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SHORT COMMUNICATION

Minding the gap: spatial perseveration error in dogs

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Abstract We investigated a combination of perseveration and detour behaviour in 50 domestic dogs (*Canis familiaris*). They were required to make a detour through a gap at one end of a straight barrier in order to reach a target. After one, two, three or four repeats, the gap was moved to the opposite end of the barrier, and the detour behaviour of the dogs was recorded. Although the dogs could solve simple detour tasks (80% correct in the first trial), they committed a perseveration error of following the previously learned route despite the clearly visible change in the location of the gap. This 'misbehaviour' occurred in 29 of 30 dogs after only two learning trials. They never reached a 100% correct performance level again even after four runs through the second gap location. The results suggest that dogs are reluctant to unlearn acquired spatial motor responses and reinforced navigation, which has important implications for experimental design, everyday dog training and our understanding of their mental capacities.

Keywords Detours · Dogs · Perseveration · Motor response learning

Introduction

In detour tasks, perseveration errors occur when participants attempt to use a previous route around a barrier despite a visible change of the location of the correct path, thus rendering the attempted route impossible (McKenzie and Bigelow 1986). Dogs can successfully master detour tasks (Köhler 1925) and, in natural surroundings, can find new short cuts (Chapuis and Varlet 1987). However, several studies have shown that dogs will stick to a previously learned path even if this no longer leads directly to the goal. Buytendijk and Fischel (1932) were the first to describe how dogs persevere with a previously successful detour path, even after changes in the set-up that made an alternative path much faster and easier. Kruschinsky (1965) also demonstrated perseveration in dogs with detours with moving targets, which disappeared behind one of two screens. Clarke et al. (1951) found that 10-month-old puppies showed perseveration errors in detour and comparable spatial problem-solving tasks. Although puppies reared without external stimulation scored consistently worse than those raised as pets, both groups persisted in following the wrong (but previously learned and reinforced) paths even if this resulted in falling from the end of a false ramp in an elevated detour test. These findings were confirmed for adult dogs reared in restricted environments by Thompson (1954). The animals kept their previously established habits in a single and L-shaped barrier task as well as in Hebb–Williams open field tests. Pongrácz et al. (2001) discovered that a majority of dogs have a tendency to replicate previous successful behaviours, while Pongrácz et al. (2003) added that the more experience a dog has with one solution, the harder they find it to adapt to a new route in subsequent trials. What is common to all these studies is that there were no systematic investigations into the number of repeats after which perseveration occurred and the timing of the dogs' detour behaviour. In addition, the number of animals in the early studies was usually small, and the detour set-ups are not comparable.

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The major aim of our study was to examine whether the cognitive rigidity of dogs after a change in the set-up in the simplest detour task (straight barrier) would depend on the number of learning trials. We also tested whether the transparency of the barrier would have an influence on the performance of the dogs. Dogs get attracted by a visible goal close to the barrier and can no longer solve the problem efficiently (Köhler 1925). Route planning in cats has been shown to be also influenced by the visibility of the goal (Poucet et al. 1983). When the goal was concealed from view, the animals were able to choose the shorter of two routes. We therefore used two conditions, a transparent and an opaque barrier (Experiment 1). The effects of a different number of learning trials on perseveration were tested in Experiment 2.

If dogs are able to successfully complete the task after a required change in their detour path, this may indicate a complete understanding of the task dynamics and an inhibition of previously learnt behaviours. The emergence of perseveration behaviour after a modification of the required detour path might indicate a lack of inhibition and a prominence of learnt behaviour over the clear visual cue indicating the correct path. Discovering the dynamics of perseveration in dogs is important to our understanding of everyday dog behaviour, their training and also their welfare.

Method

A wooden barrier made from latticed garden trellis (2 m high, 4.3 m long) was installed across the centre of an enclosed rectangle (5 m × 3.5 m) (see Fig. 1). The interstices (square gaps) in the trellis were 11 cm^2. For the opaque condition, the barrier was covered with thick, off-white cloth. An opening of 0.7 m was positioned either at

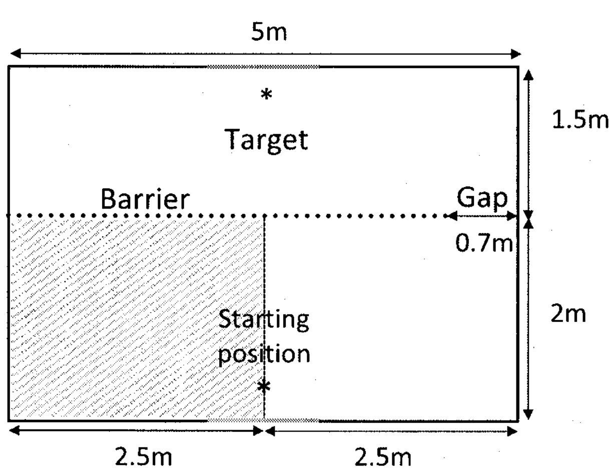

Fig. 1 Layout and dimensions of the testing space, with the gap on the *right side*. The *shaded area* is the *blocked* area for this set-up

the left or right end of the barrier, counterbalanced between subjects.

A video camera on a tripod was positioned behind the starting position of the dog. Masking tape on the floor marked the central dividing line. The dogs were led to the starting point by one experimenter. The other experimenter stood on the target spot and attracted the attention of the dog by shaking a food bowl with some treats or by crinkling a treat packet and calling the dog's name. Before the onset of each trial, the dog's body and head were facing directly towards the target. As soon as the animal looked towards Experimenter 2, it was released by Experimenter 1, who did not move or speak for the rest of the trial. Experimenter 2 continued to call the dog until it passed the barrier. After each trial, the dog was led out through an exit behind the target and returned to the testing area via another entrance behind the starting point.

Experiment 1

Twenty dogs of various breeds took part in the experiment (4 Border Collies, 6 Labrador Retrievers, 2 Dobermann, 1 Dalmatian, 2 Border Terrier, 1 Whippet, and 4 of mixed breed). Twelve were male and eight female, all between the ages of one and 12 ($M = 4.4$ years). Dogs were provided by private owners and had all been kept as pets from birth. Participants were each randomly assigned into one of two groups ($N = 10$), one group taking part in the transparent barrier condition ($M = 4.2$ years) and the other in the opaque barrier condition ($M = 4.6$ years). The sex ratio in each group was M/F: 6/4.

Each dog had four 'A' trials, starting either on the left or on the right. After the fourth trial and before the dog re-entered the testing area, the barrier was shifted so that the gap was on the opposite side. Four 'B' trials were then carried out following the same procedure. If the dog went straight to the gap without going into the blocked half of the starting area, the trial was scored as correct. The time from release to passing the barrier (with the shoulder) was coded from the video tape. Food reinforcement and verbal praise were given by Experimenter 2 upon successful completion of a trial. A trial was stopped if a dog did not cross into the target area after 2 min. The dog was then led back to the starting point and the next trial begun.

Results

Figure 2 shows the performance for both experimental conditions, opaque and transparent. The performance for both groups reached 100% from trial A3 onwards. In their first trial after the swap of the gap location (B1), not a single dog went straight to the new location. Dogs in the opaque condition performed above chance in all A trials and again in B3. Dogs in the transparent condition were significantly above chance level in A2, A3 and A4, and reached this level again in B4. Although the dogs in the opaque condition seemed to solve the problem faster in their first A trial (see Fig. 2), and with fewer detours, these differences were not significant (time A1: *t*-test, $t = 1.771$, $df = 18$, $P = 0.093$; dogs correct A1: Yates' $\chi^2 = 0.313$, $df = 1$, $P = 0.576$). No other differences in time or performance were significant. Overall, the transparency of the barrier had no influence on the performance of the dogs. Therefore, all data were combined for further analysis.

Overall, the dogs performed significantly above chance on their first four trials (binomial test: A1, $P = 0.012$; A2, A3 and A4 $P < 0.001$). Not a single dog scored correctly on B1. On trial B2, they reached chance level (binomial test: $P > 0.99$), and on the last two B trials, they were above chance (binomial test: B3 $P = 0.012$, B4 $P < 0.001$). The dogs reached a perfect performance level from the third A trial onwards. But they never reached 100% again within the four B trials. The only significant difference in the time taken for the barrier crossing between each A trial and its corresponding B trial was for the first one (paired samples *t*-test: $t = -3.703$, $df = 19$, $P = 0.002$). Although the animals could learn how to navigate their way through a gap in a straight barrier after two trials, they seemed unable to unlearn the previously successful route. In their last three B trials, their crossing time did not differ significantly from the corresponding A trials but their error rates were significantly higher for B1, B2 and B3 (Wilcoxon: A1/B1 $Z_{(19)} = 4.0$, $P < 0.001$; A2/B2 $Z_{(19)} = 2.309$, $P = 0.021$; A3/B3 $Z_{(19)} = 2.0$, $P = 0.046$; A4/B4 $Z_{(19)} = 1.414$, $P = 0.157$).

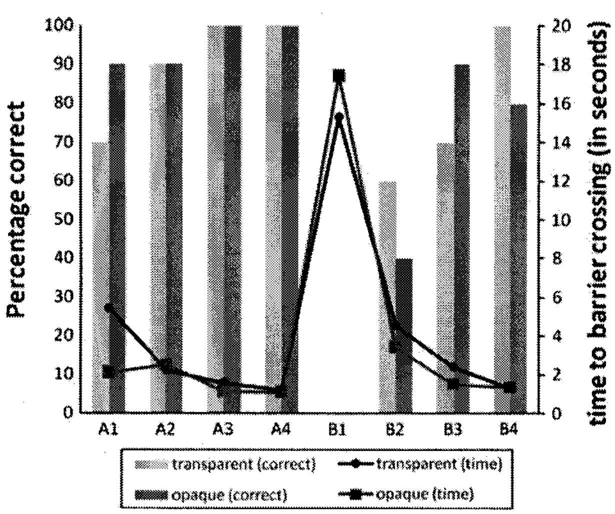

Fig. 2 Time to barrier crossing and percentage correct for four A trials, transparent and opaque barriers. Percentages between 20 and 80% are not significantly different from chance (binomial test)

Discussion

We found that the transparency of the barrier had no influence on the task performance. This was in direct contrast to Chapuis and Varlet's (1987) findings that dogs would switch to allocentric cues when the goal was not visible. Their reliance on egocentric spatial navigation (established path) was much stronger than their use of allocentric information (visible gap). This was rather surprising as the gap in the B trial was exactly the same size and distance to the starting position as the one in the A trials. The dogs seemed to abandon the use of visual cues once the route had been established and headed straight to the closed gap in their first B trial. But even over three more trials with the gap in the B location, the dogs did not recover their perfect performance levels from trials A3 and A4. The data showed that spatial detour behaviour in dogs was well established and very difficult to extinguish after four repeats.

Experiment 2

Our next experiment investigated how many repetitions would be necessary for this switch from allocentric to egocentric navigation to occur. Earlier studies have shown that dogs stick to previously learned paths on a variety of detour tasks, as discussed in the introduction. The number of repetitions required to establish perseveration behaviour in a simple straight barrier task has not yet been established.

Method

We used the same set-up as in Experiment 1, with transparent barriers only, and changed the gap location either after one, two or three A trials. Each dog still had four B trials. Thirty naive dogs of various breeds were used (14 mixed breed dogs, 1 Husky, 2 Miniature Schnauzer, 4 Jack Russell Terriers, 1 Pug, 1 Nova Scotia Duck Tolling Retriever, 1 St. Bernhard, 1 Great Dane, 1 German Shorthair Pointer, 1 Bijon Frise, 1 Tibetian Terrier, 1 Labrador, 1 German Shepherd). Fourteen were female and sixteen male, all between the ages of 6 months and 14 years ($M = 3.4$ years). All dogs were kept as pets. The animals were randomly assigned into one of three groups (A1—one A trial, $N = 10$, mean age = 2.7 years; A2—two A trials, $N = 10$, mean age = 4.5 years; A3—three A trials, $N = 10$, mean age = 3.1 years).

Results

Figure 3 shows the success rates and the time taken for the barrier crossing for each of the three conditions. In condition

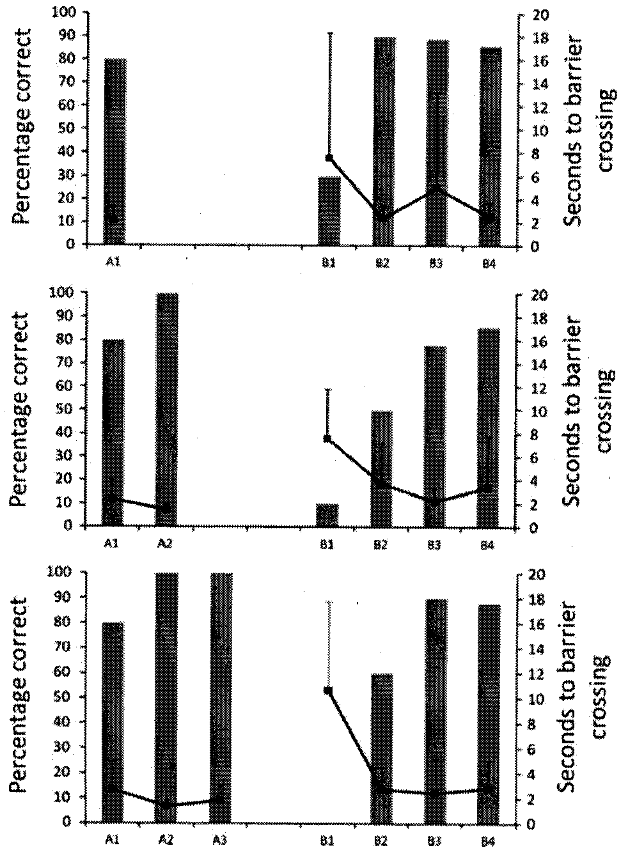

Fig. 3 Percentage correct and time to barrier crossing for one, two and three A trials. The *error bars* indicate mean time + SD

A1, eight of the ten dogs went straight to the gap in the barrier. After the change, only three animals did not venture along the previously correct path. This is not significantly different from chance (binomial test, $P = 0.344$). Even after several B trials, the dogs did not reach 100% performance levels (B2 = 90%, B3 = 90%, B4 = 86% [the data for three dogs are missing for their B4 trials due to a procedural error]). There was no significant difference in the time taken to cross the barrier between A1 and B1 ($t = -1.621$, $df = 9$, $P = 0.14$). In condition A2, there were no more mistakes for the second A run and the dogs went straight to the gap. After the change, one single dog (the Great Dane) solved the problem, and all other dogs went along the previously reinforced path. Even on trial B2, half the dogs still went wrong. They never reached the perfect performance of A2 again, even after four repeats. The time it took them to cross the barrier was significantly higher in B1 than in A1 ($t = -3.461$, $df = 9$, $P = 0.007$), but not for B2 vs. A2 ($t = -1.926$, $df = 9$, $P = 0.086$). The results for three A trials are comparable (condition A3). Again, the dogs reached the optimal performance level within two trials, and never recovered back to it within the four B trials. Every dog showed the perseveration error on trial B1, four of them still on trial B2. The time difference between A1 and B1 was significant ($t = -4.091$, $df = 9$, $P = 0.003$), but not between A2 and B2 ($t = -2.139$, $df = 9$, $P = 0.065$) and A3 and B3 ($t = -0.882$, $df = 9$, $P = 0.4$).

The time needed to pass the barrier after the swap correlated significantly with the number of A trial repetitions (Spearman's Rho = 0.454, $P < 0.001$) (including Experiment 1).

Discussion

We found that dogs exhibited a spatial perseveration reliably after two or more repetitions. Their failure to walk straight to the new (but obvious, accessible and equally distant) gap was surprising to every observer. The transparency of the barrier had no influence on the results. The performance of the dogs reminds of the so-called 'Kerplunk' experiment by Watson and Carr (1908). Although their animals, rats, needed extensive training with running down a maze until they failed to utilise visual or olfactory input, the dogs in our study only needed two repeats for their kinaesthetic feedback to take control over their movements. Like the rats that ran into walls when their maze was shortened, several of our subjects almost hit the barrier. They seemed not to process any visual input during their approach to the previous gap location. Their habitual motor response overruled other sensory input and these results show the strength of conditioned stimulus–response behaviour in dogs. As all subjects faced straight forward at the beginning of each trial, they could not utilise linear egocentric spatial information (body orientation) to guide them around the barrier to their target. In a simple, repeated detour task, the canine navigational system relies strongly and primarily on learned motor responses, even if this leads to longer routes and possible failure to reach the goal. The implications of our findings for dog training and for experimental design are far reaching. Any task that involves spatial learning needs to be designed in such a way that a dog would not be allowed to repeat any path that might need to be changed during later stages. For example, if a dog is allowed to enter the weaves in agility training wrongly more than once, it may be extremely difficult to untrain this incorrect behaviour. In experimental designs, researchers must keep in mind that a repeated visit to one target might be based on simple perseveration, not on higher cognitive abilities.

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