or omit learned behaviours that do not seem to have any advantages for them.

This high level of co-operation between dog and human resembles in many respects co-operative activities within humans since humans show also many forms of highly interactive and complex co-operative activity (Reynolds, 1993). In many cases, human co-operation depends crucially on the attachment relationship and the ability to shift the leadership (i.e. taking the role of the initiator or accepting the other as the initiator) in the course of the joint actions. Therefore, we think that the study of dog–human co-operation offers a useful model based on behavioural analogy (see also Csányi, 2000).

Both studies showed that although there was an overall tendency for the dogs to initiate the actions, some actions were clearly initiated more often by humans. This observation can be best summarised with a two-level model of co-operation. We propose that the co-operation observed between the dog and the human can be described both at an action-level (i.e. starting, avoiding, stepping up, etc.) and a program-level (i.e. getting to the shop, crossing the road, etc.). At the action-level, both participants need to follow (and copy) the action(s) of the initiator. For example, if seeing an obstacle in their way the dog starts an avoiding action, the blind person has to perform the same action. The failure of following the dog's action would cause the blind person to stumble across the object. Based on this descriptive model, at this level their co-operation can be categorised as being congruent (actions are similar), sequential (one's action is followed by an action of the other) and homospheric (actions are performed in close association). At the program-level, the co-operation consists of a chain of different actions each of which has its most likely (but not exclusive) initiator. For a continuous co-operation to take place both parties must realise who is initiating when, and they must be able to accept a continuous turn in taking the initiations of actions. Here, one might note that since for most actions we could identify a leader of the initiations, at the program-level the concept of complementary co-operation can be invoked (see Reynolds, 1993).

It is important to realise that in many cases only one member of the dyad has got at his/its disposal the full information that is needed for the successful completion of the task ahead. In other words, the dog does not know about the planned actions of its owner, in contrast, the owner is restricted of the visual information provided by the environment. Interestingly, however, each party seems to be willing to provide and accept the information that is made available by the other. Therefore, we suggest that for successful co-operation to occur the members of the dyads need not only to follow each others actions (action-level co-operation) but the leadership in initialising an action has to be changed depending on the nature of the task ahead (program-level co-operation). Members of the dyad should be able to adjust their behaviour to the behaviour of the others, i.e. co-operation here is viewed as an ability that allows for fast interchange of situation-dependent leadership (i.e. there is a shift in leadership depending on the actions performed). It can be supposed that domestication relaxed hierarchical relationship between human and dog (Kretchmer and Fox, 1975; Belyaev, 1979) and this contributes in the emergence of this type of co-operation. Effective interaction can only take place if at given actions each party is able either to accept the other's leading role or to take the lead if necessary. Without the mutual ability of shifting the role of the initiator for short intervals this would not be possible.

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