Human scent matching using specially trained dogs

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Abstract. The purpose of this project was to provide data on the success rate of dogs identifying people by scent when working in conditions similar to those used by the police in Holland and Germany. Over 700 scent samples were collected from people of both sexes and a wide age range and seven dogs, *Canis familiaris*, were trained to match human body scents. The test conditions were carefully controlled to eliminate any cue other than the body scents presented to the dog. Each dog sniffed a piece of cloth which had been in contact with an unspecified part of the body of a person and then indicated which of a selection of blank or body-scented cloths bore the same scent. The handler did not know the location of the target scent. The average score of the dogs working with body-scented cloths from six donors was 80% correct whereas a random choice of cloth would have been 17% correct. A further experiment was carried out in which three dogs were asked to match odour from various parts of the body with hand odour of the same donor collected on clean steel tubes. The average score for this task was 85% correct with a selection of six donor odours. The results show that dogs have considerable scent matching ability but that individual aptitude and the day-to-day performance can vary. Dogs used in criminal investigations should be selected for aptitude and the tests replicated so that conclusions are not based on trials from a single dog.

There is substantial evidence that dogs, *Canis familiaris*, can recognize individual humans by scent (Kalmus 1955; Szinak 1985; Sommerville et al. 1990). Traditionally dogs have been used to track criminals and lost people. Dog training societies in many countries run competitions testing this ability and police forces in Hungary (Szinak 1985), the Netherlands (de Bruin 1989) and Germany (Settle 1992) routinely use trained dogs to match odour collected from the scene of a crime with that of a suspect. The dog is given the odour to be matched and then has to select unequivocably from a line of people or from their hand odours deposited on steel tubes. This test is replicated with the choice people/odours placed in different relative positions. Although the courts of law in these countries accept dog scent identification as corroborating evidence for conviction, no account of the training and validation of the procedure has appeared in the scientific literature. Brisbin & Austad (1991) reported that dogs may have difficulty cross-matching scent collected from different parts of the body but it seemed to us that their problem might have been eliminated by further training (Sommerville et al. 1993).

The purpose of our experiments was to quantify the success in matching human odour of trained dogs working with equipment and protocols similar to those used by the police in Holland and Germany.

METHODS

Experiment 1

Subjects

Ten male dogs and handlers were initially selected from the Police Dog Training School of Lancashire Constabulary on the basis of availability. Three of these teams withdrew from training early on owing to conflicting commitments. The dogs completing the training and trials were two labrador retrievers (Ben, 1·5 years old and

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Paddy, 2 years old), one border collie (Duggan, 10 years old), one springer spaniel (Danny, 5 years old), one Rottweiler (Zac, 8 years old) and one German shepherd (Sabre, 8 years old).

Sample collection

We collected body scent on 20-cm squares of woven cotton fabric which had been washed with a standard detergent liquid in a domestic washing machine and dried in a tumble drier. The squares were stored and distributed to scent donors in standard 0·9-litre glass jars with 70-mm twist caps. The jars and caps were sterilized in boiling water and dried before use. Four squares were placed in each jar by an assistant wearing disposable gloves and using clean steel tongs. Scent samples from a variety of different parts of the body of a cross-section of the population were obtained in the jars which had been delivered to schools (infant, junior and secondary), a local engineering company, an old people's home and members of the dog training school. The donors were instructed to place each of the four cloths in a different but unspecified part of their body or clothing for 30 min and then return them to the jar, put on the cap and leave for collection the following day. Samples from over 700 individuals were collected during the course of the study and used in the dog training and trials, usually within 2 days of collection and always within 4. On any one day, the selection of odours presented to the dog was from only one establishment so as to minimize the chance of the environmental background providing a matching cue for the dog. The jars were labelled with the date of collection but there was no indication of the identity of the donor nor of the body sites from which the odours had been collected.

Apparatus

We set up the selection of scents for matching by removing the cap of the jar (while wearing disposable gloves) and placing each jar in a 9 cm high holder made of ultra polyvinyl chloride (uPVC) piping 11·5 cm in diameter. The holder was 4·5 cm higher than the jar to prevent the dog from attempting to retrieve the jar. The holders were mounted in two lines of three, each set welded to a sheet of uPVC measuring 0·6 × 2·9 m. When the two sheets were presented in line they gave the dog a searching length of 5·8 m comprising six holders each 85 cm apart. The relative position of the jars could be changed and the holders and surrounding area could be cleaned between tests. Between sessions the sheets and holders were cleaned and left standing outside in sunlight whenever possible to avoid a build-up of scent contamination.

Experiment 2

Subjects

Three dogs were used: Ben and Paddy had been trained and tested in experiment 1 but Kelly (female, labrador retriever, 1 year old) was used in place of Danny who was withdrawn because of an injury. Kelly had been recently purchased and had received no training in the police dog school.

Sample collection

The donors were targeted as in experiment 1 and the samples collected from the same institutions. The donors scented cloths as described previously but were also given a sealed jar containing six steel tubes which they were instructed to handle for 5 min each and return to the jar. The donors were not asked to wash their hands before sampling. A date and code were marked on the jars so that each set of cloths and tubes could be correlated.

Apparatus

The steel tubes, 10 cm long and 2 cm in diameter, contained 18% nickel, 8% chrome stainless steel. For the tube discrimination test, special apparatus for holding the steel tubes, closely resembling that used by German police, was made for us by British Nuclear Fuels Ltd, Springfield Works, Preston. The main advantage of this holder was that it prevented the dogs knocking the tubes so that they rolled out of line and were missed during sniffing. Another advantage was that the holder prevented the dog picking up a tube as a reward object, before it had sniffed the other tubes properly. A platform measuring 1 × 5·87 m made of 6 mm rigid uPVC sheeting in five sections was mounted 10 cm off the ground on a Dexion tubing frame. In the centre of each of the three inner sections of the platform was mounted a stainless steel plate (42 × 32 cm) to which was welded a steel jaw for gripping the scented tube. A

movable jaw operated a grip pressure of 100 psi and could be individually opened by a pneumatic system coupled to a control box to release the tube when the dog made an unambiguous choice.

Training and Trial Procedure

The training for experiment 1 progressed in easy stages in such a way as not to lose the dog's interest. The cotton squares were first introduced as toys, and training stopped at the first sign of boredom or poor performance. We minimized disciplining the dogs and allowed each to establish its preferred style of working within basic constraints. When the dogs were introduced to the training room, any that showed a strong tendency to urine marking were not used again since this would have introduced distracting odours. At first, all the procedures took place within the room so that the dog and handler could watch the distribution of cloths. The dog was presented with a cloth, with the target scent on it, to sniff in an open jar; or the handler, wearing disposable gloves, removed the cloth and held it over the dog's nose. The method used depended upon the individual preference of the dog. After presentation, the cloth was sealed in a jar to prevent odour confusion. The dog was then required to find a matching scented cloth (the target) which had been taken from the same jar as the one presented and hung over the edge of a jar holder. In addition to this holder, there were five others which were initially empty and then contained unscented cloths hung over their edges. As soon as the dog was regularly retrieving the correct one, the cloths were completely hidden in the jar so that they could not be retrieved and the dog had to indicate clearly by any preferred means (e.g. barking, scrabbling, lying down by the holder) which one of the six holders contained the target cloth. After this, 'control' cloths, scented with human odour that did not match the target one, were introduced. When the performance of the dog was good, the scent to be found was presented outside the room but the handler was told the location of the target scent (a 'training test'). When a trial was being carried out, the handler did not know the location of the target scent. Trials were interspersed with training throughout the introduction of more control odours. The number of trials run on any day would vary depending upon the dog's performance and stamina.

Initially the only reward for correct behaviour was the expression of approval of the handler. However, we soon found that some dogs could be induced to work faster for a food reward and these quickly began to show reflex salivation as soon as they sniffed the matching odour, giving the trial manager another useful indicator of the dog's choice. Although the trial manager knew the location of the target scent, he did not interact at all with the dog and endeavoured to keep out of the dog's sight line while it sniffed the samples.

For experiment 2 we first introduced the steel tubes to the dogs as play objects. Next the tubes were placed in the holder and two dogs soon learnt to retrieve them while the other dog scrabbled at the tube until the handler came to pick it up. When we operated the tube locking mechanism, all the dogs scrabbled at the selected tube until it was released. The two dogs already trained in the scent cloth method immediately retrieved one scented tube set up in the cylinders along with five unscented tubes and also salivated as soon as they found it, in anticipation of a food reward. The third dog learnt the technique rapidly. We then gave them the scent to be matched on a cloth, outside the test room in exactly the same way as in experiment 1 and gradually introduced the control scents. A tube was released by the trial manager only when the dog gave an unambiguous indication of its choice, such as, scrabbling to detach the tube.

If the performance of a dog deteriorated, during training for either experiment, efforts were made to establish the cause and, if none was apparent, the training would revert to a previous stage in the programme.

For the trials, chi-squared analyses were carried out to establish whether the dogs' performances were significantly different from a random selection and to see if there was a significant effect on correct choice of the location of the target odour in the line or the number of different control odours presented to choose from.

RESULTS

The training and testing of the dogs took 9 months (6 months devoted to the scent jar method followed by 3 months working with the steel tubes). Figure 1 shows the level of performance for one dog on each working day over a 5-month

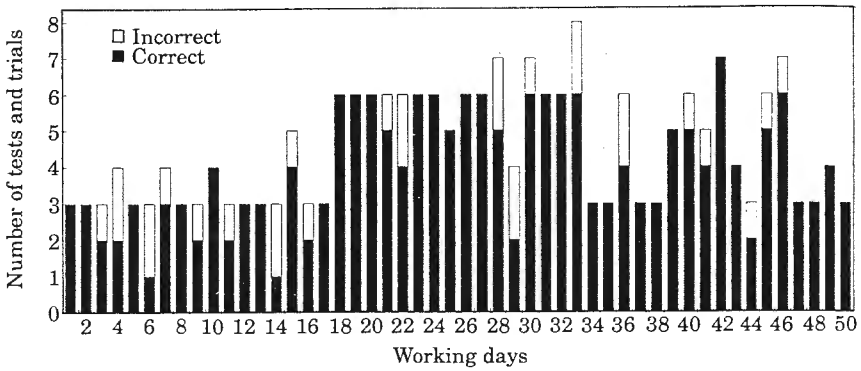

Figure 1. Daily performance of one dog (Ben) in the training tests and trials conducted over 50 working days.

period. Three of the occasions (4th, 6th and 14th working days) when the correct score fell below 60% followed a work break of 1–2 weeks and the other low score was on the day (29th) preceding the diagnosis of a viral infection.

Experiment 1

In the trials using the scent cloth in jar method for which the handler did not know the location of the matching scent, 80% of the choices were correct (random score 17% correct; $\chi^2=80{\cdot}5$, $df=5$, $P<0{\cdot}001$; Table I). The range of chi-squared values for the effect of target scent location on the performance of different dogs was 0·51–2·98 ($df=5$, $P>0{\cdot}2$).

Experiment 2

When there were six scents presented to choose from, 85% were correct (random score 17% correct; $\chi^2=37{\cdot}4$, $df=2$, $P<0{\cdot}001$; Table II). Ben's results showed no tube location effect. Kelly's results were too few to carry out a chi-squared test but there was no indication of an effect of tube location. Paddy tended to avoid tubes in position 4 but the combined deviation from a random choice was $P>0{\cdot}05$, indicating that the location of the target scent did not significantly affect the dog's choice.

DISCUSSION

Our results show that dogs can efficiently match objects bearing the scents of individual humans whom they do not know even when the scented objects have been in contact with different parts of the body and collected with no particular precautions to avoid environmental contamination. The donors we used came from a large cross-section of the community so the dogs may have been making their choices from a wider selection of odours. with respect to age and gender, than a typical

Table I. The number of trials in which a dog correctly selected a cloth from six which comprised one target scented and five unscented or non-target scented cloths

	No. of different scented cloths presented					
Dog	1	2	3	4	5	6
Ben	26 (28)	2 (3)	4 (4)	7 (8)	0 (0)	75 (84)
Danny	34 (34)	4 (8)	4 (5)	3 (5)	0 (1)	6 (6)
Paddy	18 (21)	2 (5)	4 (6)	5 (7)	0 (2)	24 (31)
Zac	13 (14)	8 (9)	5 (9)	3 (5)	4 (4)	7 (13)
Duggan	8 (10)	3 (6)	7 (13)	0 (1)	0 (0)	9 (12)
Sabre	13 (14)	3 (6)	3 (7)	1 (2)	0 (0)	5 (6)

The total number of trials is given in parentheses.

Table II. The number of trials in which a dog correctly selected a steel tube from six which comprised one target scented and five unscented or non-target scented tubes

Dog	No. of different scented tubes presented					
	1	2	3	4	5	6
Ben	23 (27)	26 (36)	6 (8)	0 (0)	0 (0)	33 (42)
Kelly	2 (2)	0 (1)	13 (13)	3 (3)	0 (0)	8 (9)
Paddy	21 (21)	12 (13)	16 (22)	3 (4)	0 (1)	18 (21)

The total number of trials is given in parentheses.

working police dog in Holland or Germany. In these countries the donors providing the control scents are of the same gender, approximate age and, some at least, of the same ethnic origin as the suspect. In our trials, the greater variety of control odours as well as the greater conformity between key odour and target odour could have boosted the correct scoring of our dogs. On the other hand, the training/trial room was not purpose built nor ideally situated, being in the busiest part of the School where the dogs were subject to considerable distraction. In addition, the control odours for each trial were all from the same establishment and this would have eliminated useful environmental cues so making the task of our dogs more difficult. In police identity parades, some of the control participants are often selected from the home police establishment. This practice may jeopardize the impartiality of dog identification in two respects. Dogs may respond differently to the odour of people they know and they are certainly likely to use a common environmental odour to emphasize the difference of a foreign odour. The influence of such effects are difficult to assess and should be the subject of further experiments.

Most instances of a sudden fall in performance were attributable to an interruption of work for 1 or 2 weeks owing to the handler having other commitments or were due to impending illness on the part of the dog. We noticed that some dogs did not perform well in the presence of observers and that the performance of most began to deteriorate as soon as the handler became emotionally involved in the dog's scoring success.

The variable success rate of individual dogs is not surprising because there was no particular selection of the dogs chosen for this study. However, it is clear that certain dogs have a greater aptitude and a more suitable temperament for this task than others. Austad & Brisbin (1993) maintain that their earlier experiments were designed to see whether dogs that had not been specifically trained to generalize individual human scents obtained from different parts of the body would do so automatically. It is likely that the particular breed chosen would strongly influence the results of such experiments and the evidence from blood hound trials suggests that this breed can generalize. The number of dogs in our experiments was too small to indicate any breed-related variation but it seems likely that with appropriate training, many breeds of dog selected for tracking and retrieval ability will achieve high and dependable success rates.

Since the scented cloths from each donor were stored in the same sealed container, a certain amount of odour equilibration is likely to have taken place. Furthermore, the donors were obliged to handle the cloths so some hand odour would have been present on all cloths. This means that we cannot claim unequivocably that the results of the steel tube trials demonstrate the dogs' ability to cross-match scent from one part of the body to another. It seems highly likely, however, that full equilibration of the less volatile compounds would not occur and that pure hand scent on the steel tubes would certainly have been qualitatively different from the cloth scent comprising, as it did, a small amount of hand odour and a large amount of other body odours.

The results were obtained using seven dogs to carry out 617 trials, each trial involving the discrimination of up to six different body scents from over 700 donors, so the study was more wide ranging than that of Brisbin & Austad (1991). Our results suggest that if dogs are selected well, sympathetically trained and entirely dedicated to scent discrimination in a well-managed unit they are likely to maintain a dependably high

performance over long periods. Furthermore, they should be able to achieve high scores when given a choice of odour from six different people. Further investigations of the dog's ability to work with trace odours, distinguish people on the basis of age and gender and reliably cross-match odours from different parts of the body need to be carried out.

The dog's olfactory sensitivity, selectivity and memory, as well as its capacity for odour pattern recognition, are unlikely to be challenged by any artificial sensor in the foreseeable future. However, variations do occur in the individual aptitude of dogs and even a good dog may sometimes perform badly, so it is essential to subject each dog to several trials when a suspect is being identified. If this is done, selected dogs should provide a valuable resource in criminal investigation and security operations.

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REFERENCES

Austad, S. N. & Brisbin, I. L. 1993. The use of trained dogs to discriminate human scent: a reply. *Anim Behav.*, **46**, 191–192.

Brisbin, I. L. & Austad, S. N. 1991. Testing the individual odour theory of canine olfaction. *Anim. Behav.*, **42**, 63–69.

de Bruin, J. C. 1989. *The Detection Dog and Science*. Report from Dog Section, Rotterdam Municipal Police.

Kalmus, H. 1955. The discrimination by the nose of the dog of individual human odours and in particular the odour of twins. *Br. J. Anim. Behav.*, **3**, 25–31.

Settle, R. H. 1992. *Human Scent Analysis Using Specially Trained Police Dogs*. London: Home Office Science and Technology Group.

Sommerville, B. A., Green, M. A. & Gee, D. J. 1990. Using chromatography and a dog to identify some of the compounds in human sweat which are under genetic influence. In: *Chemical Signals in Vertebrates* (Ed. by D. W. MacDonald, D. Muller-Schwarze & S. E. Natynczuk), pp. 634–639. Oxford: Oxford University Press.

Sommerville, B. A., Settle, R. H., Darling, F. M. C. & Broom, D. M. 1993. The use of trained dogs to discriminate human scent. *Anim. Behav.*, **46**, 189–190.

Szinak, J. 1985. Identification of odours. *Int. crimin. Police Rev.*, March, 58–63.