

Structured Generalization in Scent Training of Explosive Detection Canines

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A key issue in training dogs to locate explosives lies in the variety and state of materials to which the animal is expected to respond, and the range of circumstances within which the handler & canine must conduct the search. One of the concepts which drives scent canine training programs, is sometimes referred to as “Generalization.” Stimulus generalization is a term used by behavior researchers to describe the transfer of a response learned to one stimulus to a similar stimulus. The terms “carry-over,” “transfer of training” and “Pavlovian irradiation” refer to essentially the same process which is an inherent property of the Mammalian brain and a “given” in most learning scenarios. Generalization in the context of scent training, while reliant on the underlying mechanisms postulated by behavioral scientists in controlled experiments, is somewhat more complex when we work with scent trained canines, because **the stimuli we seek to teach the animal to identify are made up of multiple components which are highly variable and difficult to manage and control.** Generalization in scent training represents a double-edged sword for explosives detection. **Certainly, detection of a broader set of explosive compounds than actually encountered in training is a good thing; however detection of compounds similar to explosives but used in innocuous substances is a bad thing, resulting in a “false positive” or “false hit.”** In order to better understand how to productively manage Generalization in scent canines, it is important to understand some important features of the structure and function of the amazing odor pattern recognizer which our canine cohorts possess.

The Mammalian “Scent Brain”

Known scientifically as the olfactory lobes, these are major brain structures shared by all canines. Numerous researchers have noted both architectural and physiological similarities between these structures and elements of visual cortex known to be involved in the assimilation and processing of visual imagery. This would come as little surprise to many K-9 handlers who have confronted the complexity and plasticity of their animals’ scent-related behavior, however, little attention has been given to the concept of “odor-imagery” in training animals to perform scent related tasks and duties.

The Concept of an “Odor Picture”

When a dog sniffs at an object or area it is neither seeking nor responding to one specific odor. Its olfactory sensors are actively interacting with its “scent brain” to create a virtual picture formed by the spatial density and distribution of

elemental odor components in the proximity of the object being sniffed. Behavioral evidence further suggests that this olfactory mapping is then overlaid in the scent brain with a template based on similar mappings from the animal’s prior experience to yield an odor picture which is useful for subsequent recognition much in the same manner that we use visual information and experience or memory to recognize a face. This dynamic pattern of odors associated with an object can be thought of as an **odor picture.**

The “Odor Signature”

Once we realize how canines routinely process olfactory information, it becomes important to the scent training process that we address and control the component structure of specific “odor pictures” so that we can train our animals to generalize over the variety of mixtures, compounds, pollutants, temperatures and wind which are likely to be encountered in field situations. A given odor picture may be further broken down into a spectrum of specific **odor signatures**, each with attributes such as intensity and density, just as a visual picture may be made up of a combination of colors with variations of saturation and density.



It is our goal to teach the explosive detection canine to communicate its recognition of a member of a generalized set of specific target odor signatures by reflexively responding with a trained passive behavior such as sitting and orienting toward the recognized target.

C-4 is a well known explosive compound. A portion of its makeup is an active explosive compound (RDX 91%) and the balance is inert stabilizer material. The active explosive compound in the C-4 carries its own specific odor signatures. While a trained detection dog may respond to the odor picture of the C-4, we do not want it to alert to components of the odor picture in the absence of the complete RDX signature. On the other hand, we need to assure that the dog will generalize appropriately to normal variations in the odor signature of C-4 due to factors such as temperature, age, packaging and handling. Bear in mind that the greatest vapor headspace of an explosive compound may be produced by an innocuous inert component or even packing materials. For obvious reasons we want explosive detection dogs to be trained to recognize and indicate those specific target odor signatures which are

uniquely associated with the detonatable material we wish to detect, not with similar odor signatures which might be innocently encountered in ambient settings.

We must also recognize that whatever materials consistently come in contact with the target signature, will become part of the odor experience which the dog accumulates and which is added to the template used by the animal's scent-brain for recognition. This often leads to one of the common causes of false indication behavior.

A common problem in the scent-training of search animals is to minimize any systematic association of a target substance with a non-target solvent/vehicle, hydrocarbon component or container. In many instances, the vapor headspace of an explosive compound or mixture is dominated by common hydrocarbons such as hexane, toluene, acetone or kerosene which are far more likely to be encountered in a non-threat context.

Common examples of odor associations which can cause non-target associations or "false alerts" include:

- ▶ The inert materials contained within an explosive compound e.g., its plastic vehicle or "base," residual ammonia, etc.
- ▶ The container scent that has consistently come in contact with the odor material, polyethylene, galvanized metal, etc.
- ▶ The surrounding material where the target material is hidden during training; under a gas cap, near a car battery, etc.
- ▶ Human scent from handling the target materials.
- ▶ Residues of inert chemicals used in the manufacturing of the explosive substance.

When one or more of these benign factors are consistently present in the target sample used in training, there is an underlying risk that non-hazardous odor signatures will be inadvertently identified by the dog as targets.

It is therefore important that scent dog trainers be aware of this source of error and devise training protocols which will mitigate it. Systematic differential conditioning with the optional use of a mild secondary negative reinforcer will usually produce good results, but may require significant additional time and effort in training. **Due to the wide variation of vehicles, residues and containers used in home-made explosives, the occurrence of false alerts can never be completely eliminated.** Trainers and handlers must be constantly vigilant for dogs which begin misidentifying benign odors as target odor signatures so that they can rapidly deploy appropriate remedial training. The dynamics and dimensionality as to how odor complexes are represented and stored in the canine brain are not fully understood, so it is important to recognize some of the classical methods which can be utilized in observing and communicating with animals as they are being trained.



One of the greatest challenges in the scent training of animals is maintaining a moment-to-moment awareness of the animal's orientation and fractional responses to non-critical stimuli. For example, if a detection dog is initially trained on an odor such as Ammonium Nitrate and is then introduced to an explosive compound containing Ammonium Nitrate, (i.e., AN Dynamite or ANFO) with which they are unfamiliar, we may observe one of the following reactions:

1. The dog exhibits recognition of the explosive compound and performs a trained indication.
2. The dog shows interest in the material but does not exhibit a trained indication.
3. The dog shows no apparent interest at all.

It is interesting that when a number of trained dogs are presented with this situation, we observe that individual dogs usually fall into one of these three categories in a seemingly random fashion.



While the second type of response seemed to be the

most common, we were curious as to why some dogs appeared to show exceptional ability to recognize materials with which they had no experience while others did not.

The ability to generalize, as a behavioral concept, to apply a response originally learned in one set of circumstances to a different set of circumstances, appears to vary among individual dogs and may well be characterized as "skilled" behavior. In this case we are specifically referring to the ability to generalize a target odor signature contained within a variety

of odor pictures. Therefore the trainer, in addition to being aware of those instances where the animal may signal inappropriately to an incomplete set of explosive components, must also seek to vigorously reinforce those instances where the dog decisively signals to a detonatable variation of an explosive compound.



Protocols for teaching the dog to target acceptable variations of odor signatures

Development of effective target odor identification is accomplished through a process of “averaging,” “generalization” and “extinction.”

1. I find it is preferable, whenever practical, to start training with the purest form of target material available. Experience has shown that this does not mean it must be presented in 100% pure form. However a format in which the active explosives present a dominant, uncorrupted signature or vapor headspace in the odor field is desirable. In a visual analogy, this might be like arranging a picture or view for maximum color contrast between the background and object to be detected.
2. The target odor should be physically presented to the dog in a manner in which the vapor is concentrated or contained in order to minimize ambient odor associations. For example, within one of the portals of the “Herstik wall” training device.
3. Associated odors such as container and human scent should be introduced early on as distracters, and responses to those odors should be **extinction-trained** both in the initial stages of training and periodically throughout the entire training process.
4. Once the dog has learned to identify a target material, other materials containing the same target odor signature should be presented and responses to them reinforced. For example, if the dog identifies Det Cord, it may then be presented with Deta Sheet since both utilize the same active explosive ingredient, though the balance of the product contains different materials and has a substantially different surface-area

to volume ratio. This is repeatedly done during training using counterbalanced exposure to different examples of material with highly similar odor signatures. The dogs then learn to identify a class of odor signatures rather than just specific ones. Presentation of odors in this manner is sometimes referred to as **averaging**, although it is a commonly used method for training selective generalization.

5. Once a dog is able to reliably identify a set of target odor signatures, it now has a reference “picture” to use as a template against which to compare an unfamiliar odor picture. This is referred to as **generalization training**. Generalization training can succeed only with a lot of patience and the availability of a broad subset of variations of commonly used detonatable materials. The proficiency which a given dog exhibits at detecting a target odor signature as part of an unfamiliar odor complex may vary. Generalization training may be accomplished with minimal reinforcement. Proficiency at generalization seems to be a highly variable natural talent in some dogs but it can be taught to most animals provided that adequate motivation is present.
6. Dogs must not only be able to detect target signatures but they must also be reliable in not creating false alerts. Odor signatures associated with false alerts should be systematically eliminated from the dog’s set of generalized odor references. The training methodology used to accomplish this process is referred to as **“extinction.”** Extinction involves systematically presenting innocuous odors, (tennis balls, paper, plastic container material, human scent, etc.) without reinforcement, so the dog encounters them as a regular part of the search pattern during training, but separate from the target odor signatures which are systematically reinforced. It is vital that no reinforcement is given in association with these distracting odor signatures and that the dog becomes desensitized to them. In the early stages of training, undesirable associated odors should be placed throughout the wall as distracters. The wall is an excellent and simple tool for odor extinction as well as identification training. Once again, it is important that this is introduced in the early stages of training and repeated at intervals throughout the training regimen in order to avoid a significant amount of remedial work.

With patience and rigorous attention to detail, it is possible to uniformly train explosive detection dogs which will be able to reliably recognize and indicate target odor signatures when these are present in either familiar or unfamiliar contexts. Cognizance of the odor image concept, careful attention to detail, systematic planning and rehearsal of the training protocol and maintaining acute and objective awareness of each animal’s responsiveness and progress can yield reliable detection dogs for public safety. 🐾