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Cadaver dogs: Unscientific myth or reliable biological devices?

Irene Riezzo, Margherita Neri, Marcello Rendine, Alessandro Bellifemina, Santina Cantatore, Carmela Fiore, Emanuela Turillazzi *

Department of Forensic Pathology, University of Foggia, Ospedale C. D'Avanzo, Viale degli Aviatori 1, 71100 Foggia, FG, Italy

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ABSTRACT

Dogs are commonly used to detect explosives, narcotics, and other illegal materials. In the forensic setting, cadaver dogs are trained to detect and locate concealed human remains or fluids due to the high sensitivity and selectivity of the canine olfactory system and the relative ease with which dogs can be trained and handled. The need for international and scientifically validated standards has long been outlined by the literature. It is important, therefore, to establish the reliability of the handler/dog team. Our study aimed to detect the real effectiveness of dogs trained to locate human cadaveric blood in very low concentrations, through an optimized and rigorously controlled design which would rule out any possible sources of bias. The study was designed to determine the dogs' olfactory sensitivity to human cadaveric blood and how this capacity might change as the dilution of blood increases from pure blood to very low concentrations. The further step was to examine the dogs' ability to discriminate among target (human cadaveric blood) and non-target (confounding substances) odors (discriminative capability). Our results revealed that well trained dogs were able to detect human cadaveric blood samples even when very low concentrations of blood were stored in the tubes, showing high levels of olfactory sensitivity and to discriminate the target odor even when the non-target odor was orders of magnitude higher in concentrations. Although our results are based only on two dogs, the procedure we used may provide a comprehensive answer to the need for a scientifically unassailable tool for quantifying and objectifying the performance of well-trained specific search dogs in detecting human cadaveric blood traces.

1. Introduction

Due to the high sensitivity and selectivity of the canine olfactory system, and the relative ease with which dogs can be trained and handled, working dogs have been routinely used for decades as the primary means to detect a wide range of substances in environments that contain complex background odors [1,2]. Dogs are commonly used to detect explosives, narcotics, and other illegal materials. In the forensic setting, dogs, referred to as cadaver dogs, are also trained to detect and locate concealed human remains or fluids [3]. In fact, the canine olfactory system is well-adapted to the detection of a vast number of odorous substances varying in shape and size [4] as well as molecules showing subtle differences in stereoisomeric structure [5]. Even minute amounts of a particular odorant may be detected and recognized due to the extraordinary sensitivity of the dog's nose [6–8].

Although dogs seem to be remarkably effective at detecting a variety of targets, little is known about how they accomplish detection tasks or their effectiveness in doing so [6]. Similarly, little is known about how to optimize their performance [6]. Moreover, the effectiveness of these "specialist, biological devices" must be subjected to the same level of scientific scrutiny as other detection technologies [6].

The need for international and scientifically validated standards has long been focused by the literature [9–16], where it was outlined that forensic science demands a very high level of validity [9]. The existing literature concerning detection dog performance consists of studies describing basic olfactory capabilities and field studies of detection dogs have largely been limited to demonstrating the utility of dogs as detectors of various substances [6]. However, little is said about the way the dogs are trained, the experimental design of identifications, and, consequently, about the reliability of the identifications themselves [9].

Our study aimed, therefore, to detect the real effectiveness of dogs trained to locate human cadaveric blood in very low concentrations, through an optimized and rigorously controlled design which would rule out any possible sources of bias. The study

* Corresponding author. Tel.: +39 0881 733193; fax: +39 0881 736903.
E-mail address: emanuela_turillazzi@inwind.it (E. Turillazzi).

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was designed to determine the dogs' olfactory sensitivity to human cadaveric blood and how this capacity might change as the dilution of blood increases from pure blood to very low concentrations. The further step was to examine the dogs' ability to discriminate among target (human cadaveric blood) and non-target (confounding substances) odors (discriminative capability) [17].

2. Material and methods

For this investigation, two dogs (dog A: Labrador Retriever, male, five years old; dog B: Labrador Retriever, male, three years old) were recruited from a pool of ten dogs. The candidate canine had to be structurally sound, well socialized, and already under the handler's control. The animals were fed with standard dry dog food, had free access to fresh water, and were provided with daily walks. The recruited dogs had not previously been used in scientific odor discrimination work. The dogs were handled by professional dog handlers during the training and testing sessions. The training and testing process involved no violence toward dogs and was based exclusively on operant conditioning (or shaping behavior) with positive reinforcement, including the use of a clicker.

2.1. Dog training procedure

The training procedure lasted 16 months. Overall, 6240 searches and 200 h of simulation were performed for both dogs. Dogs were trained using a positive reinforcement clicker technique and food reward/praise. The dogs were trained to issue a (sitting) passive alert, without barking, upon detection of the target scent. Each session had the same two observers present. This was a double-blind study: neither handler/dog teams nor observers were aware of the conditions of each search section; they were blind both to the sample positions and to the presence/absence of the target odor. Handlers had to call out the number of the hole suspected of containing the target odor based on the dog's choice. To avoid the possibility of mistakes by the handlers (i.e. rewarding the dogs for false alert), when a handler "called an alert" the observers recorded the alert location specified by the handler. Observers recorded alerts as called by handlers and did not evaluate the validity of alerts. The experimenter was the only person who was aware of the conditions of each search section. Using a live speaker-phone system, the experimenter, who was visually isolated, then informed the handlers whether the choice was correct, allowing the handler to reward the dog appropriately

"Phase 1" commenced in which dogs had to indicate the blood sample randomly placed in a hole, with empty test tubes in the remaining holes (blank, odorless value). Approximately 2 ml of blood was placed in the sample tube. We measured and recorded the performance of detection dogs in a series of 720 tests for each dog. In particular, nine series, each containing 80 tests, were performed for each dilution in physiological solution, from "pure" cadaveric human blood to 1:1000,000. In this phase only one target sample was placed in the testing arena; all the other holes were odorless (blank). However, the dogs were requested to sniff all the containers in the testing arena. A randomly distributed number of true negative trials (no target odor present) was performed. If the response was a correct detection (i.e. the target was present and the detector dogs reported its presence), it was classified as a true positive; however the dogs were requested to sniff all the holes placed in the texting arena. If the response was a false alarm (i.e. the target was not present and the dog reported it was present), it was classified as a false positive. A false negative was recorded when the target, physically present, was not signaled by the dogs. In these cases, only for training purposes the trial was repeated to refresh the memory of the dog until the dog performed without any misses or false alarms for five consecutive trials. A true negative was recorded when the target was not present and the dogs did not issue any alert.

In "Phase 2", we selected several confounding odorant compounds in an effort to mimic the possible scents of a real crime scene. Consequently, we used the main detergents commonly employed for cleaning the scene, as well as swine blood because of its similarity to human blood in the process of decomposition, food and dog's menstrual blood, which can be perceived by dogs as a distraction. Ferrous chloride and ferric sulfate scents similar to human blood; urine contaminated by blood was also used as confounding factors.

In the first ten series, each with 80 trials, the concentration of both the target (human cadaveric blood) and non-target (confounding substances) odors were held constant (pure) across all the trials and sessions. In a later stage of the training procedure we used increasingly diluted blood (target-odor) from pure blood to 1:1000,000 dilution with the non-target odorant compounds at constant pure concentration. In each series, except for the number 10 when all the confounding odorant compounds were simultaneously present each in a different holes, only one substance was tested versus human blood: one hole contained the target odor (human blood), one hole contained the selected non target odor, and the others were blank (odorless). The four possible outcomes of phase 2 were the same we used in phase 1.

2.2. Sample collection and preparation

Blood samples from corpses of subjects dead from traumatic causes were collected using the same protocols, at the same locations and by the same research team to ensure they had the same general background odor. In total, four blood samples from different cadavers were collected within 4–5 h from death and used over the course of the training period (Table 1). The cadaveric blood was diluted using a saline solution from pure blood to a dilution of 1:1000,000. The samples were collected in 10 ml tubes and frozen at −20 °C within 10 min. Samples were transported to the testing center on dry ice, defrosted in a 37 °C water bath, and then presented to the dogs.

2.3. Experimental setup

In order to standardize the environment, it was decided that our test procedure should take place exclusively indoors. The search location was an enclosed, confined room that had not previously been used for detection dog training purposes (Fig. 1). The room was far from the cold storage area of corpses waiting for post-mortem examination, in order to minimize a potential cross

Table 1
Blood samples.

Blood sample	α	β	γ	δ
Race/sex	White male	White female	Black male	Black female
Age	22 years old	26 years old	22 years old	24 years old
Toxicological outcome	Negative	Negative	Negative	Negative