An introduction to odour

What is this note about?

This note provides an introduction to what odour is, how it is produced, and factors that may affect a dog's ability to smell, and therefore detect, an odour and its source.

Who is this note relevant for?

All dog handlers and other personnel responsible for training and deploying detection dogs.

Introduction

What is an odour?

An odour, also known as a smell or scent, is sensed when chemical molecules in the air (vapour) are detected by a person or animal. These molecules can be released by solid and liquid substances over time and diffuse (spread out) into the air. The extent to which molecules are released depends, among other factors, on how easily the substance evaporates and turns into vapour. A substance that readily produces a vapour is said to be **volatile**, and to have a **high vapour pressure**.

The molecules released by a substance fill the air space above and around it over time, which is sometimes known as the **headspace**. For example, imagine a fresh cup of coffee. The coffee is the substance releasing the molecules. The headspace is the air around the coffee that contains the released molecules, which can be detected as the 'coffee smell' (**Figure 1**). The more molecules present in the headspace, the higher the odour concentration and the stronger the coffee smell.

Figure 1: Coffee headspace. *Third party image reproduced with permission of the owner.*

How do dogs detect odours?

One of the reasons why dogs provide such a useful detection capability is because of their highly sensitive sense of smell. Smells are perceived by both humans and dogs through their olfactory systems. The olfactory system forms a network from the nose to the brain, enabling the brain to recognise odours based on molecules that are detected in the nose.

The process of smelling an odour starts when molecules enter the nose. There are many types of olfactory receptors inside the nose, which detect the presence of different molecules. Signals are sent from the olfactory receptors to specialised areas of the brain, collectively called the olfactory cortex, where the odour is interpreted and identified.

The canine olfactory system has a number of adaptations that give dogs a more powerful sense of smell than humans. For example, dogs have many more olfactory receptors than humans, making it more likely that molecules will be detected in the nose.

What can affect the odour of a substance?

The following sections introduce why substances have different odours, and some of the reasons why the odour of a substance may not always be the same. For further information on how to train dogs to detect substances despite changes in their odour, see the guidance note: 'How to train your dog to generalise across varying types and sizes of targets' [1].

The type of substance

How a substance smells depends on the chemicals that it releases into the air. For example, esters can often smell fruity, while amines can often smell fishy. The number of molecules released can also change the quality of the odour. For instance, in low concentrations (when there are a small number of molecules in the air), skatole has a floral smell to most people, while in larger concentrations it smells like faeces.

Some substances can be perceived as having a stronger, or more intense, odour than others. This may be because they are more volatile (more of their molecules are released into the air) or because the olfactory system is better at detecting their molecules. Although it can be difficult to determine how easily the olfactory system can detect different odours, it is sometimes possible to measure the amount of target substance available as vapour using chemical analysis techniques. This information can then be used to direct detection dog training, as substances that naturally release less vapour may require more intensive training.

It is important to note that the same vapour may not smell the same, either in quality or intensity, to different individuals. This can be due to a range of factors such as genetic differences and past experience.

Mixtures

While a pure substance made of a single chemical will produce a pure vapour, many substances encountered in the real world are chemically complex mixtures and so will have complex odours, made up of a combination of many different molecules. Some of these molecules will be more volatile or more easily detected by the olfactory system than others.

For example, while chicken makes up a large part of a chicken curry, the spices it is cooked in, whilst a smaller part of the overall dish, make up the main odour of the curry. The strongest identifying odour of a substance is not necessarily the part that is the largest proportionally (chicken in the curry) but may instead be the part with the most volatile or detectable molecules (spices in the curry).

The amount and surface area of the substance

The amount of substance present can affect the number of molecules released into the air. This is because molecules evaporate from the surface of the substance. If the surface area is larger, more molecules will be released and the odour concentration will be higher. A larger surface area may be created if a sample is bigger or more spread out, or if it has an uneven surface structure (e.g. it is textured, rough or granular – see **Figure 2**)[1].

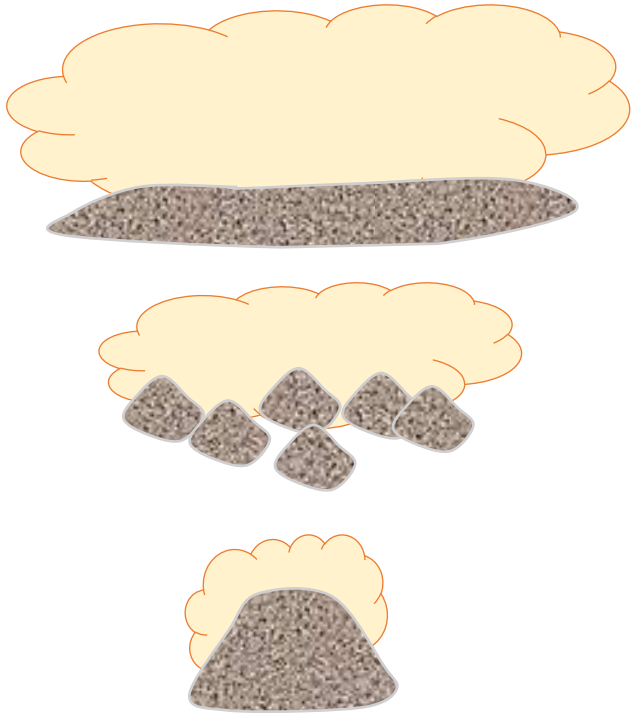

Figure 2: More odour will be released from the substance if it is spread out, as this increases the total surface area from which molecules can evaporate into the air[1].

The soak time and age of the substance

Some substances may undergo changes in their odour over time. Initially, the number of molecules released into the air builds up until a steady state of vapour release is reached (known as the equilibrium). As the more volatile components of a sample evaporate most easily, the total number of volatile components left in the sample, and therefore in the vapour, may then start to decrease over time. These changes can affect the odour, which is why it is important to vary the amount of time a training sample has been emplaced before the dog encounters it (the **soak time**).

Substances can also undergo physical and/or chemical degradation, changing the surface area and/or the types of chemicals that are released into the headspace over time. For example, milk has a mild sweet odour when fresh, but over time the odour changes and, once spoiled, milk has a distinctive rancid odour.

[1] Materials used in the training and deployment of detection dogs should be used in accordance with the instructions and safety information provided by the manufacturer, and in line with local rules and relevant legislation. It is not advised to diverge from any guidance (e.g. by breaking material up) without prior expert advice or manufacturer's approval. Note that explosives training samples should never be cut or otherwise divided or reshaped except by competent persons in an appropriately licenced explosives facility.

Contamination

When molecules are released from a substance as a vapour, they can then be adsorbed onto other nearby surfaces, causing contamination. Contamination can also occur by transfer through physical contact, either directly or indirectly (e.g. by handling two different substances). A contaminated substance can then release both its own molecules and the transferred molecules, potentially changing its odour. For example, perfume molecules may transfer from a person to a training sample, changing the target odour to include the smell of the perfume. If dogs are then trained on the sample, they may learn to detect the smell of the perfume rather than the target odour. For further information on how substances can become contaminated and measures to prevent contamination, see the guidance note: 'Why and how to control contamination' [2].

Packaging

The packaging of a substance impacts on the amount of odour available to detect. Packaging can act as a barrier that prevents some or all of the molecules from passing through. Molecules may escape through any openings or perforations in the barrier material. For example, blue cheese may not smell strongly in the supermarket because its packaging prevents molecules from being released into the air. However, once the packaging around the blue cheese is removed, the molecules are released, and can be detected as a strong blue cheese odour.

Different types of packaging will allow different amounts of molecules to pass through into the air. Factors which affect the number of molecules that pass through packaging include the type of material (its absorbency and permeability), the number of layers, the integrity of those layers, the seal, and how long the substance has been inside the packaging.

Temperature

Temperature affects the rate at which molecules evaporate and are released by substances. Both the temperature of the substance and the temperature of the environment can have an impact. At higher temperatures, a substance releases molecules at a greater rate, creating a stronger headspace. For example, a freshly made, hot cup of coffee will have a stronger odour that can be smelled from further away than a cold cup of coffee.

Air movement

The spread of molecules released from a substance is affected by the movement of the air around it. Where there is little air flow, such as in confined spaces, the molecules will build up around the substance until they fill the space. While a space that is filled with an odour can help dogs to detect that the odour is present, they may have difficulty pinpointing where odour is coming from. This is because there is no longer a greater concentration of odour closer to the target which they can use to locate it.

If there is air flow, it will tend to carry molecules further away from the substance. As the odour molecules mix with the surrounding air, they will form an increasingly spread-out odour plume, reducing the concentration of the odour as the distance increases. This will provide a concentration gradient, allowing the dog to locate the source of the odour (where the concentration will normally be strongest).

Note however, that as air flow is usually turbulent, molecules may actually be dispersed as clouds or whisps, creating pockets of different odour concentrations, rather than a smooth concentration gradient (**Figure 3**). In some cases, air flow can move the highest concentration of molecules away from the substance itself, which could result in a dog indicating in an unexpected location away from the substance.

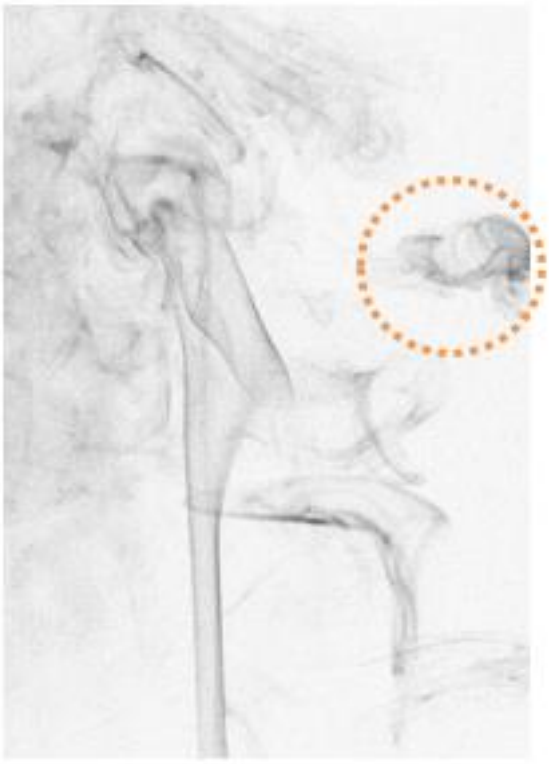

Figure 3. Molecules moving in turbulent air can create concentrated whisps (e.g. circled in orange) of odour away from the substance.

Air flow in buildings can be affected by factors including the construction and layout, air conditioning or heating, open windows or doors, draughts, the presence of electrical equipment, or the presence and movement of people. Outdoors, the air flow can be affected by weather conditions and geographical features.

Differences in air flow may require handlers to adapt their search pattern to ensure that dogs have the best opportunity to search effectively. For example, giving dogs the opportunity to search into the wind will allow the air flow to carry molecules towards them, increasing their likelihood of detection.

Masking odours

Odours of other substances within the search environment may mask target odours, making the target substance more difficult to detect.

Masking odours may be:

- Strong odours that cover weaker target odours.
- Eliminating odours that stop target odours from being detected.
- Distracting odours that cause the dog to miss or ignore target odours.

It is important to ensure that training sessions cover a wide range of background environmental odours, and that interferent odours are used, so that dogs can learn to ignore the presence of non-target odours. For further information on how to use non-target odours during training, see the guidance note: 'Using blanks and interferents to ensure effective detection dog training' [3].

Top tips

- ✓ Ensure detection dog handlers have a basic understanding of the main principles of odour (covered in this guidance note) to optimise their operational effectiveness.
- ✓ Dogs may require more intense and regular training on substances if they release fewer molecules into the air (have lower volatility) or if the molecules are not detected as well by the dog's olfactory system.
- ✓ Training dogs on different samples of a training substance (e.g. different batches, sample sizes and ages, in different packaging) will help them to generalise their responses [1].
- ✓ It is important to have good contamination control in place [2].
- ✓ Dogs may show interest or indicate in an unexpected location away from the target if the odour is stronger there (e.g. as a result of local air movement effects).
- ✓ Handlers may need to adapt their search to the environment, as it may affect odour availability (e.g. due to air flow).
- ✓ Include interferents and different environmental odours during training sessions so that dogs learn to ignore potentially masking odours [3].

Associated guides and information

[1] How to train your dog to generalise across varying types and sizes of targets DSTL/PUB89074 www.cpni.gov.uk/canine-detection-guidancenotes

[2] Why and how to control contamination DSTL/PUB89644 www.cpni.gov.uk/canine-detection-guidancenotes

[3] Using blanks and interferents to ensure effective detection dog training DSTL/PUB111065 www.cpni.gov.uk/canine-detection-guidancenotes

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