Understanding What Police Canines Detect: The Nature and Movement of Odor

Police Canine Science and Training — Article 3

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A dog may smell odor linked to a source without being right next to it. When a police canine searches a building and investigates a doorway, the concealed person may be farther down the hallway. This does not necessarily indicate an error by the dog: airflow can carry odor from the person to the doorway and influence the dog's response. To understand why, this article looks at what odor is, how it travels, and what affects what the dog actually smells.

Key takeaways: Odor can reach a dog far from its source, because airflow, temperature, and surfaces all shape where odor is available. A trained response shows where the dog performed its learned behavior; it does not by itself prove the exact source location or the chemical involved. Detection and source localization are different tasks, and training, reports, and testimony should keep what was observed separate from explanations of it.

What Is an Odor?

Odor is made up of chemical substances that can be smelled. Many materials release volatile compounds, substances that can turn into gas even when the source remains solid or liquid. These are often called volatile organic compounds (VOCs), but not all odor-related substances are organic.

Materials often release complex mixes of compounds that change depending on temperature, time, and surroundings. The odor the dog smells may differ **from the material that caused it.**

The Odor Source and the Odor the Dog Encounters

During a vehicle search, odor compounds can leak from a closed container, spread through the air, and stick to different surfaces. As a result, the dog might smell these compounds far from where the material is stored. Handlers need to understand the difference between:

- The physical source of the odor.
- The location where odor-associated material is available.
- The location where the dog demonstrates a behavioral response.

These places might be the same but don’t have to be. A trained final response shows where the dog performed the learned behavior; it doesn’t, by itself, prove the exact source location or the chemical involved. This difference is important for training, operations, and legal cases.

Odor Does Not Simply Travel in a Straight Line

The odor cone is a helpful basic idea; however, airflow around buildings, vehicles, trees, and walls can change direction, swirl, and become chaotic. Instead of a smooth cone, odor may appear in uneven patches or thin strands separated by areas with less smell.

This can explain why a dog might show interest, move without reacting right away, and then smell odor again. **Losing the scent doesn't always mean the source is gone or the dog made a mistake.**

Diffusion: Molecules Moving Through the Environment

Diffusion happens because molecules move randomly, spreading from areas of higher concentration to areas of lower concentration. This helps odor spread from an open container in still air. In real search situations, however, moving air carries odor faster and farther than diffusion alone, so diffusion is only a small part of how odor reaches a dog. The next section covers the main mechanism: advection.

Advection: Odor Carried by Moving Air

Advection means substances are carried by moving air or fluid. For example, wind can carry odor across a field, and ventilation systems can move odor through connected rooms and hallways. So, a dog's interest at a doorway might be because of odor carried there, not because the source is right behind the door.

Turbulence: Why Odor Movement Can Be Irregular

Turbulence means irregular, changing air movement that mixes and spreads substances. For example, wind around a building can create swirling airflow and uneven odor spots. In these cases, a dog might need to move and smell more air. Irregular search patterns don't always mean the dog is confused; they may show the odor is uneven.

Odor Pooling: When Odor Accumulates

"Odor pooling" means odor builds up in a certain area, like a room with little airflow or a sheltered spot. This doesn't mean odor always gathers in low places. Things like airflow, temperature, how much odor is released, ventilation, and the type of compounds affect where odor collects. It's important to watch the environment instead of assuming odor moves in just one way.

Temperature and Odor Availability

For some substances, higher temperatures increase vapor pressure and help release volatile compounds. Temperature differences can also create airflow that moves odor. But saying "heat makes odor rise" is too simple; odor movement and availability also depend on humidity, ventilation, chemical makeup, packaging, and how odor interacts with surfaces.

Humidity: An Important but Complicated Factor

Humidity can change materials, surfaces, chemical reactions, and how much scent is available. Its effect depends on the target, task, and situation, like tracking or trailing. There is no single rule about humidity that can predict how well a dog will perform in every case. Humidity should be seen as one possible factor, not a full explanation.

Adsorption and Absorption: Odor Interacting With Surfaces

Adsorption happens when molecules stick to a surface; **absorption** happens when substances go inside a material. Odor compounds can interact with upholstery, carpets, clothes, plastic, and other materials, affecting how long odor persists and when it is later released.

These interactions differ depending on the compound and material. They help explain why odor might linger after the source is gone, but they don't prove that leftover odor caused a dog's specific response.

Desorption: When Molecules Are Released

Desorption means molecules that were stuck to a surface are released. Things like temperature, airflow, and material type can affect this. While desorption might explain odor being available after the source is gone, it can't be assumed to have happened in a specific search without proof.

Residual Odor: What We Know and What We Cannot Assume

Residual odor means odor-related traces that stay after the source is gone. This can happen because of chemical transfer, odor sticking to surfaces, and later release.

If a dog signals but no target material is found, residual odor is just one possible reason. Other reasons could include an incorrect signal, material not found, or contamination. Without proof, the handler usually can't know which reason is correct.

Residual odor should not be assumed to explain every dog signal when no material is found. A strong explanation must separate what might be true from what is proven.

Why Dogs Sometimes Respond Away From the Source

Human-related odor can move from a room into a nearby hallway, causing a dog to check that area. The dog might need to gather more information and change its search approach before finding the person.

Detection means finding relevant odor information, while source localization means finding the exact source location. Training should recognize that a dog might detect odor before it finds the source.

Sniffing: How Dogs Gather Odor Information

Sniffing is active sampling: repeated breaths bring air into the nose, where odor molecules can interact with the smell system. A dog's nose shape and airflow support this specialized sampling.

A dog might change how often it sniffs, move its head, or change position while investigating. These behaviors can give useful clues to the handler but don't always prove the dog found the target odor. They should be understood in the context of training, typical behavior, and the search situation.

The Difference Between Detection and Identification

A trained response to a target odor type is not the same as identifying a specific chemical in a lab. The dog shows learned behavior based on its training and work conditions.

Handlers can talk about training methods, certifications, observed behaviors, and experience. But they should avoid claiming exact chemical identification without scientific proof.

What This Means for Detection Training

Training should expose dogs to different environments and airflow patterns, consider where the source is and how odor is available, and separate odor detection from source location. Handlers should notice behavior changes but not treat every change as a final signal.

Give dogs chances to search independently with proper control. The goal is to build flexible, effective search skills instead of depending on a fixed pattern that only works in known places.

A Practical Example: Searching an Unfamiliar Building

Suppose a dog searching a new building, stops at a doorway, even though the training aid is in another room. Rather than quickly assuming one cause, the trainer should consider carried odor, unrelated smells, and other factors. Then watch whether the dog collects more information, checks relevant spots, changes position, and stays focused without extra help. Assess the search and its results afterward: knowing how the dog found the target helps improve training.

What Supervisors Should Understand

Supervisors don't need to be experts in chemistry or airflow. But they should understand that odor can be found away from its source and that environment affects odor availability. A trained response doesn't always show the exact location of material, and a signal without finding material doesn't automatically mean a false positive or leftover odor.

Training reviews, deployment reviews, and reports should clearly separate what was seen from explanations about it.

The Most Important Lesson

A dog's nose picks up information in an environment affected by chemistry, airflow, temperature, and surfaces. Odor doesn't have to move in straight lines, form a smooth cone, stay where it started, or vanish right after the source is gone.

Know**ing these possibilities can improve training; however, handlers should not use them as unsupported reasons for dog behavior without supporting proof.**

Research and further reading

These scientific sources provide foundations for the discussion. Many of them describe general physical and biological principles, so readers should consult the individual studies before applying them to specific police canine operations.

1. **Craven, B. A., Paterson, E. G., & Settles, G. S. (2010).** The fluid dynamics of canine olfaction: Unique nasal airflow patterns as an explanation of macrosmia. *Journal of the Royal Society Interface, 7*(47), 933–943. Research examining airflow and odor sampling within the canine nose.
2. **Settles, G. S. (2005).** Sniffers: Fluid-dynamic sampling for olfactory trace detection in nature and homeland security. *Journal of Fluids Engineering, 127*(2), 189–218. Discusses fluid dynamics and odor sampling in biological detection systems.
3. **Bargmann, C. I. (2006).** Comparative chemo sensation from receptors to ecology. *Nature, 444*, 295–301. A broader scientific examination of chemical sensing across animals.
4. **Mombaerts, P. (2004).** Genes and ligands for odorant, vomeronasal and taste receptors. *Nature Reviews Neuroscience, 5*, 263–278. Explains the biological foundations of chemical detection.
5. **Thesen, A., Steen, J. B., & Døving, K. B. (1993).** Behaviour of dogs during olfactory tracking. *Journal of Experimental Biology, 180*, 247–251. Examines canine behavior during olfactory tracking.
6. **Miklósi, Á. (2015).** *Dog Behaviour, Evolution, and Cognition* (2nd ed.). Oxford University Press. Provides broader context on canine sensory abilities, cognition, and behavior.