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The nose may not know: Dogs' reactions to rattlesnake odours

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ABSTRACT

According to anecdotal reports from dog (*Canis lupus familiaris*) owners and data from veterinary studies, domestic dogs often fail to avoid, and indeed will approach, venomous snakes. Accordingly, we tested the hypothesis that odours associated with rattlesnakes will elicit investigation, but not a negative emotional reaction, from domestic dogs. In a repeated measures design using newspaper on which southern Pacific rattlesnakes (*Crotalus oreganus helleri*) and other stimulus animals (rosy boa, *Lichanura trivirgata;* mouse, *Mus musculus*; and snail, *Cornu aspersum*) had lived, we found that dogs did indeed sniff the rattlesnake stimuli more so than rosy boa or snail, but less than mouse ($p < 0.05$). Using nostril choice as our measure, whereby preferential use of the right nostril (right hemisphere) may indicate negative emotional arousal, we failed to find any evidence that rattlesnake odours elicited negative emotional states. Given that dogs are motivated to investigate, but may not be made afraid by, rattlesnake odours, our data provide a potential explanation for the reported high rates of rattlesnake envenomation of dogs.

1. Introduction

Domestic dogs (*Canis lupus familiaris*) are at risk of coming in contact with venomous snakes in regions where such snakes are common. One published report estimated that there are more than 15,000 snakebites inflicted on pets (presumably mostly dogs) each year in the United States (Peterson and Meerdink, 1989). A study of antivenom effectiveness reported 272 cases of rattlesnake envenomation in dogs treated at five emergency veterinary clinics in Maricopa County, Arizona, in just a two-year period (Witsil et al., 2015). Although the contexts of dog-snake encounters are not systematically recorded, there is reason to believe that when dogs are bitten it is often because they fail to avoid snakes they encounter. For example, in areas where rattlesnakes are common and endemic, such as Arizona, there is a market for rattlesnake aversion training classes (Titcomb, 2005). Witsil et al. (2015) reported that 83% of the envenomated dogs in their study were struck in the face/head/neck, suggesting that the dogs attempted to investigate the snake prior to the strike, although such wounds might also reflect defensive maneuvers by dogs.

Evidence from controlled studies is harder to find. Weldon and Fagre (1989) tested the hypothesis that cloacal gland secretions from rattlesnakes act as repellants to potential canid predators. They found that wild coyotes (*Canis latrans*) were just as likely to investigate rattlesnake scents as they were to investigate a commercially available odour designed to attract coyotes. Similarly, dogs living in kennels approached and sniffed rattlesnake odours as often as they did the dichloromethane in which the rattlesnake extracts were mixed. The authors concluded that rattlesnake scent repels neither coyotes nor dogs.

Many species of mammals have developed antipredator behavior aimed at avoiding snakes (e.g. squirrels, Goldthwaite et al., 1990; Owings et al., 2001; Clucas et al., 2008; monkeys, Corrêa and Coutinho, 1997; Cagni et al., 2011). Dogs are recent descendants of gray wolves (*Canis lupus*), having first been domesticated about 20,000–40,000 years ago in Europe (Botigué et al., 2017), although there are ongoing arguments about location, timing, and origins of domestication (Wang et al., 2016; Shannon et al., 2015). The 34-million-year evolutionary history of the subfamily Caninae (Wang et al., 2004) is shared with venomous snakes, which first appeared about 60 million years ago or even earlier (Vidal and Hedges, 2002). Given their formidable olfactory capabilities, and the rather potent odours produced by the cloacal glands of rattlesnakes (Weldon and Fagre, 1989), one might predict that dogs would show aversion to the odours of venomous snakes, but this does not appear to be the case. Notably, however, no study has attempted to assesses dogs' emotional reactions to snake odours.

Assessment of the emotional reactions of animals can take advantage of the fact that emotional reactions are lateralized. Hundreds of studies of mammals and other taxa point to the conclusion that the right hemisphere is specialized for withdrawal reactions and the processing of negative emotional states such as fear, whereas the left hemisphere is more involved in situations where approach and investigation are warranted (for a review, see Leliveld et al., 2013). Siniscalchi et al.

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(2010) found that dogs turned their heads to the left (right hemisphere) when a silhouette of an arched-back cat was presented simultaneously to the dog's left and right sides. The same was true when the silhouette was that of a snake, but not a dog. The authors concluded that the threat posed by an aggressively postured cat or snake preferentially invoked the right hemisphere and a negative emotional state. If these results are indicative of a fearful reaction when dogs see snakes, the tendency of dogs to approach snakes under natural conditions is harder to explain.

Here we test the hypothesis that dogs are interested in (approach and sniff), but do not react fearfully to, rattlesnake odours. The olfactory pathways project ipsilaterally to the olfactory bulb and cortex (Mori et al., 1999; Scott et al., 1980); use of the right nostril might suggest the activation of the right hemisphere and hence a more withdrawal-oriented emotional state than use of the left hemisphere. Bensafi et al. (2002) found that human reaction times to unpleasant odours were faster when those odours were sniffed with the right nostril. Siniscalchi et al. (2011, 2016) found right nostril preferences for sniffing sweat from veterinary staff and perianal, interdigital, and salivary odours from dogs who had been placed in stressful contexts. Our prediction is that, in accordance with reports that dogs often fail to avoid venomous snakes, we will see high rates sniffing of snake odours with no preference for using the right nostril in doing so.

2. Material & methods

2.1. Subjects

Subjects were 117 domestic dogs (*Canis familiaris*) of various breeds (41% female, 59% male) from North San Diego County, California, USA. All dogs were pets living in households and were recruited with their owners at three local dog parks. The dogs ranged in age from 4 to 156 months (mean ± SD = 45.72 ± 40.54) and weighed between 5 and 165 lbs (mean ± SD = 49.66 ± 29.69). Most had been spayed/neutered (93.8% of females and 72.5% of males). 'Mixed breed' accounted for 45% of the subjects.

2.2. Materials

Odour stimuli consisted of plain newspaper and four animal odours (mouse, rattlesnake, rosy boa, and snail). Five pet house mice (*Mus musculus*; 4 females, 1 male; housed in pairs), 13 (nine male, four female) southern Pacific rattlesnakes (*Crotalus oreganus helleri*), housed individually at a research laboratory at San Diego State University, two male pet rosy boas (*Lichanura trivirgata*; housed individually), and 30 pet brown garden snails (*Cornu aspersum*; housed in groups of 15) provided the odours for this study. All of these species are native to southern California. These odours were selected to represent odours that are associated with animals that live in this area and with which dogs might have some familiarity, as they might with rattlesnakes. It was particularly important to include another snake, but one that is not dangerous to dogs. Newspaper was placed inside the animals' cages for two weeks before being removed and stored in a freezer. Newspaper was collected over the course of about seven months, such that the dogs were not sniffing odours taken from a single, short period of time. To create the stimuli, we placed 1.60 g of newspaper in a 5 oz plastic cup with ten holes punched around the rim of the lid. Diameter of the lid was 7 cm. The newspaper was always handled with gloves and prepared on a surface that was cleaned with alcohol and bleach between stimulus types. Stimuli were kept in labeled bags in a freezer (-10° F) until defrosted approximately 1 h prior to data collection.

2.3. Procedure

Data were collected between April 2016–February 2017 between 09:00 h and dusk in a 3 m × 3 m sized area at the entrance to the dog parks. Owners who appeared over 18 years of age were approached upon leaving the dog park and asked if their dog(s) could participate in the study. Each owner was given information about the study and signed a consent form regarding participation in the survey. Dog owners were asked if their dog had any recent respiratory illness or had any history of repiratory/facial injury or malformation. Any such dogs were eliminated from the study.

A research assistant instructed the owner to stand in a small circle, four feet away from the stimulus presenter, and hold his/her dog on a tight leash at his/her side until instructed otherwise. During the presentations, the presenter held a single cup and called the dog over by name. The owner was asked to remain in the small circle but hold the leash loosely, thereby allowing the dog to move toward the presenter to investigate the stimulus. The cup was held at arm's length; as the dog approached the presenter moved her arm to remain perpendicular to the dog's nose, up until the moment when contact (nose within 2.5 cm of the cup) was made. At that point the presenter did not move her arm again. Owners were told to not provide any guidance or encouragement (physical or verbal). Any dogs that were directed or physically guided by their owner to sniff any stimulus were not included in any analyses. If a dog was distracted during its trial (e.g., if another dog began barking nearby) its data were not included in any analyses. If after about 30 s the dog showed no interest in sniffing a cup, the trial was ended.

Once the dog initiated a 'sniff' (nose was within one inch of the cup), the cup was held still and the 30 s presentation period began. Each dog participated in all five conditions (newspaper control, snail, boa, rattlesnake, and mouse) with each cup presented in a pre-determined random order with the presenter blind to condition. After 30 s the next cup was presented to the dog, usually within 15 s of the previous presentation. Each trial was recorded using a GoPro Hero3 or Hero4 videocamera (GoPro; San Mateo, CA, United States) worn by the presenter and angled downward to record each dog's nose. After the dog had sniffed all five cups, a research assistant asked the owner questions about the age, sex, breed, and snake experience of the dog. Both the Institutional Animal Care and Use Committee (IACUC #16-001) and the Institutional Review Board (IRB #866896-3) at CSU San Marcos approved the research.

Research assistants later coded behaviour from the videos while blind to condition using Tracker video analysis software (Brown, 2017; version 4.11.0; Open Source Physics; Aptos, CA, United States). The videos were advanced frame by frame (0.05 s frame size), recording frame numbers for all behaviours and later converting into seconds. Behaviours included time spent sniffing during the 30 s stimulus presentations (nose remains within 2.5 cm of the stimulus), number of sniffing bouts (number of times the dog moved away and then returned to within 2.5 cm of the cup, with the provision that at least 10 frames of the film had passed) and nostril use (left, right, or both). Sniffing time and number of bouts were coded by 3 research assistants; reliability was assessed by coding the same 40 trials (ICC = 0.987). A subset of 76 dogs, whose nostrils remained in clear view on the video recordings during all odour presentations, were used to examine nostril use. For nostril use, a single nostril was recorded if that nostril was inside the perimeter of the cup while the other was outside. Both nostrils were indicated when a dog had both nostrils within the perimeter of the cup (see Fig. 1). Nostril use was coded by one research assistant and reliability was assessed by a blind recoding of 20 trials (r = 0.952).

2.4. Data analysis

Repeated measures ANOVAs were run to examine differences in the amount of time spent sniffing, and number of sniffing bouts across the five odour conditions. Kolmonov-Smirnoff tests and Q–Q plots confirmed that all dependent variables were not normally distributed ($p < .05$); however ANOVAs are robust to violations of normality (Schmider et al., 2010) and analyses proceeded as planned. We ran Fischer's LSD tests to follow-up the ANOVAs when appropriate.