



Commentary

Mantrailing as evidence in court?

Kai-Uwe Goss

Helmholtz Centre for Environmental Research GmbH - UFZ, Department of Analytical Environmental Chemistry, Permoserstraße 15, 04318 Leipzig, Germany



ARTICLE INFO

Keywords:

Mantrailing
Search dogs
Evidence in court

Introduction

Search dogs are used for many tasks. A specifically challenging one is the so called mantrailing, i.e. the trailing of individual persons that are missing or fugitive. To this end the dog is provided with a scent article from the person/suspect and then started at a location where the person has been seen the last time or at the crime scene [1]. It is the task of the dog then to follow the trail of the person as far as possible in order to find the person or at least to document its path/escape route. In some countries, like the USA or Germany, the work of mantrailing dogs has been used as evidence in court (e.g. Landgericht Nürnberg 2012, Az. 13 KLS 372 Js 9454/12, Landgericht Chemnitz 2015, Az. 1 KLS 250 Js 32750/13, Landgericht Regensburg 2014, Az.7 KLS 128 Js 9348/1, Landgericht Gera 2018, Az. 1 KLS 111 Js 18563/15 (53)/24, Landgericht Frankfurt (Oder) 2020, Az. 22KLS 30/18). For clarity, this text is confined to “trailing” i.e. the identification of an individual human’s trail by a dog following at some (temporal) distance in contrast to “tracking” where the dog follows the human quite closely [1]. In tracking the dog uses ground disturbance as a cue and usually the freshest human trail is worked out.

The success or failure of the work of a mantrailing dog are potentially important to the outcome of trials in court. Therefore, it is necessary to know where the principal limitations to this kind of search work are. By far the most important question is, how old an individual trail may be before it cannot be detected reliably any more and how this depends on weather conditions and the type of surface on which the trail has been laid. This knowledge is important in court but also to decide whether it makes sense at all to deploy a mantrailing team in a specific situation. If only fresh trails can be found, then logistics would have to be adapted accordingly.

The mantrailing community is quite diverse ranging from private persons who practice this as a hobby, to semi-professional rescue teams

(e.g. red cross) and professional search units in the police and army [2–4]. There are no generally accepted standards for training or certification, instead there are numerous schools, philosophies and organizations that compete with each other. Scientific standards such as double-blind testing instead of single-blind testing are not wide spread in the mantrailing community. Reports on the performance of mantrailing dogs in general or in specific cases are usually anecdotal and do not help to elucidate the situation. These reports reach from successful trails that were worked out after several months or even years to the opinion that only fresh trails (1 or a few hours old) can reliably be worked out [5]. Even car trailing (e.g. following a person that left in a car) is considered possible by some [6]. Also, within the police units there is no common ground on what mantrailing can achieve: countries like the Netherlands and Belgium decided against mantrailing units in their police because – after some testing- they were not convinced that this works reliably in relevant scenarios [7]. In other countries like the USA and Germany mantrailing is believed to work well enough that its outcome is accepted evidence in court in some federal states, despite several documented cases of judicial error [8,9].

The goal of this commentary is a critical collection of empirical evidence combined with a science based assessment of what achievements are conceivable at all. This work has its focus on real trailing when air scenting is excluded, i.e. the target person is not waiting at the end of the trail. The question of scent matching which is a prerequisite for mantrailing was also not in the focus of this study. It is simply assumed that scent matching by trained dogs is possible (a detailed discussion of this topic can be found for example in [1,10–13]).

Specific studies related to mantrailing

Very little information relevant to mantrailing can be found in the scientific literature: Some studies investigated whether dogs can

E-mail address: kai-uwe.goss@ufz.de

<https://doi.org/10.1016/j.fsir.2021.100204>

Received 18 February 2021; Received in revised form 22 April 2021; Accepted 25 April 2021

Available online 4 May 2021

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distinguish the direction in which a person walked when brought in at a 90° angle at the mid-point of a fresh trail ([14–16] and literature cited therein). The conclusions were that dogs are not generally able to find the correct direction of a trail (i.e. following a trail forward instead of backward). These results were based on fresh (< 1 h) and short (< 200 m) trails. A study that investigated the dog's ability to differentiate twins also worked with short and fresh trails and had the target persons standing hidden at the end of the trail so that air scenting instead of trailing could not be excluded [17]. This ambiguity also occurs in other studies. Harvey and Harvey [18] had dogs working successfully on 48 h old trails but again with the target persons waiting at the end of the trail. The same happened in a PhD thesis which explicitly looked at the effect of trail ageing in mantrailing [19]. This problem was eventually acknowledged in the thesis as a potential fault (page 139). Interestingly the author of the thesis also states that it was very difficult to find dog handlers that would be willing to work on trails older than 48 h because according to their experience this would not be successful (page 144). Several studies deal with the question of scent matching, i.e. can a dog match the scent from a scent-item with the direct scent from the owner of this item e.g. [10,12,17,20]. Some of these studies also involved trailing in the experimental set up but because the target person was waiting- though hidden- at the end of a very short trail (50–100 m) the dogs may have found the target persons by air scenting rather than trailing on the ground [17,18,20]. A recent paper on mantrailing [20] with extremely fresh (5 min) and short (100 m) trails is not further considered here because serious concerns about data manipulation in this work have been raised [21,22]. Unfortunately the realm of scientific literature on mantrailing is already exhausted with this short overview. Due to this general lack of scientific information it is worthwhile to widen the view for other information that may be instructive though not resulting from a strict scientific approach: Between 2014 and 2016 the German police engaged in an internal double blind testing of mantrailing police dogs from most of the federal states (41 operational dogs in total) on trails that were 1 km long and 4 weeks old. None of the dogs was successful and even in the first part of the trail, correct directional decisions did not occur more often than by chance (if the dogs had started at all) [23]. While this seems to suggest that older trails are difficult or even impossible to work out the saxonian police in Germany has still used mantrailing results based on trails up to one year old as evidence in court in many instances.

In these cases the mantrailing evidence has focused on proving that a suspect has been at the crime scene in the past while the suspect himself denies this. To this end the dogs are employed at the crime scene (usually months after the crime had been committed because it took that time to identify a suspect) with a scent item from the suspect. If the dog handler comes to the conclusion that his/her dog could identify the scent from the suspect on the ground of the crime scene then this is taken as evidence that the suspect must have been there at some instance in the past. (e.g. Landgericht Gera 2018, Az. 1 KLs 111 Js 18563/15 (53)/24; Landgericht Chemnitz 2015, Az. 1 KLs 250 Js 32750/13, Landgericht Zwickau, Az. 2 KLs 300 Js 9055/18, Landgericht Frankfurt (Oder) 2020, Az. 22KLs 30/18). A special situation has occurred in a homicide case (Landgericht Regensburg Az. Ks 103 Js 17751/13 2020): 3 mantrailing teams of the police had allegedly indicated a one-year old trail of the victim in a specific location at a time when the victim was still believed to be alive and missing. These detections had mislead the investigation and temporarily exonerated the suspect. A partial confession of the suspect eventually revealed that the mantrailing results had been wrong.

All above cases have in common that the dog handlers started at the crime scene knowing that they had been provided with a scent sample of the suspect. Although the courts are usually aware of the danger that a dog handler may influence his/her dog ([24]; see judgement of Landgericht Regensburg 2014, Az.7 KLs 128 Js 9348/1, page 41) it is not common sense that the same standards would have to apply to mantrailing as they do to scent matching or a line-up of suspects. The

“Clever Hans effect” i.e. an inadvertent influence of the handler on the work of its dog, may also apply to search dogs and their handlers [24]. Therefore it should be mandatory that the dog handlers are started with blinded scent samples from various persons that had or had not been at the crime scene, including a sample from the suspect. Only this procedure would generate a reference for the actual reliability of the mantrailing team in deciding whether or not a specific person had been at the scene. Only the trail start and not a whole trail would have to be worked out for this purpose. In 2012 the court in Nuremberg, Germany, (Landgericht Nürnberg Az. 13 KLs 372 Js 9454/12) had suggested quality standards for mantrailing evidence in court: dogs certified by the police, scent item taken from the body of the suspect, video documentation of the search, two dogs have to search independent of each other. A requirement that not only the suspect's scent item but also others would have to be tested by a deployed dog in a blinded procedure had not been part of these quality standards. Any request for the police dogs to having been trained and tested regularly on trails as old or older than the one in question does also not occur in these standards. Note that the training and testing of mantrailing dogs is limited to a trail-age between 12 and 48 h in the police of all federal states in Germany. The federal state of Saxony does not even require their dogs to follow the trail closely in their yearly examinations [25]. Deviations of up to 300 m from the laid trail were acceptable in the past as long as the target person was eventually found by the dog (possibly by air scenting).

Scientific background

Not much is known about the nature of the odor cues that mantrailing dogs use [16]. But with some scientific reasoning one can distinguish more useful theories from others that are not plausible at closer scrutiny. Much of the below is based on the author's personal reasoning. These considerations have not yet been discussed in a wider scientific community.

It is often assumed that on soft surfaces dogs follow cues that come from ground disturbance i.e. the impact of footsteps on the surface, crushing vegetation and insects etc. releasing an odor based on this surface disturbance [16,26]. However, ground disturbance can never be assigned to a specific individual that has caused it. Since mantrailing is the search for a specific individual and since it is supposed to work on paved surfaces as well there must be a more complex explanation for this type of search than just some non-specific ground disturbance. The following paragraphs describe details of what contributes to a trail. From this information direct conclusions to the ageing of a trail are drawn.

What does it take for a human scent to be specific for an individual?

Some dozens of different human scent molecules have been detected with analytical instruments (e.g. [27–30]). Even if a dog may be able to detect more than that, it follows that the scent of an individual, in order to be unique, has to be a scent bouquet i.e. a combination of different odors rather than a single odor that would be characteristic for every human being. (Here, the term ‘scent’ is defined as the total of all odors that characterize a target, while ‘odor’ means the sensation that is triggered by a specific type of molecule when it gets into contact with an olfactory cell in the nose).

This scent bouquet has to be quite complex if we assume that each human individual has its own characteristic bouquet, as demonstrated by the following calculation: in order to allow for $3^{22} = 3 \cdot 10^{10}$ different combinations which is enough to cover all humans living on this planet we have to assume that a human scent bouquet contains 22 different odors and a dog can distinguish three concentration levels for each of these odors: not detectable, low and high concentration,. In reality the situation may be somewhat different (e.g. less scents but more detectable concentration levels or vice versa) but what is important, the identification of a human individual by a specific scent profile is only conceivable via a complex combination of different odors at

characteristic concentrations. This conclusion is important for various arguments that follow below. It is a generally held belief that such an individual scent profile exists and at least for a smaller number of persons (10–50) significant differences in the detectable scent profile have been demonstrated by instrumental analysis [29–33]. In addition, recent research has shown that the microbiome (i.e. the total community of microbes) on human skin is not identical for any two individual humans [34,35]. It is thus very plausible that the metabolic products of these microbes (mostly volatile organic chemicals = odors) which the microbiome produces when feeding on dead skin cells and skin excretions also differ between any two humans and thus cause our individual scent [1,36].

What creates an individual trail?

Now the next question is, how could a scent bouquet emitted by a human leave a detectable trail along the path of this person? We can assume that we constantly emit our scent bouquet to the environment in the form of odor molecules that volatilize from our skin. Most of these molecules are quickly diluted and carried away in the air. Due to the quick and turbulent mixing in ambient air, no trail can persist in the air for more than minutes after the scent source has gone. But a small fraction of the scent molecules will sorb to the surfaces (soil, pavement, plants...) along our path (because each organic chemical and thus each odor has a specific tendency to sorb from air to any available surface [37]). And –because this sorption process is reversible- these odors would desorb again from these surfaces within a short while after sorption has occurred and these desorbing odors could be detectable to dogs. While this might sound like a plausible explanation of the scientific basis of mantrailing there are two arguments that shed doubts on this hypothesis:

- a) Different odor molecules have different volatilities (here defined as the tendency to desorb from a surface) and these volatilities again are strongly dependent on the type of surface [38]. Hence, the scent bouquet that sorbs to a surface will not be identical in its composition to what desorbs from that surface. Thus, there would never be a complete match between an original scent profile taken directly from a human (or from a scent item that was presented to the dog) and the same scent profile after it had been in contact with a sorbing surface for a short time ([39] and literature cited therein). Dogs can be trained to accept a certain variability in a scent profile while still being able to assign it to the correct human individual, this becomes more and more difficult though the older the trail is as more and more volatile odor components are lost.
- b) At any moment in time there are odors from hundreds or thousands of different sources sorbing and desorbing from any surface in our environment. It is unclear how a dog would know which of these odors originally belonged to a specific scent profile (i.e. the one that the dog is looking for).

Along the path of a human, abrasion from clothing in form of textile fibers, small particles from the shoe soles or shed hair will be left on the ground. Typically, this material had enough time to get soaked with the personal scent bouquet of the human before it was worn off. Once, this material is in the environment it will release (i.e. desorb) this scent bouquet to the air over time [26,38]. The human scent bouquet would likely be the dominating scent emanating from these particles and it would be detectable in the direct vicinity of these particles before it gets mixed and diluted with other odors. So this could explain the existence of fresh trails, but due to the different volatility of odor molecules (see a) above) such a trail would rather soon lose its characteristic odor composition.

Another hypothesis that resembles the previous one and that is typically mentioned in the context of mantrailing assumes that the trail consists of skin flakes that we are constantly shedding (Syrotuck [26]

p. 38). At first glance this hypothesis may not appear more convincing than others. However, the skin flake hypothesis is actually quite appealing at a closer look: humans lose dead skin cells at a rate of about 0.5 million cells per day [40]. These cells have a diameter of about 30–40 μm [41,42]. The settling velocity of a single cell in calm air can be estimated to be around 5 cm/sec [43], larger rafts would settle quicker. In turbulent air this time would be longer. Hence, skin cells from the lower parts of the human body should settle close to the actual path while cells from the upper parts of the body could be blown further away due to their longer residence time in air. Up to this point this hypothesis does not differ significantly from the one before (i.e. hair, textile fibers, abrasion from shoe soles). The important difference actually comes from the bacteria that live on our skin and that are shed together with our skin cells. Note, these bacteria are in the size range of 1–2 μm [44]. These bacteria would continue to metabolize our dead skin cells even if these have been shed from the body, thus continuously producing our personal scent bouquets wherever the skin flakes fall as long as the bacteria stay active [45]. One can expect that this could produce a longer lasting odor trail than in our second hypothesis. However, on dry surfaces these skin flakes will dry out within an hour or so which would deactivate the metabolism of the complete microbiome. Re-moistening by rain or dew fall might reactivate some of the bacteria. But even if the microbiome was still active on the shed skin flakes the bacterial composition of the microbiome would change significantly within a day or so [45]. Due to suboptimal moisture supply, temperatures that are much lower in the environment than on the human body and high UV exposure the original human skin microbiome will not be able to compete with other microbes that are better adjusted to these conditions [34].

The skin flake hypothesis appears to be the most plausible and conceivable of all explanations. And it implies that ageing will change the character of a trail within hours such that the original individual characteristics get lost. The skin flake hypothesis also has another implication that is interesting: trailing should be much easier on vegetation (e.g. grassland) or fresh soil (“soft surfaces”) than on “hard surfaces”. Leaves and fresh soil surfaces are quite moist and thus supporting the activity of bacteria. In fact, bacteria are found on leaves in numbers averaging 10^6 to 10^7 cells/cm² [46]. In contrast, “hard surfaces” such as pavement and concrete etc. contain no accessible water at all (unless there were remains from a rainfall) and are thus a harsh environment for microbiota. And indeed, those dog handlers who believe in double-blind testing report again and again that soft surfaces are much easier to work at for the dog than hard surfaces. There are some videos on you-tube that demonstrate how much harder it appears to be for a bloodhound to work on pavement as compared to grass surfaces e.g. [47].

Even if one doubts the skin flake theory and one claims that there might be a scent trail that does not suffer from ageing (although nobody has yet explained how this would be possible) one would have to acknowledge that the trail age should always matter for the success because contamination of a trail with the scent from other humans passing by must increase the difficulty to detect an individual trail no matter what the scent trail consists of. On highly frequented surfaces this limitation would quickly come into effect.

How does mantrailing differ from other search scenarios?

There are scenarios where search dogs (not mantrailer) can be successful even after months. At first sight this may seem contradictory to the information and discussion above. It is therefore important to understand how these scenarios differ from the mantrailing task. For example cadaver detection dogs may have no problem indicating blood stains even after months of ageing depending on the type of surface [48,49]. The difference becomes plausible when one realizes that blood stains only have to be identified as such and not be assigned to an individual person. And what is more: in the case of blood stains the source remains present and odours continue to be released. Another example where ageing is not necessarily a critical problem for a search dog is

scent matching, i.e. assigning a shoe, a tool, glasses or a chair to the person that has (almost exclusively) used it over a long period of time. If the scent bouquet of a person can penetrate into any kind of penetrable material (typically all kinds of plastic) then over time this material becomes a source in itself. The scent profile will come off from this material for a long time in its original odor composition even if it is not being used any more by its owner [38]. And if this scent item had been used by only one individual so that this scent bouquet did not mix with others then a match of the scent item to its owner can be possible even after a long time. The critical difference to a mantrailing scenario is the long soaking time and the absence of strong scents from persons other than the target person.

Conclusion

Mantrailing is a complex task because it requires the detection of a scent bouquet rather than a single characteristic odor. In the environment such scent bouquets quickly lose their characteristic composition because the responsible bacteria stop working, and because the different components of a scent profile volatilize very differently. In addition the ongoing contamination with other odors contributes to the aging process. There is no empirical evidence and no plausible explanation for a successful work of mantrailer dogs on trails older than 24 h. Even fresh trails can often not be worked out by mantrailing dogs with a reliability that would allow to use the results as evidence in court. The search for missing or fugitive persons can make sense even with low success rates. Here, searches on trails that are up to 24 h old may be justified. The mantrailing can also be acceptable as an operational technique by the police in an effort to detain a suspect. In general, trailing regardless the age of the trail might be acceptable if first of all the successful finding, e.g. a lost person, is what counts, and false alerts or failures have no legal consequences. But one has to be aware that the search pattern of a dog is usually interpreted in some way or the other even if the search result is ambiguous. This can eventually mislead the rest of the investigation. Hence, it does not seem advisable to employ a mantrailer on trails older than 24 h.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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