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Abstract

A study involving 36 domestic dogs (*Canis familiaris*) in a simple search task provides evidence of a correlation between paw use and performance. The study was carried out to determine whether or not paw use is related to task performance. Different aspects of task performance were taken into consideration. The results of an experiment indicate that dogs departing with the left front paw perform significantly better than dogs departing with the right front paw. Moreover, gender differentiation was not replicated by our data, thus opening new avenues of research with other or other additional factors to gain insight in the gender differentiation found earlier.

Introduction

Since the discovery of hemispheric lateralised behaviour in non-human species (see, e.g., Rogers, 2002; Vallortigara and Bisazza, 2002), the research has shifted to discover the nature of that lateralised behaviour. With respect to the nature of lateralised behaviour in the domestic dog (*Canis familiaris*) the only research results published to date are (Tan, 1987; Wells, 2003; and Quaranta *et al.*, 2004). Their research results have opened new avenues for research into paw preference in dogs.

Tan (1987), the first to publish on this topic reported on paw preference in an experiment in which dogs were to remove an adhesive plaster from their eyes. Tan reports that 57.1% was right-preferent, 17.9% left-preferent, and 25.0% ambidextrous. He does not report on differences between the sexes.

Quaranta *et al.* (2004) repeated the experiment with adhesive paper (now to be removed from the snout). They observed population lateralisation (like in humans) but exactly in the opposite directions in the two sexes. Their study suggests that male dogs have a preference for their left front paw, while females for their right front paw. They report that approximately 70% of the male dogs and 80% of the female dogs showed individual preference for using either of the front paws. In more detail, they found significant left front paw preference in male dogs, and only a slight preference for using the right front paw in female dogs, although this last result might be due to the small number of samples (29 female dogs).

The research of Wells (2003) also suggests clear left paw preference in male dogs and clear right paw preference in females. To check for task-dependency, Wells experimented with three different tasks: lifting paw on command, removing a blanket placed over the head of the dog (centrally, also blindfolding it), and removing a bowl that was placed over food the dog could see and sniff. Analysing the results of the three tasks, Wells concluded that there were significantly more dogs paw-preferent than ambilateral and that there was no significant difference between the number of left-pawed versus right-pawed dogs. She also concluded that paw preference was significantly influenced by the sex of the dog (female-right, male-left). This difference in paw use with respect to sex can be seen most sharply in task 1, less in task 2 and the least in the third task. When discussing results and methods Wells also argues that the performance of dogs in task 1 may be an already

[1] Work done during her Master's project at the Vrije Universiteit Amsterdam

reinforced and learned behaviour (the way owners were teaching the command for paw-giving to dogs). This leaves an open place for debate on reinforced paw preference and true handedness. Finally, she reports significant positive inter-task correlations: 26 out of 53 dogs (16 males and 10 females) changed paw preference between the first two tasks.

Both the results of Quaranta *et al.* (2004) and Wells (2003) show left paw preference in male dogs and right paw preference in females. However, the possibility of task dependence reported by Wells makes it clear that understanding paw preference in dogs requires more research. What is it in the task or the setting that makes the paw preference change? A key to answering this question might be found in the task dependence of motivation, see, for example, Atkinson's achievement motivation (Atkinson and Feather, 1966), the attributional theory of Weiner (1991), and for an overview (Hyland, 1988).

The notion of achievement motivation might be the explaining theory for the hypothesis studied in this paper: "Paw preference correlates to task performance". This hypothesis is the result of observing dog behaviour in therapeutic work by the authors, where it seems that departure with the left front paw is indicative of a good performance of the task assigned to the dog by the handler, whereas departure with the right front paw is indicative of a bad performance. All tasks considered here involve the dog moving forward, e.g., follow the handler, go forward, fetch an object, come to the handler, and search an object. Literature research revealed no reports on anything remotely similar to this hypothesis.

The results of a first test of the "Paw preference correlates to task performance" hypothesis, as reported in this paper, support the hypothesis. The rest of this paper is organised as follows. The Task Description section describes the task chosen, the appropriateness of the task, and an analysis of paw use and aspects of performance relative to the task. The Method section describes the acquisition of subjects and data, the selection of data to be analysed, and the analytical procedure used. The Results section, presents the statistical analysis of the experiment, in terms of aspects of performance, paw use, sex differentiation, and trainings level. The Discussion relates the results of the experiments with other work and identifies future directions of research.

Task Description

The task to test the hypothesis "Paw preference correlates to task performance" has to meet the following requirements.

- Executable by dogs of all ages after leaving the breeder (approximately 8 to 10 weeks old), of all breeds, of all sexes (including neutered), and of all trainings levels.
- Involves a forward movement of the dog to perform the task.
- Allows video registration from different angles.
- Shows natural performance, not trained, or conditioned performance.
- The notion performance should be definable in terms of objective observables.

The Search Task section motivates the choice of the experiment and provides a description of the experiment. It also describes the results of a pre-test to validate the appropriateness of the experiment. The Aspects of Performance section describes the aspects of performance that were used to analyse the results of the experiment.

Search Task

Based on the above requirements, the choice was made for a search test involving the sense of smell. Smell was chosen, because of the three senses that can be used to entice forward movement (smell, hearing, sight), smell is the first active sense, see, e.g., (Scott and Fuller, 1998; Dehasse, 1994). Therefore, even a puppy should have enough experience in using that sense. To create a small setting that allows video registration, the testing arena is only 5 by 10 meters, see Figure 1.

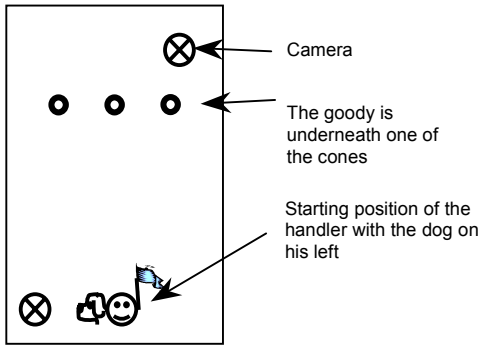

Figure 1: Setup of the experiment

The camera at the bottom (2 meter from the dog) zooms in on the dog paws. The one at the top (10 meter from the baseline) has an easy overview of the whole area. At the beginning of each trial it also zooms in on the paws, to film departure. A goody is hidden underneath one of three cones positioned at 5 meters from the baseline. A blindfold is used to keep the dog from seeing where the goody is placed. The wind comes from the top, so that the smell of the goody travels towards the baseline. The dog departs from the position with the flag as sent by its handler.

To avoid the possibility that the dogs showed trained behaviour, a setting was chosen that was unfamiliar to the dogs. To avoid conditioning or training during the experiment no more than 3 trials per dog took place. To allow for variation in paw preference per dog, exactly 3 trials were chosen. As a consequence the test is a population experiment. More details of the way the experiment was conducted are given in section Method.

The appropriateness of the experimental setting was tested using 4 dogs (1 male adult, 1 male pup of 3 months, 1 female adult, 1 female pup of 3 months). All pre-test dogs had no or only a low trainings level (puppy course). All

dogs responded actively on the smell of the goody (nose licking, nose twitching and trying to move the head forward). After release, one pup went straight for the correct cone, the other pup showed only minor interest in the goody, even when guided towards it. The two adults found the goody themselves: one in a rather straight line, the other after first exploring the arena.

Aspects of Performance

In order to test the validity of the hypothesis, the notion performance needs to be defined in objective and observable terms. Aspects considered with respect to this experiment are: duration, sniffing at the correct cone, sniffing at a wrong cone, standing still at a distance from the correct cone, moving away from the correct cone, passing the correct cone (a specific form of moving away from the correct cone), going to the experimenter, going to the handler, urinating, biting a cone. These concepts were obtained in a number of brainstorming settings with our domain experts in dog therapy, and on the basis of our literature study. The concepts were formally defined before the start of the experiments.

All of the concepts introduced above turned out to be useful, except duration. Since the experiment concerns a population test, not on individuals, the speed with which dogs perform the test differs too much and is unrelated to performance. There are dogs that go straight for the cone in a slow speed, and those that do so in high speed. Similarly, other dogs are all over the place; some in high speed, some slowly. The only aspect of speed that could be useful, is the relative speed of a dog with respect to another trial by the same dog. However, since the number of trials used in this experiment cannot be more than 3 (to avoid training), in the current setting it is not trivial to consider duration as an aspect of performance. Therefore, designing an experiment where duration can be used as performance measure is left for future work.

The remaining concepts were derived from the following principles of scenting in dogs, see, for example, (Müller, 1984; Pearsall and Verbruggen, 1982). The performance in a search task using scent can vary from perfect to abominable, and numerous variations in between. A perfect performance would be that the dog goes in near straight line from the point of departure to the correct cone. An abominable performance would be, e.g., that the dog never moves away from the departure point, or that the dog repeatedly runs in all directions all over the arena, without stopping to sniff at the correct cone. When considering the arena a number of objects carry scent related to the goody presented by the experimenter to the dog's nose: the experimenter, the goody cone, the wrong cones (because the goody has been under one of these in the past), and the places were the experimenter walked. When evaluating all these objects in terms of strength of smell, then two objects stand out: the correct cone and the experimenter. The fact that the experimenter carries an attractive small is considered for two reasons. First, the possibility cannot be excluded that (s)he carries the smell of the goody. Second, the dogs might associate the smell of the experimenter with the fact that this is the person who offers the goodies. Furthermore, the scent of the goody and that of the experimenter evaporates: the closer to the object, the stronger the smell. Therefore, going towards to the object with scent is better than moving away from the object. Combining this with the previous identification of the goody cone and the experimenter as having the strongest scent leads to the following conclusions. The dog can choose to try to find the experimenter, or the goody, or do neither. When comparing moving away from the chosen object or moving towards that object, then the first is a bad move, the second a good move. Similarly, sniffing the correct cone is better than sniffing a wrong cone. Furthermore, any other action that does not contribute to getting the goody or finding the experimenter, contributes to a less than ideal performance.

Accepting that some of the aspects mentioned above contribute to a less than ideal performance, does not imply to what extent each of them contributes. Therefore, all aspects should be noted when looking at the results of the experiments, and when analysing the data.

To analyse paw preference, a definition of paw use in departure had to be formulated before the experiment could be analysed. This led to the following criteria for accepting a trial for analysis. The dog has to stand or sit still for at least two consecutive images on the video, meaning that his paws do not move in those two images.

Furthermore, the definition of paw use has to be related to the gait in which the dog departs. If the dog departs in a walk or a trot, the first front paw to move forward is taken as the paw used. If the dog departs in a gallop in which both front paws are lifted simultaneously, the front paw that reaches most forward is taken as the paw used. The distinction between the different types of gait corresponds to the definitions of the Encyclopaedia Britannica[2].

Method

This section explains our acquisition of subjects and the procedure followed during the experiments.

Subjects

To be sure of a large enough pool of data, a number of dog schools and dog-walking centres were approached to ask for volunteers. In this manner, 98 dogs participated in the experiments. Due to mistakes with the equipment (not recording, mislaying a tape), of those 98 dogs, 25 dogs could not be used for full analysis. Furthermore, of the remaining dogs, those dogs were dismissed from analysis, that did not stand or sit still before departing, or whose handlers pulled the leash at moments that influenced the results. This affected especially the young dogs. All in all, the results of some 55 dogs passed those criteria.

Before starting the analysis, a subset (of 36 dogs) of those 55 was chosen with the aim of having a fair

[2] Search for 'canter' instead of 'gallop'

distribution with respect to trainings level, age, and gender. A low level of training means none at all, puppy- or basic levels, and a high level means GG1 or higher in Dutch training terms. Conform (Dehasse, 1994; Scott and Fuller, 1998) age was taken as adult (2 years or older for males, 1.5 years or older for females) versus non-adult. The gender issue was inspired by the studies reported in (Wells, 2003) and (Quaranta *et al.*, 2004). Thus, there were 18 males and 18 females, each group consisting of 9 dogs with low and 9 dogs with high trainings level. Non-adult dogs with a high training level are hard to come by. Therefore, 8 of the 36 dogs were non-adult: 4 of them females with low trainings level, 2 males with low trainings level, 2 males with high trainings level. Table 1 summarises the demographic data of the selected dogs.

Table 1: Dog data

Dog number	Dog name	Breed	Gender	Date of birth	Training level
2	Bizzy	Middle Schnauzer	male	02.04.2002	high
6	Sam	Jack Russell Terrier	male	1990	low
16	Kimmy	Beagle	female	1999	low
23	Tess	Border Collie	female	11.09.2003	low
24	Hermes	Labrador/Terrier hybrid	male	25.12.2002	low
25	Cato	Labrador Retriever	female	2002	low
26	Makker	Labrador Retriever	male	03.08.2002	low
27	Chiara	Giant Schnauzer	female	July, 2001	low
28	Pusha	hybrid	female	Sept., 2001	low
29	Tjaarda	Standard Schnauzer	female	2002	low
30	Sultan	Belgian Shepherd Malinois hybrid	male	August, 1999	high
31	Guston Mingus	Basset Faune de Bretagne	male	28.01.1996	low
32	Jakko	Appenzell Mountain Dog	male	22.08.2001	low
33	Max	Wirehaired Dachshund	male	21.11.2000	low
34	Bas	Jack Russell Terrier	male	1997	high
35	Hester	German Shepherd Dog	female	May, 1995	high
36	Liza	Labrador Retriever	female	May, 1993	high
37	Gondroulis	Stabyhoun/Dutch Spaniel (Wetterhoun)	male	05.05.2000	low
38	Fred	Rottweiler hybrid	male	July, 1999	low
39	Tommie	Maltese	male	07.03.2000	low
40	Champagne	Weimaraner (long fur)	female	21.05.2003	low
41	La Chouffe	Belgian Shepherd Malinois	female	20.01.2000	high
42	Chivas	Belgian Shepherd Malinois	female	06.11.2001	high
44	Tara	Bouvier des Flanders/ de Ardennes	female	27.08.2003	low
46	Lola	Cocker Spaniel	female	18.09.2003	low
47	Sammie	Cocker Spaniel	female	28.01.1997	high
48	Terry	Border Terrier	male	19.05.2000	high
49	Guinam (Numme)	Australian Kelpie	female	26.03.1999	high
73	Belle	Appenzell Mountain Dog	female	13.12.1994	high
74	Jan van het Heksewiel	Bullmastiff	male	1999	high
79	Merlin	Australian Shepherd	male	10.09.2002	high
81	Shadow	Australian Shepherd	male	28.01.2001	high
83	Nando	German Dog	male	04.07.1997	high
84	Kyro	Stabyhoun	male	27.02.2001	high
85	Amber	German Shepherd Dog	female	29.11.1998	high
86	Ginger vom Finkenschlag	German Shepherd Dog	female	18.02.2001	high

Procedure

Before entering the arena, the handler is told to walk his dog around the arena to allow exploration of the arena.

A trial begins with the handler and his dog at the flag. The handler holds the dog between his legs and blindfolds the dog either with a paper towel or in case of strong resistance of the dog, by holding a wooden board. They both face the experimental area. The instructor goes towards them and holds a goody (a piece of sausage) on a saucer under the nose of the dog. The goody is then hidden underneath one of the cones. Goodies are put on a plastic saucer that avoids sausage smears at its position on the ground and on the experimenter. Although the arena is never neutral after the first trial, every effort is made to keep the arena as neutral of scents as possible. Furthermore, other dogs are kept far from the arena, also ensuring that a dog cannot learn from watching predecessors. Each dog goes through three trials: the goody is hidden first underneath the middle cone, then underneath the left cone, then underneath the right one. After the instructor has hidden the goody he goes back to the handler and the dog. On a sign from the instructor the handler removes the blindfold and (if possible) lets the dog sit to his left. The handler then lets go of the dog and commands the dog to search. The experimenter is allowed to encourage the dog to go forward, and can even walk a few steps forward himself. However, until the dog clearly found the correct cone, the handler is not allowed to come within 2 meter of the line of cones. The handler and experimenter stay below wind of the correct cone.

After a trial is ended, e.g., because the dog found the goody, or the experimenter decided to stop, the handler takes the dog back to the flag for the next trial.

Analytical Approach

For each dog selected the video images from both cameras were annotated using a formal language based on the aspects of performance as described in Section Task Description. The formal annotation was created on the basis of at least 2 people viewing the images. If the first 2 people disagreed, 2 more people viewed the images, after which all people involved discussed the images. Disagreements mostly concerned the paw of departure and in two cases the overall performance. Disagreements over paw departure were almost always solved by agreeing on the speed the dog departed in (trot and gallop can be misleading). In one case, a double image of the left paw was mistaken by one person as the right paw being more forward.

The aspects of performance were each formalised in logic and an automated checker was used to check each aspect against each trial of each dog. The results of the automated checker were statistically analysed.

Results

Each of the essential aspects contributing to a less than ideal performance was checked against each of the trials of each dog in the selection. A summary can be made of all aspects that contribute to bad performance by recognising that all these aspects have in common that the dog does not move toward the goody. This consideration motivates the statistical analysis of what together might be termed “bad behaviour”, without denying the gliding scale of performance.

The most important results of the experiment are provided in Tables 2 and 3. Table 2 contains the χ^2-analysis of the paw-performance variables. The first column indicates the variables considered, the second column indicates the trial number, and the next four columns give the number of observations of the different combinations. The last two columns show the χ^2-value and the significance

of the χ^2-tests. For example, the first row indicates that of the 36 dogs considered in trial 1, 14 dogs started with left and performed good, 2 dogs started with left and performed bad, 3 dogs started with right and performed good, and 17 dogs started with right and performed bad. As the last two columns indicate, in this trial the correlation between paw and performance was significant (χ^2=18.75, p<0.001). In Table 2, *performance* is defined as described in the Section about 'Aspects of Performance'. Moreover, *away* stands for moving away from the correct cone, and *sniffing* stands for sniffing at a wrong cone.

As shown in the last three rows of Table 2, over all trials there is a significant correlation between paw and performance (χ^2=37.69, p<0.001), but also between paw and the more specific aspects of performance, moving away (χ^2=8.69, p<0.003) and sniffing (χ^2=16.00, p<0.001). These correlations are also present when considering trial 1 only, but some of them disappear in trial 2, and all of them disappear in trial 3. However, when only considering the dogs that depart with a specific paw, more interesting results are observable. For example, of the 18 dogs departing with left in trial 2, only two dogs move away. This amount is significantly small (binomial test, p<0.001). Likewise, of the 18 dogs departing with right in trial 3, 15 dogs perform badly, which is again significant (binomial test, p<0.008).

Given these findings, one could wonder whether the dogs were paw-persistent over the trials. This turned out not to be the case. Over the 3 trials, 55.6% (20 of 36) of the dogs switched their departing paw. A considerable subset of those dogs (50%, 10 of 20) also switched their performance accordingly (not depicted in the Table).

Globally over all trials, among the dogs departing with right, the percentage that performs badly remains more or less stable (85.0%, 94.1%, 83.3% in subsequent trials), while among the dogs departing with left it increases (12.5%, 16.7%, 55.6% in subsequent trials). The number of dogs departing with left (52 of 107, 48.6%) and with right (55 of 107, 51.4%) remained approximately constant over the 3 trials. Furthermore, for 19 of the 36 dogs, the hypothesis "Paw preference correlates to task performance" holds in all 3 trials.

Regarding the initial position of the dog before departure, a few additional remarks are to be made. If, e.g., the left front paw would be in front of the right front paw, wouldn't that make it more likely for the dog to depart with right? Since the initial position of the dog is described in enough detail in the annotation of the video images, the automated checker was used to find out in how many cases the dogs' paws were not level and what happened in those cases. Approximately 1/3 of the initial positions were skewed, of which 1/2 departed with the paw that was already in front.

As can be seen from Table 3 (variables paw-gender and gender-performance), our results do not replicate the gender differentiation found by Quaranta *et al.* (2004) and by Wells (2004), which would warrant new avenues of research to determine which other or other additional factors might play a role. The inter-task dependency found by Wells might be one such factor.

The last variable in Table 3, adult-performance, is not significant (χ^2=0.28, p<0.594), supporting the adequacy of the test, in the sense that young dogs do not perform significantly worse than adult dogs.

Table 2: Results with respect to performance

Variables	Trial	Left/Good	Left/Bad	Right/Good	Right/Bad	χ^2	p
paw - performance	1	14	2	3	17	18.75	0.001
paw - away	1	14	2	8	12	8.44	0.004
paw - sniffing	1	16	0	15	5	4.65	0.041
paw - performance	2	15	3	1	16	21.13	0.001
paw - away	2	16	2	12	5	1.83	0.176
paw - sniffing	2	17	1	4	13	18.32	0.001
paw - performance	3	8	10	3	15	3.27	0.070
paw - away	3	13	5	11	7	0.50	0.480
paw - sniffing	3	10	8	6	12	1.80	0.180
paw - performance	all	37	15	7	48	37.69	0.001
paw - away	all	43	9	31	24	8.69	0.003
paw - sniffing	all	43	9	25	30	16.00	0.001

Table 3: Results with respect to gender and age

Variables	Trial	Left/Female	Left/Male	Right/Female	Right/Male	χ^2	p
paw - gender	all	26	26	28	27	0.01	0.925

Variables	Trial	Female/Good	Female/Bad	Male/Good	Male/Bad	χ^2	p
gender - performance	all	22	32	22	31	0.01	0.936

Variables	Trial	Adult/Good	Adult/Bad	Young/Good	Young/Bad	χ^2	p
adult - performance	all	33	50	11	13	0.28	0.594

Conclusion

The main results of the paper support the hypothesis that paw preference correlates to task performance: dogs departing with left generally perform better than dogs departing with right (χ^2=37.69, p<0.001). Among the dogs departing with right, the percentage that performs badly remains more or less stable (87.3%), while among the dogs departing with left it increases (12.5%, 16.7%, 55.6% in subsequent trials). This phenomenon is interesting and warrants further research. Why the stability in right, and the shift in left?

Gender differentiation was not replicated by our data, thus opening new avenues of research with other or other additional factors to gain insight in the gender differentiation found earlier. The task dependency found by Wells (2004) might be such a factor. For example, our definition of paw preference is 'which paw hits the ground first when the dog starts walking', whereas in papers such as (Wells, 2003; Quaranta *et al.*, 2004) it is 'which paw is used by the dog to move objects off its head'.

As usual with correlations, the exact nature of the correlation is not explained by the data. Many intermediate concepts can play a role, all worthy of further research. An example is the known effect of motivation on performance, see, e.g., (Revelle, 1989). Interpreted in that light, the results indicate that dogs that depart with left have a motivational higher value for this task setting then the dogs departing with right. Next steps in the research could, therefore, be to systematically influence the motivation of the dogs to test whether or not the correlation between paw preference and performance is found again. Similarly, ways could be studied to systematically influence paw preference, and again test the correlation with performance.

Supposing that the correlation between paw and performance is indeed explained by motivational aspects, a next question is why the dogs are sometimes not motivated to search for the goody. One line of research to answer this question might be the social relationship of the dog with the handler.

A final remark involves the possible impact of the handler on the paw that the dogs use in the experiment. Although we tried to make sure that the handler always stood still when releasing the dog, in an exceptional case (s)he might have influenced the particular paw with which the dog left. In future work, the tapes will be thoroughly inspected on this aspect.

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