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Keywords

cadaver, dog, training, olfactory, accuracy

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Understanding Cadaver Dogs

Dogs have been next to mankind for thousands of years; King Frederick II of Prussia once said, “A dog is man’s best friend” (PetPlace Staff, 2017). We have all heard of this quote, and it has been evident throughout history from the civilized ancient Egyptians to the wild Vikings. The use of dogs is not a new 21st-century concept, as there is speculation that in ancient civilizations such as Egypt, Greece, and Assyria, dogs were used to make advances over enemy forces as well as help with hunting when wars were not being fought (Family and Friends Veterinary Care, 2022). Similar to the Egyptians, the Vikings used dogs to help with hunting which continued for centuries and became a common practice. More recently, in 1916, a German man started a school to train German Shepherds to serve as guides (PetPlace Staff, 2017). Another example is during World War II, in which American soldiers began to use dogs in a military capacity to such an extent that civilians donated their dogs to help the war (Svalinn, n.d).

However, dogs have been helping the military and the police before World War II. In fact, the first recorded example of a dog alerting to human remains was in the early 1800s. The bodies of two women were found in a man’s shed because a court clerk decided to take his dog for a walk around the suspect's home. This dog had no formal training to find human remains but they kept alerting to something being in the shed. Despite the incident, it took another 172 years for the use of dogs in finding human remains to be an official tool for investigators. The first cadaver dog, a yellow labrador retriever named Pearl, was employed by the New York State Police in 1974, and in the same year, she found the remains of a Syracuse College Student (Purgason, 2022).

It should be noted that cadaver dogs are a preemptive tool not a conclusionary one, as they are there to help locate possible remains based on their training. A licensed and trained anthropologist or coroner is required to come to the same conclusion that the findings are human remains. Although the use of dogs is a well-known practice in the field of forensic science today, many people do not realize the extensive training it takes to ensure impartial judgment, to perform or understand the science behind what breeds make a more reliable cadaver dog, and how they compare to other instruments used in forensic science.

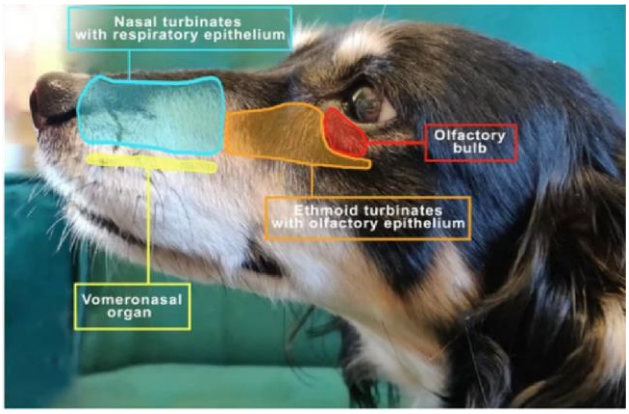
Literature Review

What Dog is the Best Choice for the Job?

The one trait that sets a dog apart from other mammals is their olfactory system, better known as their nose. According to Kokocińska-Kusiak et al. (2021), dogs, like most mammals, have a two-part olfactory system which includes a main olfactory epithelium (MOE) and a vomeronasal organ (VNO). The MOE spans from their nose to just under the dog's eye at the base of their snout. The VNO is a small organ that separates the nasal cavity and the oral cavity lying on top of the roof of the mouth. When a dog inhales, 12-13% of the air goes to the olfactory system and the rest goes to the lungs.

Figure 1

Canine Olfactory System



Note. Generalized anatomy of a dog's nose.

In the MOE, there are olfactory receptor cells (ORCs) that are bisected neurons that extend into the airway. Their job is to interact with odors, basal cells, and supporting epithelial cells. On the surface of the receptor cells, cilia can be found; each cilium only relays information to various types of olfactory receptor genes (OR genes). For an odor to be identified, a special combination of these OR genes needs to occur. “In mammals OR genes are composed of two exons, the second one containing all of the protein-coding region encompassing about 1,000 nucleotides” (Quignon et al., 2012). The article, *Genetics of Canine Olfaction and Receptor Diversity,* written by Quignon et al. (2012) explains that the first OR gene identified was an amino acid pattern of G-protein-coupled receptors (GPCRs). From this, scientists have been able to figure out that OR proteins have seven transmembrane domains and specific amino acid patterns that differ from other GPCRs. The study explained how the small size of the OR genes creates patterns allowing the inhaled air to be quickly identified through mining of the genomes and pattern recognition.

The next organ in the dog olfactory system is the Olfactory Bulb (OB), located just under the frontal lobes of the brain (reference Figure 1). “It is approximately 40 times larger in dogs than in humans, relative to total brain size” (Balance Behaviour, n.d.). Kokonińska-Kusiak et al. (2021) explain that within the OB there are bundles of nerve fibers called glomeruli that connect with incoming receptor cells. The OB is the start of the filtering and processing of information gathered from the MOE and VNO. This organ allows for discrimination between scents and they can filter out background scents to enhance a scent. A fascinating feature that dogs possess is that their whole olfactory pathway is uncrossed, unlike other sensory tracks. This means that the receptors that are received in the right nostril send a signal that flows directly to the right hemisphere of the brain, similarly to the left side; they never mix or go to the other side of the system.

Breeds

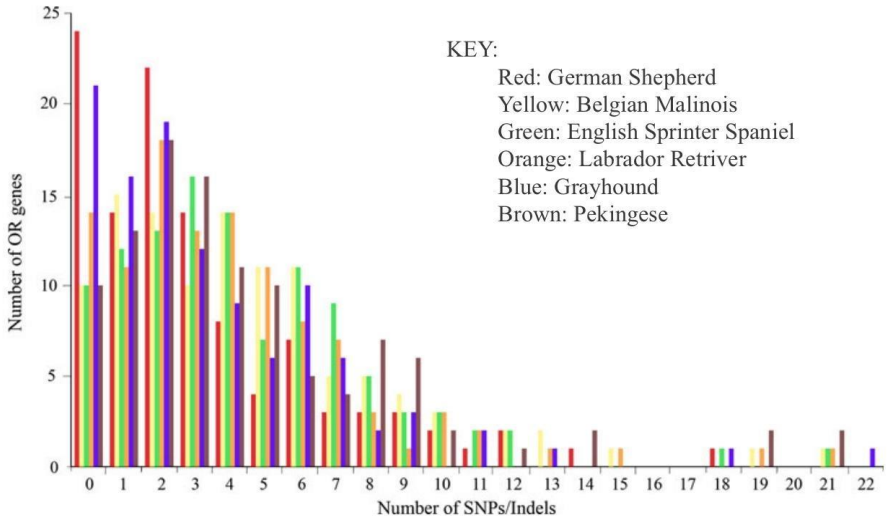
There is unfortunately not a lot of research on the different breeds’ olfactory systems when it comes to detecting dogs. Even though a range of dog breeds are used for scent detection, there is a debate about who is superior and scientists compare OR genes to determine this. “...[N]ot all dogs’ noses have an equal sense of smell. German Shepherds, which are a common breed of a cadaver dog, boast about 225 million olfactory receptors, while Dachshunds have closer to 125 million” (Mueller, 2021). As mentioned in the section above, OR genes are transmembrane G-protein-coupled receptors that hold and relay scent information to the brain. Within the OR genes, there is an SNP or single nucleotide polymorphism which “...is a genomic variant at a single base position in the DNA” (adenine, thymine, cytosine, or guanine). “According to the National Human Genome Research Institute, scientists study if and how SNPs in a genome influence health, disease, drug response, and other traits" (n.d.).

In *Genetic Diversity of Canine Olfactory Receptors* by Robin et al. (2009), they ask the question of what breeds are known for having superior skill at odorant detection and what gene alleles encoding OR genes give them the ability. In their research, they studied 48 dogs of six breeds: German Shepherd Dog (GSD), Belgian Malinois (BM), Labrador Retriever (LR), English Springer Spaniel (ESS), Greyhound (Grey), and Pekingese (Pek). They selected specific OR genes to represent the larger number of families (gene families) that are located on 20 chromosomes. These OR genes were also selected because they are found in genomic regions readily. When analyzing the sequences between breeds' levels, the total number of SNP varied a great deal. The dogs can use these genes in different ways to allow for a diverse degree of smell. Mueller writes that the more receptors a dog has, the better suited they are to complete the daunting task of locating human remains (2021).

In Grimm-Seyfarth's article on wildlife detection dogs, it is shown that the chosen dog breeds studied exhibit a high number of OR genes and specific SNPs that work more efficiently (2021). The breeds used in this study were pointers, setters, spitz, retrievers, waterdogs, scent hounds, and sheep/cattle dogs. As shown in Figure 2, there are varying degrees of SNPs between the different breeds of dogs. The study concluded that retrievers, bird dogs, and water dogs were used in 18.3% of cases (in 453 cases), Sheepdogs and Cattle dogs used 17.4% of the time (in 428 cases), and Pointers and Setters were used 12.8% (in 315 cases) (2021). These statistics show a preference for which dogs people utilize for detection. These dogs have exhibited the ideal behavior and traits that are needed for the working dog's lifestyle. When looking into what dogs are best for a task, the two things that need to be taken into account are genetics and breed; these traits will lead to a successful dog.

Figure 2

Six breeds of dogs' SNPs



Note. Distribution of SNPs and indels in 109 dogs from six breeds.

The Training Behind the Dogs

It is crucial to select a puppy that shows signs of intelligence and commitment in order to begin training for the work they would encounter throughout their adult life as a scent detection dog. Research on detection dogs, conducted by Maclean and Hare (2018), covers various studies that detail the criteria of the training on what makes working dogs actively focused, control their temperament, and perform in highly stimulating environments. Working dogs are put into situations where they encounter animals, unknown people, and other stimulants, creating an environment where they are required to remain calm and stay focused on their job. Maclean and Hare discuss the cognitive skills that are essential for working dogs to be certified. The training that they go through is more than the average dog; it is teaching them to tap into their natural senses to "...flexibly and spontaneously respond to barriers that might prevent the completion of a trained goal." They also have to "...maintain a mental representation of the referent of the

verbal command… in short-term memory even though it is not at first visible" (Maclean & Hare, 2018). Among other cognitive abilities required for specialized jobs, they cannot exhibit behaviors like being overly nervous or afraid. Ideal traits are "...being lively and interested in their environment, willing to work long hours, and reasonably intelligent and quick to learn… Boldness has been linked with success" but too strong of a prey drive leads a dog to think too much about the reward and not the task (Ensminger, 2012).

Also, many working dogs have to perform off-leash and it is key to have drive and discipline to perform searches and still return. Ensminger (2012) goes over what kind of training police dogs go through to perform at such a high level. He notes that in the past 20 years, the training style has changed for the better; previously aversive techniques were used, such as yanking on the leash, yelling, and even as far as hanging the dog by its collar. Today they are trained with positive reinforcement, including treats, toys, or praise depending on the dog's response. Ensminger talks about how dogs trained with positive stimuli perform significantly better than the dogs that are trained with aversive techniques.

The premise of all training is similar to a household dog but differs when asked to perform tasks such as smelling targeted scents. Depending on what the dog is being trained for, it could be as short as six weeks to some six years (California Rescue Dog Association n.d., Medium, 2018). For example, cadaver dog training could start as young as eighteen months and can last up to four years. Once the right dog is found and their behavior is indicative of training the process begins. The first step to training a cadaver dog is to imprint, to teach the dog target scents it will need to detect in the field. There are two ways to do this: the first is to use real cadaver material in various stages of decomposition or even soil samples found around a body; the second option is to use fake or artificial scents. Further, into a dog's training, it is important

to take into account external factors such as wind, temperature, terrain, and water, which are essential to a dog's training (Dorriety, 2007).

Cadaver dogs, like other scent-detection dogs, go through stages of training. Stage one is to get the dog generalized to the scent. Stage two determines if they can detect a scent that is not fresh. Lastly, stage three is to add decoy scents to see if the dog can distinguish differences (Oldenburg, 2016). It is important in all training to ensure that the dog's performance is consistent at the task being asked to perform before continuing and to not be reluctant to work on a previous step if the dog is not performing well (Rebmann, 2000). In recent years, the FBI has brought up the importance of End of Session Cues (EoSC). EoSC indicates the end of training or the day's work by using stimuli such as the trainer or handler taking off their work collar or having a play session (Martin et.al., 2020). It is crucial to follow basic training procedures to ensure that a dog is ready to participate in fieldwork when needed.

Cadaver Dogs

Accuracy

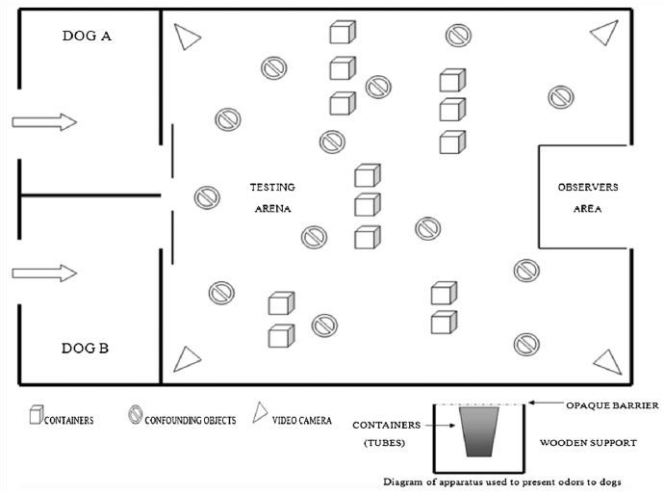
There is speculation regarding the accuracy of cadaver dogs and whether or not handlers are leading their dog. Although there is not a surplus of data and studies, there has been enough research to see a trend that cadaver dogs are useful in the field. Many people believe using dogs is an uncommon tool in police investigations. "The use of dogs to locate human remains is popular because they are accurate, relatively inexpensive, quick, thorough and can cover large areas functioning during day or night" (Lasseter et al., 2003, 1215). Riezzo et al.(2014) performed a study testing the capability of a dog's olfactory senses in locating human cadaver blood at differing concentrations. They performed a set of 2,920 trials for each dog. The first dog (dog A) was a male Labrador Retriever, five years old, and dog B was a male Labrador

Retriever, three years old. In this study, they performed two different blind off-leash phases to test the abilities of the dogs.

The first phase was to test if the dogs could indicate blood at a random location within the testing arena while placing odorless values (blanks) in the other locations. Within phase 1 there were nine series of 80 trials each; each series had a different concentration of blood ranging from “pure cadaver blood" to “1:1,000,000.” Dog A performed an overall 96.33% positive predictive value (PPV) in phase 1 with a total of 18 false positive alerts out of 720 trials. Dog B performed an overall 93.99% PPV with 39 total false positive alerts.

Figure 3

Diagram of the testing area



Note. The controlled testing environment that Riezzo et al. performed in their trials. Riezzo, I., Neri, M., Rendine, M., Bellifemina, A., Cantatore, S., Fiore, C., and Turillazzi, E. (2014). Cadaver dogs: Unscientific myth or reliable biological devices? *Forensic Science International.*

The second phase is divided into two parts. Part one contains testing the dog on a one-to-one ratio of blood to several different confounding odors. The odors mimic what a real crime

scene potentially smells like. Riezzo et al. (2014) described what odors were used in the testing arena:

> [W]e 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 [are] similar to human blood; urine contaminated by blood was also used as confounding factors (p. 214).

In this first part, dog A had a 97.78% PPV, and dog B had a 93.36% PPV. The second part of this phase was to dilute the blood percentage compared to the confounding factor starting with a 1:1 ratio and going to 1:1,000,000. In the 1,400 trials, dog A got an average PPV of 91.20%; dog B got a PPV of 89.15%. All around the two dogs got PPV of 95.10% (Dog A) and 92.17% (Dog B). It is evident by the percentages that these two dogs performed very well even when confounding scents were present.

Limitations

An important point to remember is that cadaver dogs are notably accurate, but they are not always precise in locating target scents. When a handler asks its cadaver dog to search for its target, it does not know it is supposed to look for a specific person. All it knows is to follow and be alert to the scent of decomposition from a human. Sometimes these dogs can alert an unmarked grave of a Native American or a nearby cemetery. (Harbo & Nelson, 2022). "Even a past injury in the location a dog is looking could cause the dog to indicate human remains are present. It could be somebody [bleeding] there or somebody got cut bad there… Any number of things could have happened over the years that caused human decay in that spot" (Harbo & Nelson, 2022). In the case of Gabby Petito, the search for her and her boyfriend resulted in

finding the remains of six additional missing individuals (Park, 2021). While there is not a 100% success rate, there is remarkable accuracy making cadaver dogs a necessary tool in the field.

In Real Life

In recent years, the amazing work performed by cadaver dogs has been broadcast through the media for millions to see. For example, Mr. Dostie and his 12-year-old lab, Buster, have worked together for the past several years. It is estimated that together they have located a minimum of 200 missing people from "crime victims to missing Americans lost in World War II battles in Europe and on the South Pacific Island of Tarawa" (Daily Mail, 2014). In addition, Buster has done searches in Belgium, Charles Manson's hideout location, and Key West, Florida, in which Buster found an 1860s ship that could have been carrying approximately 294 African slaves (Pelisek, 2013).

Not only are cadaver dogs used to find missing people or possible murder victims, but they are also used in mass disasters like 9-11. Hundreds of dogs aided in the search to locate the bodies of victims, including several firefighters who lost their lives trying to save others (Bahr, 2021). The help dogs have been utilized in the search for missing people after the fires that occurred in California in the past years. IC is an Australian shepherd who was part of a voluntary team that looked for victims in the Camp Fire of 2018 located in Butte County, California. The volunteers and their dogs searched 135,000 acres in the hope of finding the 230 people who were still not accounted for at that time but with so much destruction and death it can be hard for them. (All Dogg, n.d.).

A famous publication about the successful search performed by a cadaver dog was in 1986, in the search for Helle Crafts, a Connecticut wife, who went missing without a word. The police suspected that her husband had something to do with the disappearance. It was reported

that they had a bad marriage but without a body, there was no case. It was not until a report of someone using a wood chipper in the middle of the night in a snowstorm that police decided to call in Lady, a German shepherd cadaver dog. Lady was able to lead the police to fragments of human tissue, including a fingernail with nail polish on it that matched Helle Crafts (Bovsum, 2021). The help of these dogs allows for victims to be found when they might not be able to when using other tools and techniques.

Instrument Versus Dog

Looking at the different tools used for searches can range from cadaver dogs to sophisticated technology. There are the canines that have olfactory senses that have evolved for thousands of years and we have ground penetrating radar (GPR) that was specifically designed for this type of work. GPR "works by sending a small pulse of electromagnetic energy into the ground and measuring changes and contrasts in the signal when it's reflected in the receiving antenna" (Admin, 2021). There are some limitations to both. As stated before, cadaver dogs are not perfect, they can make mistakes or alert to the wrong cadaver scent present. The GPR has a few limitations from the depth range to the mobility of the machine.

The first issue is that GPR can have a limited depth range due to the electrical conductivity of the medium, the transmitted center frequency, and the radiated power. As the conductivity of the medium increases, the penetration depth decreases, a higher frequency can not penetrate as far as lower frequencies, but a higher wavelength gives better resolution (Concrete Structure Investigations, n.d.). Another limitation is when scanning high-conductivity materials like clay or other soils with a high salt concentration, the signal of the GPR will be scattered (Studocu, 2012). In addition, GPR can not be used in all terrains since it has wheels that need to be grounded at all times. Rough terrains like the stoney, bumpy mountains, or thick

wet undergrowth of forests are not compatible with the GPR. This is where cadaver dogs persevere because they do not have limitations when it comes to terrain (Butnor et. al. 2001).

Another limitation of GPR that cadaver dogs can do is tell where remains have been. A cadaver dog is trained to pick up on the smallest scent left by a set of remains and indicates that a set of remains made contact with the item or space. A perfect example of this is evident in the expert testimony of Carren Gummin, the founder of Canine Search Solutions, was the handler of Molly, a cadaver dog employed by the state of Colorado. During Gummin's testimony in the case of Mark Redwine who was on trial for murdering his son Dylan, the defense attorney did their best to confuse the jury on whether or not Molly was alerting to the correct scent. They used the fact that Molly alerted over 20 times when on Mark's property; at the garage, the exterior of the house, and Mark's truck. Molly alerted 12 times on the road leading away from the house, but nobody was found on the premises (Sylte, 2021). It was later discovered that Dylan's body was just eight miles away from his father's house (Patmore, 2022). Molly's alerts on the road indicate that she could smell the route that the boy's body took. GPR has only one use and that is when a body is buried in the ground, while a cadaver dog has many other applications leading to more
discoveries.

Conclusion

As demonstrated in this paper, the forensic science community and families all over the world have greatly benefited from the use of cadaver dogs in the field. The use of cadaver dogs in forensic science has been a longstanding practice and it continues to grow and evolve with advancements in science, technology, and overall training. Unfortunately, the extent of their training and the science behind their abilities is often overlooked by the general public even

though the role of cadaver dogs has proven to be invaluable when it comes to scent detection. The extensive training and money that is put into these dogs to ensure that they are impartial and working to their best ability, makes them the best animal for the job. By understanding the dog's breed, genetics, personality, and the training they are put through, there is hope that more people learn how useful and amazing cadaver dogs prove to be. So many people who thought that there was no hope left when searching for their missing loved ones have been able to find closure with the help of a cadaver dog.

Unfortunately, in today's world, concealment and death seem to be something that has become more normal, and currently, there is not a more mobile and effective piece of technology that can do the same work as a cadaver dog. The need for cadaver dogs will always be there as long as people continue to feel the need to hurt one another. It is believed that the unbreakable bond between a dog and its handler cannot be replaced by up-and-coming technological improvements. The future use of cadaver dogs is not concrete, but with the ongoing technological advances and the consistent help of research, there is hope that the use of cadaver dogs will continue to improve, and more people within the community see just how vital cadaver dogs are to forensic science. A thorough understanding of the extensive training, in-depth research for breed selection, and the science behind specific dogs' anatomy will continue to advance the use and development of cadaver dogs in the future of forensic science.

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