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Dogs are able to generalise directional acoustic signals to different contexts and tasks

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ABSTRACT

Previous studies suggested that dogs are able to use both egocentric and allocentric cues spontaneously in specified spatial tasks. They can also learn rapidly 'go-left/go-right' tasks based on stimulus location but relying on stimulus quality. At the same time, relatively little research has looked at the possibility of whether dogs are able to solve a spatial problem based on previously trained signals in novel situations. In the present study we have examined whether dogs are able to rely on quality differences in sound stimuli for directional behaviour and to generalise this rule in different field conditions. First, we trained 16 adult pet dogs in the lab to go left and right based upon qualitatively different sound signals. After having reached the criterion, subjects participated in five field test sessions that included several novel targets (balls/trees/humans) at different distances (7–18 m) and angular deviations (36°–87°). We wanted to see whether these aspects of the novel context affect the dogs' performance. After having reached the criterion, subjects participated in five field test sessions that included several novel targets at different distances and angular deviations. The test sessions were followed by a control session in the laboratory in order to exclude the Clever Hans effect. We found that dogs chose the target object that matched the sound signal significantly above the chance level in each test condition and also in the Clever Hans control. Their performance was not affected by different targets and distances, but decreased as a function of angular deviation. These results suggest that dogs are able to learn the 'go left/go right' task based on qualitatively different sounds and utilise this rule in novel situations. The angular deviation in choosing the correct target direction proved to be an important factor in the dogs' performance in a novel context.

1. Introduction

Dogs (*Canis familiaris*) are descendants of territorial predators, wolves (*Canis lupus*), and it is expected that they are able to learn and use the location of objects in space (Gallistel, 1990). Two different types of basic mechanisms are used for spatial navigation. The egocentric orientation relies on one's own body position in space, while in the case of allocentric orientation the animal uses the position of an external cue (beacon or landmark) as a reference (Pohl,

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1973). Relying on either type of information has advantages as well as disadvantages. Allocentric cues provide high flexibility for the animal because they allow the utilisation of several different pathways to the same target. Egocentric spatial information provides relatively inflexible information for navigation, however it is useful to rely on if environmental conditions are permanent, no environmental cues are available or the goal is near the animal (Fiset et al., 2006).

Several studies have shown that dogs are able to use both egocentric and allocentric navigation spontaneously to solve different spatial tasks (e.g. Head et al., 1995; Milgram et al., 1999; Chan et al., 2001) and that their spatial encoding process is flexible and can be adjusted to the particularities of the situation. For example, Fiset et al. (2006) examined the geometric components used by domestic dogs in an object permanence task and reported that dogs preferred a linear egocentric frame of reference when they were searching for the location of a disappearing object regardless of the distance between their own spatial coordinates and those of the hiding position. Thus, dogs' performance in finding the hidden object did not differ when the object was moved from 100 cm to 142 cm from the starting point, that is, they did not simultaneously use the vector components of direction and of distance to locate the target object. At the same time, dogs seem to have difficulty using allocentric cues to locate a hidden object in some situations (Fiset and Malenfant, 2013), but they may be able to use allocentric spatial information when the linear egocentric information is not available. Fiset et al. (2006) also found that the angular deviation between adjacent hiding locations and the position of the dog had an effect on dogs' performance: the subjects performed more correctly if the angular deviation between the two hiding places was 15° rather than only 5°. Dogs tried to minimise angular deviation from the target in a detour task in which the shortest route to reach the desired goal was unavailable but the target was visible. Thus, they preferred the less divergent path over the shortest route. However, if the target was invisible they chose the shortest route regardless of the angular deviation (Chapuis et al., 1983).

In a landmark discrimination task Milgram et al. (2002) trained dogs to choose the food-container closest to a small landmark (yellow wooden peg) in a two way choice task. Next, dogs were exposed to a similar task with a novel landmark (pink heart-shaped object), and finally, this novel landmark was moved to novel positions. Dogs' performance remained stable throughout these novel conditions. The authors concluded that dogs generalised both to the shape and relative position of the landmark, thus they were using a general concept of the landmark to solve this two-way choice task.

Dogs are also able to learn go/no-go tasks based on differences in stimulus quality and go-left/go-right tasks based on differences in stimulus location, whereas the opposite stimulus-action pairings are more difficult to learn (Lawicka, 1964; Dobrzecka et al., 1966; Dobrzecka and Konorski, 1967; Konorski, 1967; Dobrzecka and Konorski, 1968; Lawicka, 1969). These results raise the Quality-Location Hypothesis suggesting that the quality of a stimulus best serves as a cue for the quality of a response, whereas the location of a stimulus facilitates the orientation of the action. Although several researchers assumed that this hypothesis is fundamental to understanding possible constraints of learning (e.g. Miller and Bowe, 1982), others argued that the quality-location distinction effect in these studies stems from the experimental design and is highly affected by the inclusion or exclusion of naturalistic features (e.g. Harrison, 1984; Neill and Harrison, 1987). The finding that herding dogs can be directed by voice commands (or whistles) of different tone and pitch of the human shepherd during cooperative herding (McConnell and Baylis, 1985) also casts some doubt on the Quality-Location Hypothesis.

The main goal of the present study, therefore, was to find out whether dogs trained to perform oriented movement (go left/right) in response to different acoustic signals are able to generalise this experience to novel contexts. In this latter phase of the training we also investigated whether or not salient objects placed in the target area improve dogs' learning efficiency in the go left/right task. We assumed that dogs trained to approach a conspicuous target (small object on the ground) upon hearing the signal would show a better performance than those who had to approach a specific spatial location (left/right corner) in the room. The less specific nature of the latter task (i.e. the absence of a specific target object which could be approached) predicts a slower learning rate (c.f. Fiset et al., 2006). In the second part of the study, dogs were exposed to novel situations where they had to rely on the same acoustic signals to solve a series of new spatial tests. We applied several novel targets in these test situations at different distances and angular deviations in relation to the dogs' starting position. We measured the dogs' performance which was calculated on the basis of the number of correct choices after receiving the sound signal. We assume that dogs' performance would not drop in the novel context independent of their distance to the target, partly because they are able to generalise learnt behaviour to novel contexts (Lindsay, 2000); for example, Braem and Mills (2010) reported that dogs are able to generalise a novel acoustic signal (verbal cue)-action association learnt in Room A to Room B.

2. Materials and methods

2.1. Subjects

Sixteen adult pet dogs (mean age ± SE: 5.5 ± 2.5 years) were recruited for this study. The participants were 5 male and 11 female dogs from different breeds (3 Border collies, 2 Mudis, Hungarian Vizsla, Labrador, Golden Retriever, Groenendale, Beauceron, Nova Scotia Duck Tolling Retriever, Croatian Sheepdog, Boxer, 3 mongrels). All dogs were clicker trained (by the means of the shaping procedure) and trained for fetching and going ahead. Regarding the training of the "going ahead" command, dogs were trained for two different tasks as a part of the obedience training: (1) based on the combination of owners' verbal and hand signals, owners used clicker-training to positively reinforce moving away from the owner in a straight line (0% deviation) in a given direction without a visible target, (2) dogs were also trained with clicker to go