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**Scent as Forensic Evidence and its Relationship
to the Law Enforcement Canine**

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Scent as Forensic Evidence and its Relationship to the Law Enforcement Canine

Law enforcement agencies around the country use specially trained dogs for a variety of purposes. The primary reason is that they are cost-effective means for crime control (O'block, Doeren, & True, 1979; Lilly & Puckett, 1997). At this time, dogs still possess abilities that far exceed that of existing technology. Unfortunately, empirical evidence documenting how the canine utilizes his amazing olfactory skills is far from complete and little scientific testing of law enforcement canines has been conducted (Department of the Treasury, 1993). Only through a review of the literature in a range of law enforcement functions can even a fuzzy picture of the nature of scent, as a form of forensic evidence be perceived. This review of the literature attempts to link the commonalities found in research of different disciplines and form a better understanding scent that will drive future research.

ORIGIN OF SCENT

Man has utilized the scenting power of dogs for thousands of years (Chapman, 1990). The ability of dogs (*Canis familiaris*) to detect human scent is strongly documented throughout the literature. Human scent is composed of skin flakes, perspiration, skin oils and gaseous components (Pearsall &

Verbruggen, 1982; Kristofek, 1991). Depending upon the task, police canines utilize different aspects of these components. When tracking the scent of a suspect, the canine follows the skin flakes and disturbances to ground vegetation. If it is an article recovery, the skin oils of the suspect have contaminated the object sought. Canines are capable of locating such objects (i.e. guns) up to 48 hours later (Kristofek, 1991).

Airborne scents from fatty acids in the skin oils allow the police canine to detect a hidden suspect (Kirchner, 1977; Kristofek, 1991). According to Bryson (2000),

...sweat glands produce perspiration as the body's temperature rises, also in response to emotional stimuli such as stress or fear. The eccrine sweat glands-located all over the body, but concentrated in the armpits, soles, and palms-react primarily to heat stimuli and emotional stress, and regulate the body's temperature. Factors such as age, race, sex, size, physical and psychological conditioning affect the amount a person sweats. Additional factors, such as food, clothing, and lifestyle, cumulatively affect the air or ground scent picture presented to the searching dog.

(p.123-124)

SCENT DETECTION ABILITY

Syrotuck (1974) reported that a comparison of olfactory cell counts between humans and canines indicates that a dog's sense of smell should be at least 44 times better. Other researchers estimate the dog's sense of smell as 100,000 times

greater than humans (O'block, Doeren & True, 1979). It has been established that dogs were able to distinguish the odors of different people (Kalmus, 1955; Moulton, 1975) and it is believed the most probable advantage canines' possess is scent discrimination or the ability to distinguish one scent from others. Based upon these early findings, an entire field known as odorology sprang up to deal with the forensic applications of scent discriminating dogs.

Williams et al (1997) at the Institute for Biological Detection Systems (Auburn University) found that training dogs to detect as many as ten odors did not cause deterioration in performance. Additionally, extensive periods of time (120 days) without refresher training were documented. Odor identification remained stable without maintenance. However, it should be noted that this took place under controlled conditions and even the authors note that modification of training techniques for work dogs was not recommended.

SCENT DISCRIMINATION

Scent discrimination is not a new concept. The first documented case of scent discrimination dates back to the reign of Pyrrhus (300-272 B.C.):

...A certain slave for some unknown reason had been done to death by two men when they met him on a lonely road. His dog, who was with him and sole witness, remained by the body. The King passed that way on a royal

progress, and observed the animal by the side of the corpse, had his charioteers halt. "Bury the body," he commanded, "and bring the dog to me." Some time elapsed: the dog remained with his new master and accompanied him when he went to a review of his troops. As two of the soldiers marched smartly past, the animal flew at them with such a fury that he all but tore them to pieces. No further evidence was needed, for in order to escape from the dog, the criminals confessed to their guilt (Chapman, 1990 p.9-10)

Kalmus (1955) demonstrated in his experiment that canines were able to discern the individual odors of seventeen men, women and children. Given the scent from person, the dog was instructed to locate an object (handkerchief) with the same scent. This same skill was then extended to locating the track of an individual. Kalmus hypothesized that scent discrimination between people "must be based on differences between complex mixtures of a number of chemical substances" (p.30).

Taslitz (1990) challenged the reliability of the canine scent evidence and specifically attacked the concept of the scent line-up. He found that there was inadequate scientific support to maintain the standard required under *Frye v. United States*, which states that scientific evidence may be admitted at trial only after it has been generally accepted as trustworthy by scientists in that relevant field.

Tolhurst (1991) devised a methodology for storing scent material as a form of physical evidence. Strict protocols for

the collection and storing of scent objects allowed comparison at a much later date. Although anecdotal in nature, Tolhurst's theories regarding scent contamination drives later research by defining scent as evidence that must be protected if it is to be of use.

Settle et al (1994) studied the success rate of dogs identifying people by scent. Seven hundred scent samples were collected from a wide range of individuals, while seven dogs were trained to match human body scents. An 85% correct matching rate was determined. Of additional interest was the fact that some dogs did not perform well in the presence of observers and "the performance of most began to deteriorate when the handler became emotionally involved in the dog's scoring success" (p.1447).

Hargreaves (1996) discussed the method for conducting a scent line-up, based upon a method pioneered by Dutch Canine Units. *First*, scent is collected at the crime scene. An object is carefully secured in an airtight container and protected as evidence. Scent has been preserved in this manner and used successfully up to three years later. *Second*, a lineup is prepared. Six stainless steel pipes are scented by the suspect and five other persons by holding them for five minutes and then lined upon the floor. The canine is given the scent from the original piece of scent evidence and is instructed to locate a

matching scent. A number of controls are used to insure fairness:

1. The suspect and the five other individuals are the same sex and same race.
2. A second line of pipes is included (with no suspect scent) to preclude the possibility that the canine feels compelled to make a choice.

Schoon (1996) examined the experimental designs used in four different scent identification lineups. A mixture of two designs led to a 75% accuracy rate. A number of issues were identified from handler error to problems in the training of the dogs.

Schoon (1998) proposed an improved method of scent lineup to determine reliability. The "Performance Check" method was designed to assess the dog's willingness to work as well as establish a strong control. The 'check' person would handle an object and a trial lineup would be conducted in order for the dog to establish its ability to discriminate scent. If the dog was successful, the real lineup would take place, the dog would be given the scent from the evidence and the 'check' person's scent would be included in the lineup along with the suspect's scent. Schoon found that many of the dogs were disqualified after the 'check' phase (approximately 50%).

1. Positive identifications	36.4%
2. False identifications	5.3%
3. Correct nonidentifications	47.3%
4. Misses	18.2%

Wojcikiewicz (1999) discussed the reliability of scent identification at a paper presented at the International Academy of Forensic Science. He found that scent line-up had been used in a number of countries since the 1960's and 1970's. Unfortunately, he found no established standard or uniformity. As a result, the evidentiary use of the scent lineup varies.

BUILDING SEARCH

Law enforcement is often called upon to investigate break-ins or locate criminal suspects within residences, businesses and other structures. This type of operation is time consuming as well as hazardous to law enforcement personnel. Rensberg (1986) found that that greatest danger to officers conducting a building search is the ability for suspects to remain in concealment and ambush officers as they approach. As a result, the use of canine teams to locate hidden suspects has become a routine part of the job (Eden, 1993).

This ability has proven useful for law enforcement agencies since the police dog is able to clear buildings more accurately

and safely than officers alone (Ellis & Kirchner, 1990; Bryson, 2000). For example:

...in London, a watchman saw three men slipping surreptitiously into a construction site and called the police. Several officers searched the grounds for two hours and found nothing...when the watchman remained adamant, a police dog, Rex III and his partner were called in. In fifteen minutes, Rex found all three of the would-be-thieves, including one who had climbed to the top of a forty-foot crane and was hiding there. (Newlon, 1974, p.19-20)

Building searches, by their nature, present challenges that affect scent detection. If a suspect hides within a closed area, the scent will pool within that area and intensify (Bryson, 2000). If that same suspect were to then leave that area and find a new spot to hide, the canine would still be drawn to the first area where the scent is strongest (U.S.A.F., 1973).

Air currents within the building are another obstacle. Swirling along a river of air, scent is carried along walls and is disrupted. This turbulence made by natural and manmade objects may cause the dog to 'alert' in the wrong location (Bryson, 2000).

Wolfe (1991) found that canine teams were able to locate hidden suspects 93% of the time in comparison to human teams that were successful 59%. Additionally, as the square footage of the building increased, the accuracy of the human teams

decreased and their time involved with searching increased. Wolfe points out that the canine teams performed at 100% accuracy in all but one building. She hypothesized, but was unable to prove, that chemical /gasoline type odors may have interfered with the dog's ability. Scent contamination may also have taken place since time constraints forced researchers to reuse buildings with as little as fifteen minutes between searches.

AREA SEARCH

The area search function is similar to a building search, only it is performed outside. Unlike a building search, wind instead of air conditioning can play an important part in the successful discovery of hidden suspect. The area to be searched is contained by a perimeter of law enforcement personnel and the canine is released into the wind. The scent is carried in an ever-widening cone shape that may be distorted by features of the terrain (U.S.A.F., 1973; Rapp, 1979).

During this function, the canine may be operating out of sight of the handler. According to Eden, "most police dogs killed in the line of duty are off-line at the time of their deaths" (p.96). There are two opposing schools of thought regarding canine apprehension. The first is known as bark and hold (circle & bark, harass & delay or the reasonable force

method). According to Yarnell (1998), circle and bark developed to protect the canine that might be working away from the handler and would be killed by suspects that had learned to protect themselves from dogs that only attack. The idea is the dog delays the suspect until the handler can arrive and apprehend him. In an area search, the dog will bark but will not engage the suspect unless he moves. Critics of this system believe that it places the dogs at greater risk by allowing the suspect the opportunity to arm himself (Eden, 1993).

The second is bite and hold. The canine is sent and the apprehension is made by the dog that engages (bites) the suspect and does not release until the handler arrives. The dog trained in this system engages the suspect without provocation. Obviously some injury can occur to the suspect during this type of operation and critics feel that too much control is left to the canine (ACLU, 1992; Campbell, Berk, & Fyfe, 1998). However, neither the strengths nor the weaknesses of either system are of concern to this research, but are important to note since the dog may perform differently based upon the style of training.

During the area search function, Cumrine's Probability of Detection (POD) outlines the issues that can determine success or failure. As a starting point, this scale suggest ideal conditions for an 85% POD are:

- 15% wind...10mph

- 15% low cloud cover
- 15% temp....65 degrees
- 15% open terrain
- 10% some daylight
- 15% 100 ft grids (if performing a grid type search (e.g. missing person rather than suspect).
(Cumrine, 2000:S.A.R. Website FAQs)

For each element that is less than ideal, subtract 10% from your probability of detection. It should be noted that this scale was designed for search and rescue and not for apprehending suspects that actively resisting detection. Additionally, the handler must make visual identification of the person sought. The least developed sense of the canine is sight and the best-recorded recognition of a stationary object was at 585 meters (Schmid, 1936).

ARTICLE OR EVIDENCE SEARCH

If an object is touched, human scent transfers to that item (Bryson, 2000). During an article recovery, the skin oils of the suspect have contaminated the object sought. The object is composed of a scent different than that of the surrounding area. According to Bryson (2000), scent "diffuses away from objects with time" (p.220). As time passes, the scent of the object

begins to take on the odor of the surrounding environment. Although canines are capable of locating such objects (i.e. guns) up to 48 hours later (Kristofek, 1991), delays work against the dog (Bryson, 2000).

Similar to an area search, the canine brought downwind and directed to search the area. Or, items of evidence can be identified while the dog and handler are actively tracking a suspect (Guzlas, 1993). According to Bryson (2000), the dog indicates it has located an object by 'alerting' through one of the following behaviors:

1. Aggressive (digging or scratching)
2. Nonaggressive (sitting or lying down)
3. Complex (sitting and barking)

TRACKING

Tracking is the ability of the dog, using his nose, to follow an invisible scent path to find a person (Pearsall & Leedham, 1958). As with other scent related functions, it is strongly affected outside conditions:

- *Temperature* (U.S.A.F., 1973;Remsberg, 1986;Smith, 1991;Bryson, 2000)
- *Humidity* (U.S.A.F., 1973;Rapp, 1979;Bryson, 2000)
- *Differing amount of scent for each person* (Pearsall & Verbruggen, 1982;Krisotofek, 1991;Bryson, 2000)

- *Wind* (Pearsall & Leedham, 1958;U.S.A.F., 1973;Rapp, 1979; Remsberg, 1986;Eden, 1993;Bryson, 2000)

There is a certain amount of controversy regarding exactly what the dog actually smells when he is tracking (Kristofek, 1991). Some feel that the dog is following the actual scent of the suspect (Pearsall & Verbruggen, 1982;Kristofek, 1991) while others believe that the dog is following the scent of crushed vegetation or ground disturbance (Rapp, 1979) and even other believe it is a combination of both (Bryson, 2000). Tracking evidence is accepted in 45 states provided that the proper foundation is laid (Clede, 1998). According to Hunt (1999), a properly trained dog can successfully follow a trail that is up to ten days old.

EXPLOSIVES DETECTION

Police canines can be taught to detect a wide range of substances and their specific odors. Explosives commonly detected include:

- Gelatin (dynamite or nitroglycerine gel)
- Nitroglycerin and ammonium nitrate
- TNT (trinitrotoluene)
- Smokeless powder

- C-4 or Flex-X (plastic explosive)
- Primer Cord

The explosives canine indicates his alert passively (sitting or lying down) and has a detection reliability of 95%, which is 40% better than a human searching for the same device (Kristofek, 1991). The New York City Police Department conducted an evaluation of explosives detection dogs in an urban environment (O'Neil, 1972). Two dogs were used to locate different types of explosive packages. The success rate ranged from 65% to 80%. One study of reliability (Knauf, et al, 1975) found that the dogs were 88% for C-4 and 54% for TNT. However, small sample size (three dogs) and an admitted contamination error may have contributed to the low scores.

Williams et al (1998) at the Institute for Biological Detection Systems (Auburn University) found an average successful detection rate for discriminating specific odors in excess of 85%. They found that dogs learn to depend upon the most abundant vapor constituents of a substance for identification of that substance. Therefore, learn to identify a substance (i.e. explosive) by using only a few compounds.

NARCOTICS DETECTION

According to Williams et al (1997), "the dog and its

handler remain the most widely used, broadly sensitive, accurate, fast, mobile, flexible, and durable system available for detecting illegal drugs and explosives (p.1) Narcotics detection canines indicate their alert passively or aggressively (scratching). A trained dog's alert can be used as probable cause to search or obtain a search warrant (Bryson, 2000). The key issue in the establishment of probable cause is the documented reliability of the canine and handler (U.S v. Trayer, 1990; Drug Enforcement Administration, 1995). The drug detection ability includes (but is not limited to):

- Marijuana (cannabis sativa)
- Cocaine hydrochloride ($C_{12}H_{21}O_4$)
- Crack cocaine (cocaine freebase)
- Heroin ($C_{21}N_2O_5$)
- Methamphetamine ($C_{10}H_{15}N$)

Like the other scent related functions, the scent cone is affected by the turbulence as it is diffused from the source (Bryson, 2000). The scent odor from the narcotic drifts at the whim of the air currents (Robicheaux, 1996). If the narcotics are hidden within a motor vehicle, scent may seep out through gaps as it is pushed by wind on the opposite side of the vehicle (Remsberg, 1995).

Waggoner et al (1997) at the Institute for Biological Detection Systems (Auburn University) set out to determine the

threshold for detection of odor. Four of five dogs in the study detected the odor of cocaine successfully 80%-90% at .1 ppb but success rates declined rapidly below .05 ppb. Additionally, humidity as an intervening variable was identified. When exposed to high humidity levels, the degradation of cocaine is much higher causing the production of methyl benzoate as a byproduct. They were unsure as to effect on the test dogs and suggested future studies of the effect of humidity levels on the detection of cocaine. However, Waggoner et al (1997) stated that their article should "help maintain the well deserved credibility of the dog as a detection technology competitive with or superior to other detection technologies" (p. 225).

ACCELERANT DETECTION

The Bureau of Alcohol, Tobacco and Firearms (ATF) trained a Labrador retriever to detect accelerants and reliability equaled or exceeded the laboratory instruments (Bryson, 2000). Unlike patrol dogs, arson dogs are "imprinted" with accelerant odors using the Pavlovian technique, which means that the dog does not get fed unless it correctly detects the desired odor (Clede, 1988). This method focuses the dog's survival drive to act as motivator to search regardless of the conditions (Berluti, 1990).

Tindall and Lothridge (1995) study determined that of 42

accelerant detection teams, 60% performed without error. Missed accelerants made up the majority of errors (28 of 40), while 20% of all canines tested had false indications. Tindall and Lothridge (1991) determined that "a properly trained and maintained canine would be more sensitive and accurate than electronic devices for the same purpose" (p.57).

Kurtz, et al (1994) studied the level of detection of certain accelerants by canines. Two dogs from the Illinois State Fire Marshal's Office were used for this study. Gasoline, kerosene and isopar residues were detected at a level below that of laboratory instruments. False alerts were detected in charred carpet and styrene but were proofed of the latter as the study continued. Kurtz, et al (1994) made special note of reliability of studies that involve animal responses:

1. It is subject on the part of the handler what constitutes a positive alert.
2. Sampling protocols influenced results.
3. Canines are not all equal when it comes to their abilities.

Kurtz, et al (1995), in a later study, examined the effect of background interference on the ability of canines to detect smaller amounts of accelerants. Thirty four (34) canines from the Canine Accelerant Detection Association were used for the study. A wide range of skill levels between the teams was

detected. Burnt carpet background caused the largest number of "false alerts". As the quantity of the accelerant fell below a certain level (2- μ L), the dogs were less successful discerning accelerant from the background odor of other burnt material. Kurtz, et al (1995), felt that field and training records would establish future credibility of dog teams.

Kurtz and Midkiff (1998) studied the use of accelerant canines as reliable evidence in criminal proceedings. The issue at hand is the delay from the canine alert to the actual laboratory testing of samples for traces of accelerant. This delay can cause the evaporation of flammable liquid prior to analysis. In these cases, the alert of the canine, standing alone, could not be admitted as evidence. In other cases, no laboratory tests were ever conducted on the sample to verify the identification of accelerants made by the dog and evidence provided by the canine was allowed to corroborate the testimony of the officers (State v. Reisch, 1992). Kurtz and Midkiff (1998) suggest that although the olfactory ability of the canine may exceed that of the laboratory test, it is important to use both to demonstrate a "rate of confirmation" in order to lay the proper foundation for canine testimony.

CADAVER DETECTION

Cadaver dogs are trained to locate the scent of human

decomposition. A scent cone spreads from a deceased person in the same fashion of that of a live person. However, the odor that the dog searches for in this case is a generic scent of death caused by the chemistry of decomposition (Rebmann, David, & Sorg, 2000). The scent can also be moved by water from a gravesite causing the dog to alert some distance away from the body. Further confounding the issue is the fact that the water that moves the scent can be above or below ground (Rebmann, David, & Sorg, 2000).

Komar (1999) conducted ten blind field tests with eight canine teams that simulated actual search conditions. Recovery rates of the human remains ranged from 57% to 100%. Handler error and inexperience were identified as issues that actually lowered the success rate.

CONCLUSION

Although each of the studies cited previously comes from a range of law enforcement disciplines, a number of conclusions can be made that influence the direction of future research.

First, a number of environmental factors have been identified that impact the ability of the canine as well as the nature of scent as it is perceived. Temperature, humidity, and wind were documented in numerous studies. These factors already identified open the door to criticism of existing research by

demanding addition effort in their control during research. And to further confound empirical study, other factors not yet identified properly in the research may come into play. For example, if one were to study scent detection within the laboratory setting, the scientist is able to control for a number of the environmental factors. Temperature and humidity can be maintained constant and wind, in the form of air conditioning can be eliminated. However, the canine is a biological instrument and as such can influence findings inadvertently. There is almost an endless list of factors that can influence the performance of the dog. Food consumption, sleep, exercise and stress all have the ability to negatively impact performance. When dealing with multiple dogs, this problem multiplies exponentially. In order to generate findings of any rigor whatsoever, extreme effort must be made to insure that each dog's life (inside and outside of the lab) is as similar as possible. Serious canine researchers such as Auburn University's Institute for Biological Detection Systems actually document and control food consumption while maintaining the dog's weight between 85% - 95% of their normal weight.

Second, handler error was identified numerous times throughout the literature. The olfactory ability of the dog has little relevance if the handler cannot properly interpret the alert of the dog. Future research should require more autonomy

on the part of the dog and off-lead exercises without the handler present may provide with greater accuracy the actual ability of each dog. Hypothetically, the canine could be given instructions through an intercom system and his progress monitored via one-way glass or video surveillance.

Third, contamination problems or issues occurred in the majority of the research. As demonstrated by the large discrepancies in the actual definitions or medium of transference, it has been difficult to control for a variable that is difficult to quantify. Therefore, it is prudent that future research identifies contamination possibilities and designs methodologies that are able to control for this volatile variable. However, since contamination is a very real factor for practitioners of canine law enforcement, rigor in the laboratory environment may not translate into usable information in the field. Therefore, it is only prudent to conduct more research in the field while documenting rather than controlling environmental concerns. Over time, sufficient data could be collected that withstands the scrutiny of academia while providing valuable insight to those whose very lives may depend upon it.

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A useful practical reference, *Canine Olfaction Science and Law* provides a wealth of information beneficial to a wide range of disciplines. It aids trainers and handlers of detection dogs as well as various professionals in healthcare, law enforcement, forensic science, and environmental conservation to gain a better understanding of the remarkable power of the canine nose while encouraging further advances in applications. Reviews.Â Relating Analytically Determined Decomposition Profiles to Canine Scent Alerts. Cocaine on Currency. Conclusion.Â Canine-Reliability Determinations after Harris. Types of Canine-Reliability Evidence Submitted. Daubert Challenges to Canine Sniff Evidence after Harris. Training for Law Enforcement. Training for Officers of the Court.Â There will undoubtedly be debate as to the ultimate impact of forensic science in many of the exonerations reviewed. The extent to which forensic science is a contributing factor in each case will often include a certain degree of subjective interpretation because the majority of erroneous convictions involve complex investigations, multiple contributing factors, complicated juror decisions, and mistakes from policies and practices that have since changed.Â It is most important for forensic scientists to understand that the work we do and the conclusions we reach â€” either in forensic reports or testimony â€” have lasting effects on peopleâ€™s lives, so we must pursue every effort to understand and identify our weaknesses.