The aim here is to provide an overview of the general principles of learning relevant to the training of a REST (Remote Explosive Scent Tracing) dog. A complete review of these principles can be found in many psychology texts or dog training guides (e.g. Catania, 1992; Pryor, 1996).

REST is a detection system in which the odour from suspect land is transferred to a dog at a testing station, via a filter. Air from the suspect land is vacuumed through the filter, and the role of the dog is to determine whether or not the filter contains the odour of a mine. At present, there are no standardised training or operational procedures designed to ensure either quality and level of skill for a REST dog, or for the execution of the analysis by the dogs. The results of a REST analysis may therefore vary in practice.

Results from practical tests using REST dogs indicate that the system gives consistent detection of mines, and the system has been used operationally for some years by Mechem in South Africa (see Chapter 4, Part 1) and, more recently, by Norwegian People’s Aid (NPA) in Angola (see Chapter 2, Part 2).

Creating a desired behavioural pattern

Most organised dog training is based on the idea that behaviour consists of a chain of functionally related smaller units or actions. Training has the goal of linking these simple actions together to produce a more complex behavioural pattern. The pattern will involve the expression of the set of simple actions in a desired sequence.

For example, here is a set of actions: A1, A2, A3, A4, where these actions can be anything that the dog is capable of doing (e.g. A1 = “sit”, A4 = “stay”). The desired sequence is A2 A3 A1 A4. The trainer first teaches the dog to express each of the actions individually, using reinforcement. So the dog will be trained to “sit” (A1), to “stay” (A4), etc., and these training experiences will occur at different times. Reinforcement will be used to encourage the expression of each action, and to perfect the way in
which the action is expressed. The notion of reinforcement is described in detail below.

Now the dog is expressing each action well, and the trainer can begin linking the actions into a sequence. So A1 is linked to A4. In effect, in the mind of the dog, A1 and A4 become one behaviour, and it is the combination of actions that is now reinforced. Eventually, the trainer will link all four of the desired actions to create a complex behavioural pattern, which is reinforced as a unit. An example would be to train the dog to walk a line (A2), sniff at a series of filters (A3), sit (A1) and stay (A4).

In reality, this process uses the same procedure to develop the pattern as was used to train each of the desired actions separately.

The trainer has now done what is called in technical terms forward chaining — the creation of a behavioural sequence by linking previously established actions in the dog’s repertoire.

The challenge when using forward chaining is to break the behavioural pattern into small pieces that can be handled with a small amount of prompt (assistance). If too much prompt is provided, the result can be a dependency of the dog on the assistance provided by the trainer, and a rapid loss of response when the assistance is removed. The optimal application of the principle involves providing a minimum of prompt, even though the initial learning process may be slower than can be achieved with more prompt.

Prompt here means assisting the dog to express an action. For example, pushing down on the rear end of the dog while training the action of sit. It is essential to understand that prompt can be something very small — something in the body language of the trainer for example — and the ability to recognise that a prompt is being given to the dog depends on the trainer, and their experience.

During the process of learning, a close relationship forms between the dog and the dog handler. A training programme consists of a repeated series of events in which the trainer encourages the expression of an action (“assistance”), the dog attempts to do the action, and reinforcement is provided. Training means teamwork.

Many of the stimuli which influence the learning process cannot be controlled by the dog handler/trainer, but are nonetheless present and are, in many instances, used by the dog (Gordon et al., 1981). This implies that skills learned by a dog can be difficult to transfer into different situations and with different persons. When dogs are to be moved from the training situation to actual projects where they are to carry out tests/analysis (e.g. the REST system), the same difficulties will be encountered. We are therefore faced with considerable challenges in organisation and practical execution — when test results must be exclusively based on the dog’s reactions, without any form of influence by the test procedures.

**Shaping**

A method that can be used for training is referred to as shaping (successive approximations) (Catania, 1992; Bandura, 1986). Shaping is one of numerous forms of learning, but its value lies in being entirely reward-based, making it a very effective
technique for dog training. Shaping is based on reinforcement of an action or behaviour demonstrated by the dog. Reinforced behaviour is likely to be repeated with increasing frequency and reliability. Shaping entails starting out with minor tendencies in a dog’s behavioural pattern and directing those tendencies towards an end target behaviour. All animals display varying behavioural patterns. In many instances, it is sufficient for the dog to move in a certain way or look in the right direction. With shaping, such tendencies are reinforced in order to increase the probability of repetition. Most dog trainers use some form of shaping in this way, often unknowingly. For example, when the dog is doing something right (something the trainer wishes the dog to do more often), the trainer uses his/her voice (praise) as a reinforcer.

The voice (praise) is the reinforcer, and the action being reinforced is the immediately previous action of the dog when the praising voice was heard. Praise could also be patting the dog, a food titbit, a ball or a game. All of these things provided by the trainer are reinforcers that the dog associates with positive feelings. The reliable appearance of the praise leads the dog to repeat its action with increased reliability; and that is the essence of shaping.

**Shaping with the clicker**

It is similarly possible to shape behaviour using a whistle or “clicker”. Such aids are used in the same way as the praising stimuli referred to above. The sounds are nothing more than a “uniform voice”, i.e. a sound stimulus at a more controlled level of volume and frequency than is possible using voice or the other kinds of praise, and allowing more precise control of the timing of presentation.

If clickers are to be used, the dog must learn that the sound of the clicker predicts the appearance of a reward. The trainer therefore starts the learning process by presenting the sound of the “clicker” when the dog gets something rewarding, i.e. food, or some other form of reinforcement (a process of secondary reinforcement, as described by Hilliard in Part 3 of this chapter). Food is recommended as the most potent reinforcement to establish the rewarding nature of the clicker. It will require as many as 30-50 presentations of the clicker to establish it as a predictor of food. The trainer begins by sounding the clicker and giving food to the dog. The trainer is actively offering food to the dog in association with the clicker. Eventually the dog will begin to turn towards the trainer at the sound of the clicker in the expectation of the food appearing. Now, the trainer becomes more passive and so encourages the dog to move towards the trainer in order to receive the food, which the dog is beginning to associate with the sound of the clicker. Eventually, the trainer becomes completely passive and the dog will be focusing on the trainer in anticipation of both the sound of the clicker and the appearance of the food. Now, the problem for the dog is to get the trainer to give the clicker sound because it knows that the click predicts food.

At this point, the clicker sound has been established as rewarding and the dog will work for the sound of the clicker in the absence of any other reward. However, use of the clicker as the reward will involve ongoing maintenance of that conditioned association. Thus, there will be a need to continue to offer a reward in association with the clicker, but at a reduced frequency. In other words, the reward need not be offered every time the clicker is sounded. The reward used to maintain the clicker as rewarding can now be anything that the dog finds rewarding — the ball, praise, food, petting, etc.
From this moment on, almost any activity can be reduced or increased as desired. If the clicker is used when the dog is active and exploring, the dog will tend to exhibit increased amounts of exploration. If the dog is calm, sitting, lying or focusing on a search, the clicker can be used to increase this behaviour.

Shaping is most simple in practice using the dog’s current behaviour. Because the clicker is used simultaneously or immediately after an action has been offered, the dog will repeat the action more often. In some instances, actions are offered regularly, and so are easy to shape because there is plenty of potential for reinforcement. In other cases, the trainer may have to be patient and wait for the action to be offered. It may be tempting to assist the dog at times, but experience indicates that the less assistance given, the faster progress is made.

Note the language here: the trainer waits for the dog to offer a desired action. The dog is the initiator of actions, and the trainer is a passive participant who provides rewards when the action is offered. The dog is in control of the learning process.

Efficient training requires reinforcement at precisely the right moment. Experience shows that a dog will easily make the link between the sound of the whistle or “clicker” as a reward and the desired action. It may seem frustrating when a dog interrupts desired action to get reinforcement, but a precisely given reward will result in the dog immediately returning to the same situation/action in an attempt to manipulate the trainer to give more “rewards”. Timing is essential! Some dogs, as a result of this type of training, become very activated when they understand that their own activities result in reinforcement (see box below). In effect, the dog leads the training process by searching for the actions that the trainer wants to reinforce, and offering them for reward. This is therefore a completely positive experience for the dog.

**SHAPING WORKS . . . FOR HANDLERS AS WELL AS DOGS**

Shaping can even be used to train new dog handlers/trainers as well as dogs. When a dog is being transferred from its trainer to a new dog handler, the original trainer can involve the new handler in the training process using the following procedure.

The clicker is used to communicate with both the dog and the new handler at the same time:

To the dog: CLICK = “yes, that is exactly the action that I want you to give me”.

To the new handler: CLICK = “this is the action of the dog that I want you to reward”.

The new handler can then offer the reward that the dog associates with the clicker. The problem for a new handler is to practice the principle of timing, which is so important for the reinforcement process to work effectively. Without that practice, the new handler is likely to make many timing mistakes, and could even detrain the dog. Thus, the original trainer uses the clicker to improve the observational and timing skills of the new handler, without interrupting the training of the dog.
Shaping is more suited to certain types of training than others. Shaping is particularly suited to a situation where the aim is to form new behavioural patterns, or when training particular aspects of a whole programme.

**Multiple-choice training**

*Multiple-choice training* is one of many terms used to describe methods where the aim is to teach dogs to discriminate stimuli by using their sense of smell. An example of such a method has been developed by Fjellanger Dog Training Academy and is described in Chapter 2, Part 2.

The principles of the method were developed with input from both active training and service dog environments (Moulton *et al.*, 1960; King *et al.*, 1964; Military Dog Training Centre Norway, 1978–1981; Craig, 1980; Moulton and Marshall, 1976) and practical experience from work with most types of specially trained sniffer dogs. A number of different apparatus models (Apparatus for Discrimination of Source Material — ADSM) have been designed to organise training so that discrimination of scent substances is optimal for dogs. Shaping is used as a training tool.

The learning methodology avoids development of a dependency between trainer/handler and dog, because the dog controls the learning process and does not need the assistance of a handler for learning to proceed. Behaviour is maintained with no dependence by the dog on the trainer, hence avoiding loss of training effects if the dog is transferred to other handlers. The apparatus may be utilised for an analysis concept such as the REST system, or may be used as a calibration/control tool for the dog’s responses to the scent substances to be detected.

**Stimulus discrimination**

How do dogs process impressions of the world when learning new skills? The principle involves the development of links between stimuli and actions that are appropriate responses to those stimuli, and is referred to as *discrimination* or *stimulus discrimination*. To organise dog training well, reliable reinforcement is needed to ensure that behaviour is repeatable over different situations and with different caretakers. To have control over the learning process, it is essential that the relevant stimuli be identified and controlled. A dog can learn a skill such as sitting on the command “sit” when in front of the dog handler, but when the handler turns away from the dog and gives the same command, there is no reaction. In this situation, it is likely that body movements and eye contact are the effective stimuli rather than the command. In other words, stimuli other than the command being used by the trainer are being used by the dog to create the action “sit”.

From as early as the very first training session, the dog will be gathering information from all aspects of the environment. Each repeated situation will influence the skills being learned. Initially, replication of the stimulus conditions can be seen as a positive aspect, as the numerous stimuli from the surroundings help to induce the desired behavioural patterns and contribute to quicker progress. Later on, it is preferable for behavioural patterns to be triggered more accurately and by more carefully defined stimuli. In some instances, these may be signals/commands, and in other cases visual
stimuli or odour signals. A central challenge of dog training is to both identify and achieve control over which stimuli trigger the desired response.

Several stimuli occurring simultaneously are often referred to as complex stimuli. Learning processes where complex stimuli form a part of the discriminative stimulus are known as contextual learning (Dickinson, 1980). All dog training involving interaction of dog and handler is a form of contextual learning. Research on learning in mazes has shown that animals can establish structural maps of the training/test situation and use these spatial cues as discriminative stimuli influencing their behaviour, rather than using other senses which the trainer may assume are being used (Olton, 1983; Olton and Samuelson, 1976). In another example, the difference in size and lighting of a training/test room affected the training (Gordon et al., 1981). The differences in situation regarding location, time of day, scents, sounds, persons present, etc., are stimuli which affect both dog and handler. The implication is that there must be careful control of the context of learning and of the design of the operational testing apparatus for REST dogs. “Skinner boxes” (Skinner, 1938), and experiments carried out in scent chambers for dogs (Moulton et al., 1960; Waggoner et al., 1997), are situations where the trainers have very precise control over the training conditions. It is not anticipated that such a level of control would be available or even desirable in the training and use of REST dogs.

Scent discrimination and threshold for detection: an example of discrimination training

The anatomical structures used by dogs and humans for detecting and processing odour information are not the same. Detection thresholds of dogs are many times higher than for humans. The biggest anatomical difference is the number of sensory receptor cells (Moulton et al., 1960), which is best illustrated by a comparison of the size of the scent organs. In humans, the scent organs are approximately 5 square centimetres in surface area, whereas for dogs they are 75-150 square centimetres. The cerebral cortex processes information from the olfactory sense. In dogs, about 33 per cent of the entire cortex is used for this task, whereas in humans it is only 5 per cent (Atkinson et al., 1990). In dogs, the high number of cells in the olfactory organ combined with a significant part of the cerebral cortex being used for processing odour information may account for their outstanding skills at discrimination and detection of very low odour concentrations. Attempts have been made to find the lowest threshold that a dog can detect (Moulton et al., 1960; Moulton and Marshall, 1976; Krestel et al., 1984; Phelan, Chapter 5, Part 2), but direct comparisons among these studies are difficult to make because of differences in the methods used. Dogs can be trained to detect odours at vapour pressures well below the detection capability of currently existing chemical detection devices, and lowered detection thresholds can be obtained using training and practice effects (see Chapter 5, Part 2).

The method used for training is important. The choice of reinforcer, amount of training, desired indication signals, system used for sensitisation of odours, etc., are all important factors influencing the end result. The capacity of the sense of smell to detect and discriminate substances varies in the same way as any other physiological function. A better sense of smell is generally attributed to some dog breeds than others (Moulton and Marshall, 1976; Myers and Pugh, 1987). Even within one breed, the sense of smell will vary according to the training and physiological condition of the individual dog. For example, there is proof of impaired sense of smell with various illnesses, e.g.
distemper and Parva influenza (Myers and Pugh, 1987). There may be differences between the sexes (Moulton et al., 1960) and the threshold for detection is thought to reduce when a bitch is on heat (Parlee, 1983).

The physiological function of the olfactory organ can also partly account for the dog’s capacity to detect low scent concentrations (Fig. 1). The flow of air through the nasal cavity is controlled via three channels (Miller and Evans, 1993; Fjellanger, 1991). The upper and lower channels determine how the air is carried to the olfactory organ. Air carried through the upper channel (3) is led to the olfactory organ. When the dog starts to sniff (uses its nose to detect a scent), negative pressure gathers in the lower channel (1) so that the air is sucked through the upper channel, over the olfactory organ and down into the choana.

When a dog is sniffing, there is not just a one-way flow of air into the nasal cavity. Each sniff consists of five to seven small inhalations and exhalations per second of about 50 millilitres of air. The air blown out has a high humidity and can gather molecules outside the nose. Because the same air is sucked back in again immediately, any odour molecules that are released by increased humidity are likely to be drawn into the nose. Thus, the operation and physiology of the nose helps to explain the dog’s excellent skills in detecting low scent concentrations.

Reinforcement

*Reinforcement* is a consequence of behaviour that influences the probability or frequency of that behaviour being expressed in the future. The frequency can increase or decrease.
A reinforcer is an identifiable stimulus that is detectable by the dog, such as food, praise, etc. To work, the process of reinforcement requires that the dog make a link between the occurrence of the reinforcer and the expression of the behaviour. The timing between these two events is critical.

**Positive and negative reinforcers**

Reinforcement involves the use of rewards to increase or decrease the probability of an action by a dog. Rewards can be food, a ball, kong (a ball on a short string), or any other objects the dog is fond of, praise, playing, body language expressing happiness, etc. These are all positive things for the dog and will probably increase the occurrence of an action. They are therefore referred to as positive reinforcers.

Positive reinforcement is very easy to understand. As a result of an action, the dog has a pleasant experience, and so it is more likely to do the action again. If the dog is uncomfortable, due to a positive punishment, it will display this with avoidance. The expression of that avoidance may be something obvious like running away, but where the dog has limited choices (e.g. because it is under the control of the handler) it may also be camouflaged in minor signals in the body language. Examples are yawning, licking round its mouth, pulling back its ears, lowering its tail or lowering its body as it walks. These are all signals of discomfort, and when encountered in training and practical work, are most often a sign that something about the situation is unpleasant for the dog. If the dog acts in a way that reduces the discomfort, then it is improving its current state through avoidance. If it is able to remove the negative feeling, this will work as a negative reinforcer (the removal of a discomfort) and as such lead to an increased probability of the action being repeated. The process is referred to as negative reinforcement of behaviour.

An example: the dog is asked to search a set of filters where the handler does not know the location of the targets. The dog is uncomfortable with the situation because it is sick today. The handler forces the search using aggressive voice, staring at the dog, or jerking on the lead. The dog has limited choices because it is on lead and is under pressure to search. The dog knows from previous experiences that an indication will result in an end to the search. The dog gives an indication at a randomly chosen filter. From the handler’s point of view this is an operational situation, and it must be assumed that the indication is real. From the dog’s point of view, the search ends and the negative experiences of voice, jerking etc., are all removed, which is why this scenario is about reinforcement. The effect of this example will be to reduce the quality of search expressed by the dog, to make the dog feel uncomfortable in the presence of the handler next time, and to increase the occurrence of false indications (= reduced correct indications).

**Distribution of reinforcement — intermittent reinforcement**

When an action is reinforced every time it occurs, the process is known as continuous reinforcement. When an action is repeated several times before the reinforcer is activated, the occurrence of the reinforcer is intermittent and the process is called intermittent or occasional reinforcement.

A fundamental principle of learning theory is that intermittent reinforcement is more effective at maintaining a response than is continuous reinforcement. Rewarding a
behaviour every time it occurs produces an expectation by the dog that the reward will appear whenever the action is offered, which is effective in inducing new behaviours. After such a training procedure, just one occasion of the action being offered by the dog without being rewarded will lead to a reduction in the likelihood of the action being offered again.

In a typical dog training situation, the occurrence of a desired behaviour (e.g. sitting on command) will be established by reinforcing the dog every time it sits. However, once the behaviour is given consistently to the command, the appearance of the reward becomes less reliable. The dog may be rewarded every third time it sits on command, or even better, it is rewarded after a variable number of times of sitting on command. Initially, the reward will still appear rather often (e.g. after 2, 1, 3, 1, 2, 1, 3, 1, 1, 4, 1, 2, 1 times). But as training goes on and the dog is offering the behaviour reliably without the reward being provided, the rate of appearance of the reward can continue to be decreased (e.g. after 5, 3, 6, 2, 7, 4, 8, 1, 9 times). This is called variable frequency (ratio) reinforcement.

However, a trainer of a search dog has to deal with a different kind of behaviour – a behaviour that is continuous in time (e.g. searching) rather than a discrete action (e.g. sitting). A primary training aim will be to extend the search intensity of the dog in time. This problem must be dealt with by adjusting the reward rate in time. To extend search intensity, the trainer will maintain a record of the period that the dog searches for without interruption, and the training aim will be to extend that average period of search. For example, if the dog naturally exhibits search behaviour without becoming distracted for an average of 30 seconds, then the aim could be to increase that length of time to an average of one and a half minutes over the next few training sessions. Initially, the reward will appear quite often in time, say at an average rate of every 30 seconds because the dog already searches reliably for that period of time (e.g. after 10, 20, 70, 30, 20, 50, 60, 10, 30, 10, 20 seconds). Then the next two sessions could be 60-seconds average (e.g. 40, 80, 30, 90, 60, 20, 100, 60 seconds) and 90-seconds average (e.g. 50, 140, 80, 100, 10, 170, 110, 70, 90 seconds). Now, the search intensity of the dog is being maintained for an extended period of time relative to the original natural search behaviour. This is called variable interval reinforcement.

The amount of time spent searching can be thought of as “number of filters checked by a REST dog”. If in one minute, the dog will check six filters, then in one-and-a-half minutes it can check nine filters. The dog checks filters at a standard rate, so the method used to increase the search time of the dog will be to increase the number of non-target filters to be checked. Here, number of filters can be equated with time of searching, because more filters = more time searching, and a bigger number of negative targets between the positives = extended maintenance of searching behaviour. Note that the principle of unpredictable appearance of the reward described in the first scenario also applies to this second scenario of rewards being offered in time. It is the average time of search between finding a positive that is slowly extended by the trainer, but the appearance in time of each positive is quite variable, as indicated in the numbers used in the example in the paragraph above.
SHAPING, WITH A CLICKER

A clicker is a little plastic tool with a steel tension spring that produces an audible two-tone clicking sound when pressed. The clicker has been used in dog training for some years, and the sound (click) has been established as a conditioned stimulus with the shaping method of training. The dog responds to the click and the clicker can therefore be used as a signalling tool.

1. Press the clicker to produce a two-tone sound. Give the dog a titbit, in small portions. Give the dog something especially tasty at the start, for example, small morsels of fried chicken or liver, rather than large pieces of dried food.

2. Click when the dog does something you want it to do. Start off with something simple, preferably something the dog would want to do independently (e.g. sit, come to you, sniff randomly, raise its paw, walk at heel).

3. Click exactly when the dog is behaving the way you want, not afterwards. Click only once (in-out). The timing of the click is decisive. Do not worry if the dog stops what it was doing when it hears the click, this is only natural. Give the dog the titbit afterwards, the timing of this reward is not as important.

4. Click when you notice the dog consciously (or coincidentally) beginning to behave in the way you want. It may be tempting to help the dog do as you want or move where you want, but the less help you give, the quicker the dog will progress. You can of course try to help to a certain degree, but train the dog to manage without help as quickly as possible. Your aim is to have the dog offer behaviours to you in the hope of getting you to reward it.

5. Train for short periods only. A dog can learn a lot more in five minutes than over one hour of boring repetitions. You can achieve notable results and teach your dog a whole range of new things by using just a few clicks during the day, as a part of your normal routine. Always have the clicker with you and seize upon opportunities when the dog begins doing behaviour that you want to see repeated.

6. Clicker training is most simple in practice when you start off with things the dog already does: sitting, lying, coming to you, or walking at heel. If you click as soon as or immediately after the dog has acted as you want, then the dog will repeat the behaviour more often.

7. Do not wait for the dog to complete its action or behaviour. Click and give a reward for small movements in the right direction. If you want the dog to sit, and it starts to lower its haunches, then click. If you want it to come to you, and it takes a few steps towards you, then click. This is what is known as shaping behaviour.

8. When a dog has learnt to do something to make you click, it will start to repeat this behaviour spontaneously (i.e. is offering the behaviour) to get you to click. It will do something then look directly at you as if to ask: “Was that right?”

9. If it is a minor activity, you can increase interest by varying the type of reward you use, sometimes with a titbit, other times a pat, ball or game. If you want to let the dog know you are especially happy with its behaviour, then increase the number of titbits and show your pleasure in your body language – do not use the clicker more often.

10. Once a behaviour is established, reduce your reward rate (i.e. the rate at which you give the clicker reward) so that the offering of the behaviour is only being rewarded intermittently. Now the dog will offer the trained behaviour, but will also be motivated to offer new behaviours, which you can also potentially reward.
11. Stop a training session when things are going well, or you have reached a new level, or when the dog is performing perfectly.

12. Abolish unwanted behaviour by clicking for the behaviour you want. Instead of shouting at the dog for barking, click when it is quiet. Stop the dog pulling at its leash by clicking and giving a reward whenever the leash falls slack.

13. Once the dog is offering the behaviour reliably, it is time to introduce an additional signal, such as a word or sign with the hand, to link the behaviour to a command. Give the signal directly before or at the same time as you click for correct behaviour. Ignore correct behaviour when offered without you giving the signal.

14. Do not attempt to demand that the dog offers behaviours. Clicker training is not about commanding the dog. The notion of a command is that it is a convenient signal for you to use in the future to communicate with the dog. If the dog does not react to the signal, it is not “disobedient”, it just has not learnt the signal properly yet. Continue the training by finding new locations (persons, times), give the signal and click for correct behaviour.

15. If you become irritated, put the clicker down. Do not confuse shouting, pulling the leash and correction, with clicker training. You will only break down any relationship between you and the dog, and the dog’s interpretation of the clicker.

16. If you get no results, then change strategy - remember there are many “roads to Rome”. Often the timing is wrong, you may be clicking too late. Get someone who understands the clicker training principle to watch you, or maybe even help use the clicker.

17. Most importantly, clicker training is a great way to enhance your relationship with your dog. Have fun!


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