



Scent lineups compared across eleven countries: Looking for the future of a controversial forensic technique



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ABSTRACT

A scent lineup is generally a procedure whereby a dog's alerting behavior is used to establish that the dog detects two scents, one from a crime scene and one from a suspect, as deriving from the same person. The aim of this article is to compare methodologies of using dogs in scent lineups as a means of identifying perpetrators of crimes. It is hoped that this comparative approach, looking at countries where the method is currently or has in the past been used, will help determine what issues should be addressed in order to assure that the scent lineup will have a future as a forensic technique. Participants from eleven countries—Belgium, The Czech Republic, Finland, France, Germany, Hungary, Lithuania, The Netherlands, Poland, Russia, and the U.S.—completed a survey questionnaire regarding key aspects of the scent lineup procedures used by the police in their countries. Although there was broad overlap on certain matters, such as the use of control and zero trials, collection of decoy scents from individuals of similar gender and race as the suspect, materials for holding scent, frequency of cleaning and changing stations, and use and timing of rewards, there were significant differences in the degree of blindness required, who calls an alert (handler or experimenter), and whether handlers can work with more than one dog. The gap between recommendations and results available from the scientific literature and procedures used in police practice was greater for some countries than others, even taking into account that some scientific methodologies might be expensive or impractical given agency resources. The authors make recommendations about how to go forward if scent lineups are to remain a valid forensic technique.

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1. Introduction

Trained dogs working in scent lineups have, in many countries, been considered a valid identification method for identifying perpetrators who left their scents at crime scenes [1–3]. This sort of forensic technique (sometimes denominated

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osmology or odorology) remains controversial despite its usefulness. The results of such identifications were sometimes introduced as evidence in criminal courts as the primary or even the only evidence, although many judges insist that scent evidence must be corroborative. Initially, testimony given by dog handlers was, and in some countries still may be, accepted in courts as sufficient proof of the reliability of this identification method [4].

Many of the programs were initially created by police authorities, which implemented procedures and rules derived from practical experience of handlers working with dogs [1,5]. Courts, however, began raising questions as to the reliability of a methodology based on practical experience, and scent lineup procedures became a subject of scientific inquiry, particularly beginning in the 1990s [6–10].

A positive attitude of law enforcement officials to the lineup procedure, and a need for a practical identification method that could be implemented with quality controls, led to the creation of police units with dedicated staff and specially trained dogs, often centralized for a country or a region of a country. Unfortunately, handlers performing scent lineups have sometimes made excessive claims as to the perfection of their dogs despite a sparsity of studies conducted with scientific scrutiny to support such an optimistic view of the reliability of this method [2,11]. Therefore, the technique has sometimes been attacked as “junk science” and the quality of the evidence produced by the technique has been called into question by lawyers, judges, and the press [12]. Prosecutions have sometimes resulted in acquittals when the evidence produced by a scent lineup appeared flawed or was declared inadmissible [13]. Worse, some convictions have been overturned because of questionable methods or from subsequent evidence indicating that a conviction was wrongful [14]. The public image of scent identification procedures may have also suffered from reports that scents of potential dissidents were stored by the East German Stasi for dogs to match with scents of individuals whose scent could supposedly be found on flyers critical of the government [15].

The costs involved in maintaining scent lineup programs have led police administrators and governments to question whether the technique is worth the expense and trouble, and in some countries scent lineups are no longer being conducted despite the belief of police authorities and prosecutors that the results are useful in investigations and prosecutions (e.g., The Netherlands). Since the lineup method was initially developed and improved by handlers working mainly on the basis of practical experience, only occasionally with input from scientists working in the area, a general lack of standardization across countries and even within many countries as to almost all details of the method is not surprising. Even when scientists were involved, their suggestions were often ignored or only implemented in part. The authors therefore undertook a comparative analysis of programs across their respective countries to determine how much variation exists in lineup methodology between countries, and to survey the current status of scent lineup programs. The authors make recommendations as to what should come next if this method is to continue to be used and developed.

2. Materials and methods

After preliminary communications between researchers in several countries, an initial group of those participating decided to collect data on specific aspects of the programs with which the participants were familiar. The desire was to gather information on how scent lineups have actually been conducted, not on what best practices should be, though many of us express

opinions on how various aspects of our country's programs could be improved. Comparing the true reliability of scent lineups across countries, taking into account the differences in procedures, would be difficult, particularly due to the logistic and organizational difficulties in establishing that dogs of identical or similar proficiency are being deployed in each location. Such a study would also require that a large number of law enforcement agencies collaborate on an international comparative experiment, which the authors agree was logistically impossible.

The lead authors therefore established a list of questions in several stages of communications (made primarily by email) and collated the responses in order to describe variations and overlaps between programs, and thereby built a basis for discussing the present status of and the best future for the technique. In the survey, we limited comparisons to the methodological aspects of the lineups, without having comparative identification results as such. Methodological details were finally collected from 11 countries where the lineup identification is currently, or was in the past, applied by the law enforcement agencies, which are Belgium, the Czech Republic, Finland, France, Hungary, Lithuania, The Netherlands, Poland, Russia, Germany, and the U.S. Due to the federal structure of some countries, e.g., the U.S. and Germany, rules and practices may differ in different parts of these countries. In all countries except the U.S., responses were based on the direct knowledge of the respondents of the centralized or major canine identification facilities in their countries. As the lineup procedure is conducted according to unified regulations which are specific for each country and no variation of the method was expected within countries, only one leading unit responded, generally represented by a police expert with a good knowledge of the method applied in that country.

In the U.S., reported judicial cases provide detailed information on scent lineups and other scent identification procedures actually introduced in criminal trials. Of the 50 states in the U.S., courts in only 17 states have produced decisions regarding a total of approximately 170 scent identification procedures, with the majority of procedures occurring in Texas and California. Although data on only this limited number of lineups could be gathered from judicial decisions, the handlers involved testified that procedures they conducted, generally with minimal alteration of methodology, had been used in thousands of cases, e.g., [16], trainer had produced scent identification evidence in between 1700 and 1800 investigations [17], scent lineups conducted for over 30 law enforcement agencies [18], dog had worked 760 human scent identification lineups [19], handler had made “thousands” of scent identifications [20], handler had performed over 1000 scent lineups and claimed his dog had never been proven wrong, yet one of those cases resulted in a wrongful conviction, as later established by DNA evidence, resulting in the State of Texas awarding \$2 million damages [21]. Thus, judicial opinions and orders describing scent lineup procedures collectively provide the most accurate picture possible of scent lineups actually used in criminal prosecutions in the U.S.

As the responses were collected, the questions were divided into ten general categories, which we believe is best displayed in a tabular format in ten tables, which are included in Section 3.

3. Results

As expected, a general lack of international standardization of the lineup methods resulted in a great heterogeneity of data and responses from different countries to particular questions formulated in the questionnaire. Tables 1–10 summarize the responses provided by the participants to 29 questions.

Table 1
Collecting and handling of scent samples.

Country	1.1. Materials that may hold scents of suspect and decoys	1.2 Storage of crime scene scent samples	1.3. Time restrictions as to how long after crime scent lineup may be conducted	1.4. Time restrictions as to taking of scents of suspect and decoys and use in lineup	1.5. Are stations in the lineup cleaned or replaced between trials or for consecutive dogs?
Belgium	Stainless steel tubes	Material evidence collected at crime scent stored in plastic bag	Up till 30 days	Not prescribed, but generally 1–2 days	Steel tubes are used only once in 1 lineup with 1 dog
Czech Republic	Aratex (76% cotton, 21% rayon, 3% polyamide), but another product is being tested	Material evidence collected at crime scent stored in glass jar	Between 2 days and 8 months	Between 2 days and 8 months	Jars may be replaced between dogs; this is up to the handler during training
Finland	Stainless steel tubes; we were on the way to start to use Kings Cotton	Material evidence collected at crime scent stored in special plastic bag for arson samples, or glass jars, or scent sample taken with Kings Cotton gauze stored in glass jar, all at room temperature and preferably dark	No formal limitations, usually within 1–2 years	Not prescribed, but generally 1–2 days	Steel tubes are used only once in 1 lineup with 1 dog; we changed to have tubes in glass jars on platform; jars used only once
France	Kapp Péterné® (Hungary) cotton squares (for body and trace scents)	Material evidence collected at crime scent stored in glass jar	No specified limits but trace scents often collected within 24 h of lineups; most common storage time between 1 day and 3 months	No specified limits but trace scents often collected within 24 h of lineups; most common storage time between 1 day and 3 months	Jars are changed randomly between successive trials in training, and scents are replaced between dogs; in official trials, jars are rearranged between runs of the same dog; cotton squares in jars are replaced between trials using different dogs
Germany Nordrhein-Westfalen Former German Democratic Republic	Stainless steel tubes Cloth stored in jars			Not specified, preferably as soon as possible 24 h after the scent is taken	Replaced between trials For consecutive dogs replaced scent article Replaced between trials; if the dog matches the target scent five times surely, the target scent is exchanged
Hungary	Special 15 × 20 cm, constant-composition textile made for only this purpose. It has to be made of woolly and loose material	Material evidence collected at crime scent stored in glass jar	24 h between collection of scent and use for an ID; after 3 years scent samples are destroyed	24 h between collection of scent and use for an ID; after 3 years scent samples are destroyed	A dog performs 5 trial; the glasses used for the lineup are not exchanged or cleaned, only their position is changed
Lithuania	Bleached flannel cut to 30/40 cm strips	Material evidence collected at crime scent stored in glass jar	Scents can be used 24 h after the collection, but not before; body scents can be stored for 1 year only	Scents can be used 24 h after the collection, but not before; trace scents can be kept in the storage room for 5 years whereas body scents can be stored for 1 year only	Stations are cleaned between each trial and jars containing scents are replaced; collected scented material is discarded and the jars cleaned before sterilization
Netherlands	Stainless steel tubes	Material evidence collected at crime scent stored in plastic bag, or scent sample taken with Kings Cotton gauze stored in glass jar, all at room temperature and preferably dark	No formal limitations, usually within 1 year	Not prescribed, but generally 1–2 days	Steel tubes are used only once in 1 lineup with 1 dog
Poland	Adsorbant swabs consisting of sterile cotton sewed in sterile gauze in closed bags manufactured by TZMO S.A. Poland			Minimum 24 h unless immediate ID is necessary	A separate set of jars is used for each dog; if a dog has marked a jar during a run, that jar is replaced before the next run of the same dog
Russia	Cotton fleecy fabric (5 × 3 cm)	Sheets of cotton fleecy fabric with scents of suspect and decoys stored in glass jars with tight metal lids in refrigerator	No specified limits. Lineup procedures are usually conducted within 24–72 h after sample collection, but time interval between sample collection and lineup can be increased to several weeks or months	Samples are frozen immediately in chemically clean dry ice, and can be stored up to 5 years in carbon dioxide	Each dog sniffs clean jars with the order of presentation changed
U.S.	Scent lineups have often used objects collected at the crime scene, but also footprints, sometimes transferred to scent pads by scent transfer units (STU 100)	No specified requirements or materials but samples often collected on gauze pads with scent transfer units (STU 100) [16]	No specified requirements but courts have considered storage and contamination issues, such as where all decoy scents were stored in same duffel bag in Ziploc bags [55]; FBI uses glass containers (testimony of Dr. Kenneth Furton in [45])	Not prescribed judicially and seldom mentioned, but cases state testing may follow sampling in hours up to 3 years in one procedure	There is no such requirement and some cases indicate stations were not changed or moved between successive runs or different dogs

Table 2
Characteristics of decoys.

Country	2.1. Requirements on use of decoy scents in lineup	2.2. Whether decoy scents must be taken from individuals similar to the suspect in sex, age, occupation, or other specified criteria	2.3. Can decoys be police officers?	2.4. Is there a requirement that all scents, including decoys, be novel (unfamiliar) to dogs during training or testing (certification) stages, or in actual judicial trials?
Belgium	Scents from 6 decoys are collected for lineup of 7 scents, 1 being a suspect; there are 2 such lineups	No identity requirement but scents must be collected at same place and time as suspect's scent is collected	Yes	Generally no requirements, some scents may be sporadically re-used Training: novel Certification: novel Judicial trials: novel
Czech Republic	Practice is to use 6 decoy scents and 1 suspect (target) scent per lineup	4000 body scents are stored for maximum 2 years, selected for specific lineups based on the profile of the suspect; decoy scents are destroyed once used	No	Training: novel Certification: novel Judicial trials: 1st dog novel 2nd dog scents that were used for the 1st dog
Finland	Scents from 6 decoys are collected for lineup of 7 scents, 1 being a suspect; there are 2 such lineups	No identity requirement but scents must be collected at same place and time as suspect's scent is collected. If suspect is female there should also be female decoys	Yes, some of them, but not from officers involved or in any way connected with investigation	Generally no requirements, some scents may be sporadically re-used Training: novel Certification: novel Judicial trials: novel
France	Practice is to use 4 decoys in lineup of 5 stations; scents can be trace scents or body scents	Decoy (distracting) scents are collected from unrelated persons identical to the sex, age, and ethnicity of a suspect	Rarely, but only in training phases	Training: novel Certification: novel Judicial trials: novel
Germany Nordrhein-Westfalen Former German Democratic Republic	1 target scent, 6 decoys taken in a similar way on stainless steel tubes 1 target scent, 6-8 decoy scents	Similar to the suspect as to the sex and age, but this is not specified in the method Similar to the suspect as to sex, age and profession (for example butcher), but this is not specified in the method	In practice yes, but not specified in the method In practice sometimes, but not specified in the method	Training: unknown Certification: unknown Judicial trials: unknown Training: novel/re-used Certification: unknown Judicial trials: unknown
Hungary	Time between collecting scent from decoys and the suspect has to be as short as possible; collecting scent from person being under the effect of strong medicine or drugs and from menstruating women is not allowed	Only the sex of the decoy and the suspect have to be identical	Yes, but not from an officer who was at the crime scene; no official rules	Training: novel/re-used Certification: novel/re-used Judicial trials: novel/re-used
Lithuania	9 distractors are placed on the circle and 1 target	Decoys are chosen in order to be as similar as possible to the target and the main factors are sex and age	Sometimes, if the officers have never had contact with the dogs before	Training: novel Certification: novel Judicial trials: novel
Netherlands	Scents from 6 decoys are collected for lineup of 7 scents, 1 being a suspect; there are 2 such lineups	No identity requirement but scents must be collected at same place and time as suspect's scent is collected	Yes	Generally no requirements, some scents may be sporadically re-used Training: novel Certification: novel Judicial trials: novel
Poland	Scents of 10–20 decoys are collected; separate scents are collected for each dog used	Decoy scent samples are collected from same sex and ethnic group as suspect, within 5 years of same age, in a similar occupation, with similar diseases and medicines (if relevant)	Yes, but not from officers involved or in any way connected with investigation	Training: novel Certification: novel Judicial trials: novel
Russia	13 jars are prepared for each trial; 10 for decoys; more than 1 suspect's scent can be used; 1 of the last 3 jars the dog sniffs contains a marker sample, the scent the dog is provided before traversing the lineup	Some decoys should be of same sex, age, and profession as suspect, though not all decoys must be so; forensic investigators assure sampling of decoys and suspect are close in time	Yes, if unfamiliar to dogs used in lineups	Training: novel/re-used Certification: novel Judicial trials: novel
U.S.	No standard practice though of 59 cases mentioning decoys, 22 were used in lineups of persons, 11 in lineups with crime scene objects, and 26 in lineups using scent pads	No judicial requirement; 13 cases mention that the handler used decoys of the same race or ethnicity, and 14 mention decoys of same gender; most cases give no indication	Decoys were specified as officers in 10 cases, including police officers in uniform in lineups of persons; many other procedures probably used scents of police officers as decoys	Training: No requirement, and decoys frequently re-used Certification (generally tracking dog certifications): sometimes re-used Judicial trials: No requirement, decoys frequently re-used

1. Collecting and handling of scent samples

Scent samples are the essential items for the conduct of a lineup identification procedure. The properties and methods of handling and storing of scent samples are crucial for the reliability of the identification. Therefore, courts frequently question various details concerning how scent samples are obtained stored and used in scent lineups [16].

1.1. Materials that may hold scents

Material used for collecting scent from objects or spots at crime scenes must fulfill several conditions. It should be effective in absorbing scent, not react chemically with odor molecules and thereby alter the odor, be easy to store over long periods without changes of odor quality or intensity, be easy to handle (e.g., for multiplication of samples for testing, or be reusable for testing in the lineup), and not itself contain an odor known to be aversive or

Table 3
Control and disqualification trials.

Country	3.1. Number of disqualifying control trials	3.2. Negative check (zero) trial requirement (as control or within identification trials)	3.3. Time intervals between trials
Belgium	Valid tracking certification and additional valid scent lineup module certification	No	3–4 lineups can be conducted per day, though there is no required limit
Czech Republic	2 lineups (minimum) using crime scene and suspect scents, but additional control trials possible	Prior to 1 April 2018, such trials were required after one or two lineups performed correctly; zero trials not required after that date	Quickly, perhaps 1–2 min; dogs can work 5–6 runs per day, but sometimes 15–16
Finland	Valid certification required, and correct execution of 2 control trials	No requirement during official lineups but used during certification test	Runs follow closely and 4 runs can take 2–4 min; between run 2 and 3 team should have a short break in next room, 3–5 min depending on handler. 3–4 lineups can be conducted per day, though there is no required limit
France	3 lineups with procedure similar to training, 15 min before official ID tests	Zero trials used during training stages, disqualifying trials, and official ID lineups	Minutes, no more than 6–8 trials per day
Germany Nordrhein-Westfalen Former German Democratic Republic	One control trial per dog to exclude scent attractiveness Not specified	Not specified Not specified	Usually consecutively on the same day, no precise time interval given Not specified but usually consecutively on the same day, no precise time interval given; depends on the dog; performance was assessed by handler
Hungary	Different (1–3) depending on the department.	No requirement	It depends on the dog. Generally, there is no time intervals between trials but if the dog needs rest, break is allowed
Lithuania	Prior to each official test, all dogs must complete 2 trials correctly	Negative check trials are inserted during training; one negative check every three trials	During the training period, dogs run the circle several times per day; there are 15 min intervals between successive trials, once a dog is certified, it is trained once a day, between 2 and 5 times a week
Netherlands	Valid certification required, and correct execution of 2 control trials	No requirement during official lineups but used during certification test	Runs follow closely and 4 runs can take 2 min; 3–4 lineups can be conducted per day, though there is no required limit
Poland	3 lineups (minimum), 2 with sample randomly placed in lineup, and 1 zero trial with no matching sample	Not conducted during official trial sequences; one zero trial out of 3 control trials sequence	Lineups are separated only by time needed to change samples or positions; dog can perform only 1 set of tests per day
Russia	All dogs used must be tested against decoys, with showing of interest leading to disqualification	No requirement	4–5 trials per dog per day, but can be less of dog appears not to be motivated
U.S.	No statutory or judicial control-trial requirement, though some handlers run proofing trials	No requirement, though sometimes used by specific handlers	Generally runs follow closely on one another, though one case indicated a 10-min gap between a proofing procedure and a lineup

attractive to dogs. In most countries, cotton pads or a mix of cotton with synthetic fabrics, are used. In some countries the pads used for collecting scent samples are specially manufactured for this purpose and are sealed in sterile bags. Cotton pads are easily stored in sealed sterile glass jars, and can be multiplied either by cutting into smaller pieces or by putting additional pads in the jar to pick up odor by diffusion from pads previously placed in the jar.

In a number of countries the same material that is used to collect scent samples at crime scenes is also used to collect scents from the suspect and the decoys for use in the lineup. In The Netherlands, Finland, Belgium and in the German federal state of Nordrhein-Westfalen, steel tubes are or have been used to collect scents from the suspect and the decoys for use in scent lineups. The idea of using such tubes is to enable a sort of self-rewarding of the dog by retrieving the target tube, which is not fixed by an electromagnet, whereas the decoy tubes are fixed.

1.2. Collecting and handling of crime scene scent samples

Collecting scent at a crime scene is the first step of osmological identification. In some countries, material evidence itself is collected. In other countries, scent samples are collected directly at the crime scene. Material evidence, or spots or objects from which scent samples are collected, are chosen by a forensic technician on suppositions concerning where a perpetrator may have left scent. Thus, scent samples may be taken from weapons or

tools presumed to have been used by the perpetrator or places that must have been touched, e.g., handles of doors, furniture, etc. In most cases, however, it is not known if a scent sample collected at the crime scene contains any odor molecules, unless fingerprints are found on the object from which scent samples were taken.

Both material evidence and scent samples used for forensic investigations are considered to be evidence and therefore have to be precisely labeled, described, handled and safeguarded to avoid confusion with other samples, contamination with other odors, or destruction. It is not always possible to know when the scent was left at the crime scene because it is not always possible to estimate exactly when the crime occurred. The retention of human odor on various surfaces and materials has been the subject of research that will need to be taken into consideration in developing standards for obtaining and storing scent samples [22,23].

1.3. Collecting and handling of suspect and decoy scents

Scent samples taken from the suspects and decoys are full scents that can be collected and stored at recorded times and used within a specified period to ensure similar intensity. As with crime scene scent samples, scent samples from suspects and decoys used for forensic investigations must be precisely labeled, described, handled and safeguarded to avoid confusion with other samples and contamination with other odors. Destruction of the suspect and decoy scent samples is seldom a problem because the suspect and decoy sample donors generally remain available for repeated collection of scent samples.

Table 4
Experimental setup of the lineup identification.

Country	4.1. Number of stations in a trial	4.2. Number of trials before an identification can be used as evidence in a criminal prosecution	4.3. Number of dogs used in an official identification
Belgium	7	No evidence in criminal prosecution – only an indication	1
Czech Republic	3–7	3 (by same dog)	Depends on number of trace scents collected at the crime scene; if only 1 scent, then only 1 dog
Finland	7	2 control runs on 7 scents (6 decoys + 1 suspect), followed by 2 runs using crime scene scent without control person A (5 decoys + 1 suspect) = 4 runs	1 dog per lineup, no more than 1 lineup is necessary
France	5 in lineup	2 matching combinations (trace scent to body scent and v. v.) are used with negative check trials between tests; then other dogs perform similar sequences	Minimum 2, but 7 were used in a case with a high level of crime scene scents
Germany	7 in lineup	6 trials (including pre-testing); matching of suspect to crime scent is recognized if 3 dogs independently of each other match the tube touched by the suspect	3
Nordrhein-Westfalem	6–8 in lineup		Not specified, but in practice at least 2
Former German Democratic Republic			
Hungary	5 in lineup	5 trials	Minimum 2 dogs
Lithuania	10 in circle	2–3 trials and the results must be confirmed at least by another dog (so 2 dogs minimum for a judicial ID)	At least 2
Netherlands	7	2 control runs on 7 scents (6 decoys + 1 suspect), followed by 2 runs using crime scene scent = 4 runs	1 dog per lineup, no more than 1 lineup is necessary
Poland	5 minimum but generally 6 for line; 10 minimum for circle	3–5 control trials, followed by official trials (runs), which can vary depending on number of dogs used, but 3 minimum trials for ID to be declared; outcome of each dog must be consistent if 2 dogs used	2 dogs for an official lineup
Russia	12 in circle; lines not used	3 runs per dog with alert to suspect's scent by all 3 dogs is considered sufficient for proof of ID; if 1 of first 3 dogs does not alert to suspect's scent, dog 4 provides sufficient proof with an alert to the suspect's scent on 3 runs	3 dogs minimum (or 4 if 1 of first 3 does not alert correctly)
U.S.	Highly variable; often not specified, but in 1 case there were only 2 stations, 1 case had 3, 7 cases had 4, 12 cases had 5, 15 cases had 6, and 1 case had 7	Most judicial cases found a single run with an alert sufficient for admission of evidence; 60% of cases involved 1 dog, 20% involved 2 dogs, and 30% involved 3 dogs	No specified number, and dogs could perform more than 1 function (in 20 cases, dogs were used for more than one function, usually tracking in the initial part of the investigation, then for a scent lineup once a suspect was apprehended)

1.4. Time restrictions as to taking of scents of suspect and decoys and use in a lineup

Some countries emphasize that the timing of sampling decoys should be close to the timing of sampling a suspect for scent. Some countries also have time limits as to the interval between when a sample is taken and when it can be used in a lineup. Primarily for organizational and logistic reasons it is usually not possible to conduct lineup procedures immediately or shortly after taking scent samples, particularly those obtained from crime scenes. Therefore, scent samples have to be stored until they are exposed to dogs. Assuming odor molecules can diffuse from the scented material, even if stored in closed jars, or may change their properties with time, a standardization of the storing time, especially setting a maximum storage time, is preferable for making odors comparable in strength. Obviously, the time interval between collection of a sample and using it in a lineup can be specified if such data are properly recorded. If decoy samples are collected at a time that is significantly different from when a suspect's scent was collected, this could represent a bias. Therefore, these two collection points should be as close as possible.

1.5. Are stations in the lineup cleaned or replaced between trials or between dogs?

Thoroughly cleaned sniffing rooms, isolated from any olfactory stimuli, are generally required in European programs, and stations are cleaned or replaced between dogs and sometimes between runs of the same dog. Stations must generally be moved between runs of the same dog, and replaced entirely between runs of different dogs.

Tops or edges of jars or containers with scent samples in the lineup may be touched by a dog's nose or salivated upon, resulting in contamination or additional marking of the samples. This in turn

may influence the outcome of subsequent trials. Therefore, cleaning the work room and cleaning or replacing the containers or scented items for each trial is widely recommended and often required. However, since cleaning may create additional logistical problems, there may be a preference for replacing rather than cleaning containers or stations for each trial. A station holds the jar or container with scent. Some osmological laboratories also shift stations between consecutive trials. This, along with procedures for cleaning or replacing jars or containers, can assure that the order of the stations as well as the order of the containers is random. In other laboratories, the stations (which may be fixed to the floor) remain in place and only the jar or container's position is randomized.

2. Characteristics of decoys

Decoys are scents from individuals other than the suspect. Obtaining and proper use of decoy scents is necessary to ensure unbiased indications can be made by dogs in a lineup. The purpose of using decoys in the lineup is to demonstrate that the dogs discriminate scents of different humans and thus a matching of scents can be accomplished. Using decoys increases the reliability and validity of identification. Theoretically, the more decoys (and hence stations) in the lineup, the lower is the probability that indications of the target sample are made by chance.

2.1. Requirements on use of decoy scents in lineup

Decoy scents are used in all countries surveyed, though the number of decoys varies considerably, ranging from 4 up to 12 in a single trial. As a matter of practicality the number of decoys may be

Table 5
Alerting of dogs.

Country	5.1. Who calls alert?	5.2. Requirement that all stations be sniffed (even after correct alert)	5.3. Is video-recording of official trials required or standard?
Belgium	Handler	No	No – handler makes written rapport
Czech Republic	Handler in prior procedure, but now the expert in the experiment	Yes; target scent sometimes placed at end of line so dog must sample all stations to correctly alert	Only when ordered by judicial authority
Finland	Handler calls, and gets a light signal when dog is correct; we started to change it. Handler was sitting with his back to lineups, no eye contact; supervisor would call the alert	No	No; all lineups was video-recorded for supervisor use
France	Technician	No, sufficient to sniff stations until dog alerts	With positive ID, lineup is repeated and videotaped
Germany	Assistant	No, but this is not specified in the method.	Yes
Nordrhein-Westfalem	Handler (dog's behavior is "down")	Once alerted, the position of target scent must be swapped	No
Former German Democratic Republic			
Hungary	Handler (generally, though sometimes there is a separate experimenter)	Not an obligation	Only on request
Netherlands	Handler calls, and gets a light signal when dog is correct	No	Not usually
Lithuania	The judicial expert who placed the target in the circle	When the target is placed far away from the beginning of the circle it is not absolutely required. However, there is no strict requirement. Sometimes the dog handler asks for his dog to sniff all stations, sometimes not. In general, all stations are checked	No
Poland	Alerts are expected to be clear to anyone; experimenter indicates by a light signal if alert was correct	No (though required during training)	Required if crime could result in sentence greater than 3 years imprisonment, or upon order of court or prosecutor; generally conducted anyway
Russia	Experimenter	Yes (because marker in last 3 stations)	Yes, uniformly
U.S.	Handler	No judicial requirement, but procedures of some handlers require all stations be sniffed	No judicial requirement but occasionally done

limited in part on the size of the sniffing room which has to allow for enough distance between stations so as to avoid confusion in assessing which station is actually being indicated by a dog. Care should also be taken to avoid possible effects of scent plumes drifting over one or more neighboring stations, which is most likely to happen when the stations are too close to each other and when there is any movement of air in the room.

2.2. Do decoy scents have to be taken from individuals who are similar to the suspect in sex, age, occupation, or other specified criteria?

Theoretically, the more the decoy scents are similar to that of the suspect with regard to gender, age, occupation, and other criteria, the greater certainty that a dog has been able to distinguish an individually unique, genetically determined and unchangeable component of the suspect's scent. Thus, using decoys that are similar to the suspect increases the reliability of the identification of an individual as a perpetrator (see [24,25]). Most countries require or prefer that decoy scents be taken from individuals of the same gender and race or ethnicity, and often of similar age. Other criteria as to similarity of scents may include the profession of individuals sampled, where they live, diseases they have, and medications they use.

2.3. Can decoys be police officers?

Often there is a practical problem in collecting decoy samples from a sufficient number of individuals, though decoys cannot be police officers in the Czech Republic and only exceptionally in several other countries. Since police officers are readily available as scent donors, there may be a tendency to collect decoy samples from them. It cannot always be determined whether the police officers from whom decoy scent samples have been taken were

alien or familiar to the dogs used in a scent lineup. If the dogs are familiar with scents of police officers used as decoys, the dogs may show a tendency to indicate a novel and/or distinctive scent of a perpetrator, independently of matching or not matching to the scent collected on the crime scene. This, in consequence, increases the likelihood of a false indication to an innocent suspect.

2.4. Is there a requirement that all scents, including decoys, be novel (unfamiliar) to dogs during training or testing (certification) stages, or in actual judicial trials?

In literature on scent lineups, concerns arise that dogs may memorize individual odor samples, even if large numbers are used during training or in judicial trials. In cancer detecting dogs this may have consequences in indicating by dogs the memorized pattern samples that were frequently used during training, rather than generalization on a common odor of cancer markers [26]. In scent lineups used forensically for human identification purposes, frequent use of the same samples as decoys during the training stages, or during certification or in judicial trials, may result in a so-called pseudo-match-to-sample [27]. Therefore, repetition of the use of samples from the same donor should be avoided. Ideally, novel samples (donors) should be used for each trial. However, requirements as to the scent samples used as decoys (Table 2) make the availability of novel decoy samples in numbers sufficient for each procedure, including control trials, practically impossible and thus necessitate re-use of some samples. The responses to question 2.4. indicate that the osmology experts are aware of the problem of a systematic use of novel samples, even if there are no formal requirements but only recommendations in this area, but re-use of samples is sometimes inevitable. Out of 11 countries surveyed, in 7 countries only novel samples are used both in

Table 6
Degree of blindness.

Country	6.1. Degree of blindness required as to the placement of the target scent	6.2. Must an experimenter who is aware of the position of the target sample be totally isolated from any contact with the handler and dog?	6.3. Means by which observers and handlers communicate, including visual or acoustic signals, a clicker, etc.
Belgium	Single-blind (technician present is aware)	No	Verbal notification by technician
Czech Republic	None	Not relevant because handler is not blind	Not applicable (no observers)
Finland	Double-blind	Yes	Visual (light)
France	Single-blind (technician present is aware, though required to avoid looking at handler)	No (but technician is alien to the dog)	Verbal notification of handler by technician
Germany	Single-blind (handler must be blind)	No, but this is not specified in the method	Green or red light, but not specified in the decree
Nordrhein-Westfalem	Depended on individual case, sometimes double-blind, sometimes single-blind, sometimes the handler knew position, especially if scent sample was taken by handler	No, but this is not specified in the method	Not specified
Former German Democratic Republic			
Hungary	Suspect/lawyers may observe the tests being visually isolated from the dog, the dog handler and the experimenter by a one-way mirror. The experimenter and the dog handler know the position of the target scent in the lineup, however, do not follow the dog and do not give any signals to the dog	No	The experimenter and the dog handler are allowed to communicate directly (verbally). No communication is allowed between observers and the dog handler or the experimenter
Lithuania	Single-blind (handler never knows where the target is placed in the circle)	No (technician is present in the room)	Visual and clicker
Netherlands	Double-blind	Yes	Visual (light)
Poland	Double-blind (expert observes through one-way mirror)	Yes	Visual (lamp), to tell handler to bring dog into or exit from sniffing room, another lamp signals that indication was correct or incorrect (or that experimenter deems dog refusing to work)
Russia	Double-blind	Yes (observes through video monitor)	Acoustic (clicker)
U.S.	Handler was stated to be blind in 13 cases and not to be blind in 4; double-blindness seldom mentioned	Generally no such separation of function in judicial cases though double-blindness as to observers mentioned in 1 case	Judicially described procedures with handler blindness sometimes indicate a second officer verbally notified the handler when the dog alerted correctly

Table 7
Handling of dogs during trials.

Country	7.1. Rewards that may be used for the dog, in control trials including treats, toys, etc.	7.2. Timing of rewards
Belgium	Retrieving tube after hearing choice is correct	Immediately after correct indication (self-rewarding of dogs by retrieving a target tube released from the electromagnet in the lineup)
Czech Republic	Petting, 1 treat for reward	After a hit or correct response
Finland	Retrieving tube when green light appears for handler; we changed it to give food and after that toy first click or verbal, depending on handler	Immediately after correct indication (self-rewarding of dogs by retrieving a target tube released from the electromagnet in the lineup); we changed this so that after correct alert/indication dog remained at the right position pointing or standing or laying down, handler went to dog and gave reward he wanted to use to dog (food, ball/toy, tube); we also changed to tubes in glass jars on the lineup
France	10 g Knacki® sausage upon correct response; ball at end of trial, but varied depending on the preferences of dogs	After a correct alert and technician signals handler; or at the end of a negative check (zero) trial
Germany	Depends on individual dog, mostly toys	Immediately after correct indication
Nordrhein-Westfalem	Not specified, but in practice treats after each correct indication	Not specified, but in practice immediately after each correct indication
Former German Democratic Republic		
Hungary	Different rewards, praise, petting, food, toy	After indicating of the target scent or after refraining from a false alert and returning to the handler
Lithuania	A treat or a toy, depending on dog's preference	Reward is given when a dog indicates the correct station
Netherlands	Retrieving tube when green light appears for handler	Immediately after correct indication (self-rewarding of dogs by retrieving a target tube released from the electromagnet in the lineup)
Poland	Food treats, toys after completion of a test	Rewards can be given after a run, after a correct response, or after returning to handler; after completing an entire test, dogs are given a toy to retrieve
Russia	Food after experiment gives acoustic click signal	Seconds after acoustic signal given
U.S.	Nothing judicially specified, but handlers regularly use treats, praise and petting	Generally not indicated but assumed to be after a trial is completed

training, certification, and judicial trials, in 2 countries novel samples are combined with those re-used, in 1 country samples are frequently re-used. From 1 country no information was available, probably due to a failure to distinguish between novel and re-used scent samples.

3. Control and disqualification trials

The goal of control trials is to check (1) the disposition of the dog and its motivation for olfactory work before further tests are

Table 8
Dog characteristics and training.

Country	8.1. Breed preferences for scent lineups	8.2. Age requirements for dogs performing scent lineups	8.3. Period of training before dogs can make an official identification or certification requirement
Belgium	Mainly German Shepherd	No requirement but dogs begin training at about 1 year old	Generally about 1 year for tracking, training on scent lineups is optional and begins after dogs are certified for tracking
Czech Republic	German shepherd	Qualified at 2 years	1 year after dog is 1 year old preceded by 10 weeks of basic training Generally about 1 year
Finland	Commonly crossbreds of Malinois, German shepherd, and Dutch shepherd	No requirement but dogs begin training at about 1 year old and train for a little less than 1 year	
France	German shepherd	Dogs enter program at 2.5 years, oldest working dog is 9 years	Dogs must give no false alerts over 200 trials, followed by 1.5–2 years training
Germany	German shepherd or Belgian shepherd, but not specified in the method	Not specified	Not specified, depends on the individual dog's training performance
Nordrhein-Westfalem	German shepherd	Age over 1.5 years (according to Derda [56])	4 phases (240 h) of an intensive training (according to [62])
Former German Democratic Republic	German shepherd		6 months
Hungary	German and Belgian shepherds or their mix	No requirement but a dog must be able to fulfill its tasks, though generally from 1.5 to 9 or 10 years	
Lithuania	German shepherd	From 2–3 years old when they begin to about 10 years old	Training lasts approximately 1170 h.
Netherlands	Commonly crossbreds of Malinois, German shepherd, and Dutch shepherd	No requirement but dogs begin training at about 1 year old and train for a little less than 1 year	Generally about 1 year
Poland	German shepherd and Labrador retriever, but also Rottweilers and others, sometimes reflecting handler preferences	Dogs qualified at 1–2 years, and sometimes retired at 10 years	6 months at Kynology Department of Police Training Center, but up to 12 months of handler training with handle
Russia	Jackal-dog hybrids	1.5–10 years	Basic training c. 3 months, match-to-sample training c. 2 months, learning scent lineups c. 1 month
U.S.	Bloodhounds used in more than half of published cases, though German shepherds and Labrador retrievers occasionally used	No age requirements have been specified by courts; age of dogs were occasionally given, ranging from 2 years old to 11, with an average age of 6 years	No requirement, but individual handlers select dogs for training at about 1 year; period of training highly variable; training as a tracking dog was sufficient for a dog to participate in a scent lineup in a number of judicial decisions

performed, and (2) whether the scent of a suspect is, for any reason, “attractive” to a dog, i.e., might be indicated regardless of actual matching or not matching to a reference or evidential scent. Control trials are those in which the target odor sample placed in the lineup and the sample given to the dog to sniff at the starting point of the lineup (matching scents) are from the same person. For an official trial, that person cannot have been involved in the forensic investigation and must be verified as having never been present at the crime scene. Other scents in control trials are decoys, including sometimes the scent of the suspect who will be subsequently tested in an official identification trial. Most European countries surveyed employ control trials, generally just before a dog is used in an identification trial. Such trials are rarely mentioned in U.S. cases and have never been judicially required. All European countries surveyed except Belgium employ control trials before a dog is used in identification trials.

3.1. Number of disqualifying control trials

A dog can be used in official identification trials if it successfully completed control trials. The number of control trials varies among respondent countries. In some countries, e.g., The Netherlands and Finland, there is a fixed pattern of applying control trials, whereas in other countries, e.g., Poland, it is up to the osmology expert to determine how many control trials should be conducted for qualification or disqualification of the dog before official identification trials. In some countries, e.g., the U.S., there is no requirement for control trials, though some handlers conduct them. Generally, the number of control trials has to strike a balance between several experimental needs: (1) checking of the dog's disposition for work on a particular day, (2) not making the dog bored or tired because of the length of the activity, and (3) leaving sufficient laboratory time

for all trials to be conducted according to the identification protocol (Figs. 1 and 2).

3.2. Negative check (zero) trial requirement (as control or within identification trials)

In a negative check or zero trial, there is no item in the lineup that matches the scent provided the dog before it runs the lineup. Such a negative check might be one of the control trials or might be performed in between the identification trials. Zero trials are considered to be more difficult for dogs than normal control trials since they require a dog to refrain from indicating any sample, which can nevertheless happen, for instance, if the dog is overly motivated to earn a reward. However, zero trials increase the certainty that the dog will not indicate at any accidental station when there is no matching sample in the lineup. Such trials are sometimes used in European practice, though there is no requirement in the Czech Republic or Russia, and in The Netherlands and Finland such a control is only part of the certification process. There is no requirement for such trials in the U.S., though such trials are sometimes performed.

3.3. Time intervals used between trials

If matching consecutive pairs of scents occurs too quickly, short-term olfactory memory may cause the dog to remember the previously sniffed scents and the dog may tend to duplicate a prior response and thus fail to match subsequent scents correctly. Although separating stations by greater distances may help slightly, rooms where trials are conducted are generally too small for this to be an ideal solution, so it is best to build in a delay of several minutes between trials. The temporal gap between trials is also important in (1) allowing time for the dog to receive a reward, (2) letting the dog understand that one trial is over.

Table 9
Osmology expert and handler qualifications.

Country	9.1. Qualification requirements for handlers	9.2. Can handlers have more than one dog?	9.3. Frequency and length of training sessions after teams begin performing scent lineups
Belgium	Handler tested with dogs on proficiency but also pass a theoretical test	Usually only 1 dog	Usually 50 h/month but this includes training on tracking
Czech Republic	Handlers obtain a certification with their dogs, which involved annual retesting, though this has ceased	2 is common, 3 is exceptional	6 or more training trials per day is common but up to handler
Finland	Handlers tested as team members with their dogs on proficiency, but also must pass a test on legal, forensic, and scientific scent matters; handlers should be police officers	Handlers may have 2 dogs, but dogs have only 1 handler; dogs were living at handlers home; if handler was a long time out of work (pregnancy+maternity leave or sick leave) another handler could handle that dog	Not specified, usually 2–3 scent IDs per day, 2 + 2 days per week; dogs were also trained for id-tracking and id-scent search (articles and locations)
France	Police officers undergo dog handling training sessions of 3 months, followed by a final exam that allows them to join the canine center	Handlers may have 2 dogs, but dogs have only 1 handler	6–8 training trials per day, 5 days per week
Germany Nordrhein-Westfalen Former German Democratic Republic	Not specified, only dogs and handlers from the Nordrhein-Westfalen State police school for police dog handlers Dogs had to be trained at the special school of the Ministry of the Interior for service dogs in Pretzsch (<i>Spezialschule des Diensthundewesen</i>)	Yes, in practice 2 dogs Not specified, but in practice two dogs	Not specified, depends on the individual dog's training performance; annual certification required Not specified
Hungary	The dog handlers and their dogs have to complete a special course	Yes	Minimum 2 h 3 times a week
Lithuania	Dog handler must pass a certification exam every 18 months	Handlers may have 1 or 2 dogs	1 h, 2–5 times a week
Netherlands	Handlers tested as team members with their dogs on proficiency, but also must pass a test on legal, forensic, and scientific scent matters	Handlers may have 2 dogs, but dogs have only 1 handler	Usually 2–3 scent IDs per day, 4 days per week
Poland	Obligatory training for osmological ID is conducted by the Police Kynology Department of the Police Training Center, which includes an exam involving theoretical aspects; during training, each participant trains 2 dogs; other requirements for other aspects of osmology work	A handler trains 2 dogs, but maximum is 3	1 training session of 6–20 trials per day, 5 days per week
Russia	No specific certification but handlers must undergo an educational program in osmology	Program has all handlers working with all dogs	Daily training if possible with 1–3 trials
U.S.	None judicially required and many are self-taught; some have military training in working with dogs	No limit, though many have 3 or even more	No specified requirement, highly variable in cases, but some U.S.-based police dog organizations recommend 4 h per week

4. Experimental setup of the lineup identification

Experimental setup may influence the outcome of the identification procedure and affect its reliability. Unfortunately there is little experimental data comparing variations in such setups [7,8,28].

4.1. Number of stations in a trial

Countries vary from 3 to 8 stations in a lineup, though circles of 10 and 12 stations are used in Poland and Russia. Theoretically, the greater the number of stations in the lineup, and the fewer holding target samples, the lower the probability that a correct hit will occur by chance alone. However, there are some limitations as to the optimum number of stations in the lineup, such as available space in the sniffing room for proper distances between stations. Another question concerns how many odors a dog may keep in memory while working a lineup, so that the longer the lineup, the more odors the dog sniffs, potentially resulting in the dog no longer holding the scent it is supposed to match in memory. Although the question of how many odors a dog can be trained to identify has been a research subject ([29], concluding dogs could be trained to identify at least 10 odors [26], 12 odors for at least one dog), the significance of canine working memory in lineup situations requires further study. Also, dogs may omit some stations if there are too many of them, which introduces another difficulty for statistical evaluation.

4.2. Number of trials before an identification can be used as evidence in a criminal prosecution

There are generally requirements for a number of identification trials before evidence can be used in a prosecution, though this has not been true in the U.S. The number of official trials that may be conducted may be limited by the number of scent samples available for a trial, particularly if procedures specify that scent samples are to be exchanged between every trial and every dog.

If dogs are rewarded during control trials, where the expert knows which target sample is correct, this may cause problems in official trials where the expert does not know if there is an actual matching of a suspect's scent to the evidential scent collected at the crime scene. This may lead to the situation where a dog, frustrated as a result of not obtaining a reward, begins to make false alerts.

4.3. Number of dogs used in an official identification

The number of dogs for an official identification varies from 1 to 3—in very rare cases, 4 or more—depending on the country and local logistical capabilities. Some countries require that more than 1 dog reach the same result before a scent lineup can be considered in a prosecution. Theoretically the more dogs used and the more that indicate identically, the more statistically reliable is the lineup identification, even if the dogs are not necessarily responding to the same set of odorants from an individual. However, when more dogs are used in an official test, certain issues should be taken into

Table 10

Measures undertaken to decrease judicial skepticism or public mistrust as to the reliability and validity of scent lineups in criminal prosecutions.

Country	10.1. Must the probability of a correct indication by chance be estimated, or such an estimate standard?	10.2. Have experimental studies been undertaken by independent scientific institutions to assess validity and reliability of scent lineup identifications?	10.3. Are scent lineup identifications currently performed by police as evidence for courts (or specify periods when such were performed)?
Belgium	Because of fixed practice, probability is known	No	Not as evidence but in early investigation lineup results steer the investigation
Czech Republic	No	Yes	Yes
Finland	Yes	Yes	Yes
France	No	Yes	Yes
Germany	The probability of correct indication by chance, using three trained dogs has been calculated as 1:1.2 million	Yes, by Prof. Dr. Hans Hilden, Universität - Gesamthochschule Paderborn.	Currently no
Nordrhein-Westfalen	No, but not specified	Not specified	1988–2011 Nordrhein-Westfalen
Former German Democratic Republic	No	Yes, but the police were not involved and were not advised of the results	1989–2012 Baden-Württemberg
Hungary	No	No	Yes
Lithuania	No, assuming that the probability of a single correct hit by chance is 1/10, and scents are replaced after each trial, of each dog and hits must be confirmed 2 to 3 times by the same dog and by at least another dog, the total probability is deemed very low.	No	Yes
Netherlands	Yes	Yes	No
Poland	No, though under previous procedures this was calculated and published	Yes	1962–currently
Russia	Because of fixed standard practice, such probability is known	Yes	Yes
U.S.	No, though one 2011 Texas case criticized a handler for not calculating a rate of error	Not as to procedures used by police and contract handlers; research has been done by U.S. researchers on identification issues	No reported uses for 8 years but some states have not judicially precluded uses of scent lineups

account. First, such an increase in reliability is only true if the dogs are working independently from each other, meaning that they are working on physically different scent samples in the lineup to prevent any cues from an earlier dog indicating on a particular sample. Second, dogs leave odor traces on the floor and in ambient air in the sniffing room, which may interest or distract dogs used in subsequent tests (especially if males and females are used in sequences) even though they were previously familiarized with these scents during training. Therefore, a thorough removal of all odor traces in the sniffing room between each dog is recommended. Third, although all dogs are formally certified, their performance in a lineup may differ. When more dogs are used and there are discrepancies between their indications, it is difficult to justify simply accepting the results of better dogs and ignoring the results of dogs found over time to be poorer performers.

5. Alerting of dogs

Since a dog's alert may be interpreted as matching scent found at a crime scene to scent of a suspect, which practically means an

identification of the perpetrator of a crime, the certainty that the dog has in fact alerted faultlessly becomes crucial in the forensic and judicial use of scent identification procedures.

5.1. Who calls an alert?

Alerts can be called by handlers in some countries, e.g., Hungary and the U.S., but must be called by experimenters or technicians in others. Alerting by a dog should be overt and readable to anyone but some dogs may have unique alerting behaviors readable only to their handlers, while other observers may have doubts as to whether the dog is alerting or just hesitating. Therefore, the question of who calls alert may be important for the outcome of the identification procedure. It is, in any case, essential that the person calling the alert be unaware of the position of the suspect's odor since that may bias his judgment.



Fig. 1. An example of the lineup (Poland).



Fig. 2. An example of the lineup (Lithuania).

5.2. Requirement that all stations be sniffed (even after correct alert)

Some countries require that all stations be sniffed in the running of a lineup but others do not. During training dogs are taught to sniff all stations in a lineup. However, when dogs become familiar with a routine, they may develop a habit of not sniffing all stations systematically, and some are likely to stop after indicating, particularly if rewarded.

5.3. Is video-recording of official trials required or standard?

Some courts require evidence that a lineup identification be made in accordance with state-of-the-art techniques so as to eliminate doubt that the suspect's scent matches the scent found at the crime scene. Some countries videotape procedures regularly, some only for more serious offenses, and some only when evidence is being collected for specific use in a criminal trial. In some countries, defense lawyers can ask to view videotapes of official identifications introduced at trial. Analysis of video-recordings may provide additional information as to the sniffing and alerting styles of dogs and may be a useful material for scientific studies. Clear alerts on videotapes may be particularly persuasive in judicial settings.

6. Degree of blindness

Although scientific researchers place a premium on having as high a degree of blindness as possible, practical implementation of the scent lineup procedure by police departments has resulted in considerable variation on the blindness required in the conduct of scent lineups.

6.1. Degree of blindness required as to the placement of the target scent (i.e., whether the handler must be blind, whether an experimenter or technician within sight of the dog or the handler must be blind, and whether any other participant present during a lineup must be blind)

There are variations in the degree of blindness required for a scent lineup, though only in the Czech Republic, Hungary and partly in the U.S. may the handler know where the target sample is placed. Some countries (The Netherlands, Poland and Russia) require double-blindness, such that an experimenter or technician who knows where the target is placed cannot be within view of the handler or dog running the lineup or anyone else present in the room where the dog is running the lineup. In the remaining countries the questionnaires reported the degree of blindness which can be considered as single-blind, meaning that only the dog handler is truly blind, while the presence of other persons (experimenter and/or assistant), who are aware of the position of the target odor sample, is allowed within view of the handler and the dog.

Dogs have adapted behaviors to bring them close to humans over the course of their domestication, and thus have considerable skill in reacting to commands and even subtle cues given by their human caretakers [30,31]. This ability is advantageous in many tasks of working dogs. However, in some specific tasks, such as the lineup procedure, where the dog has to make a decision on its own whether to perform or refrain from performing a specific task, a dog's looking for support or cues from humans calls into question the integrity of the dog's responses to odor samples. Ultimately, in the lineup procedure, dogs have to match odors whose status as matching or not matching are unknown to either the osmology expert or the dog handler. However, during the training or control trials the matching status of odors is known to both the expert supervising the trials and to the dog handler (no blindness), or only to the expert but not to the handler (single-blind trials), or to neither of them (double-blind). No blindness is useful during the initial phase of training when an immediate reward for obeying a command to indicate the target sample is necessary. Single-blind trials are useful for control trials or for maintenance training where

the time interval between the dog's correct response and the reward must be short. In such trials, the experimenter, who knows whether the dog's response was correct or false, may give an acoustic or visual signal so that the dog can be rewarded.

In double-blind trials, neither the experimenter nor the dog handler nor any person within the range of the dog's senses is aware of the matching status of the tested odor samples. True double-blind trials are used during official testing of the suspect's odor sample for matching it to the sample collected at the crime scene. In such a trial no rewarding of a dog for indication of the target sample is appropriate since no one knows the matching status of the odor sample.

6.2. Must an experimenter who is aware of the position of the target sample be totally isolated from visual or auditory contact with the handler and the dog?

Dogs may respond to cues of individuals within their view other than their handlers [32]. Courts have occasionally recognized that cueing could come from persons, other than the handler, watching a scent lineup who knew the location of a target [33]. Sometimes the distinction between double-blind and single-blind trials is vague, however. If, for instance, the technician or the experimenter is totally isolated from any contact with the handler and the dog, and the handler is unaware of the position of the target sample, it could be assumed that such tests are double-blind.

6.3. Means by which observers and handlers communicate, including visual or acoustic signals, a clicker, etc.

Under a single-blind procedure there is a technical issue of how the signal confirming that the indication of the dog was correct or false should be given so as to reward or not reward the dog properly. The signal should be easy to operate from outside the sniffing room and audible or visible to the handler. Usually the signal is given only after a correct indication by the dog and a lack of signal means that the indication was false. Alternatively, another signal (e.g., another color of the lamp or another tone of an acoustic signal) may be given to differentiate a correct indication from a false alert. After consistent use of a signal system, a dog may become conditioned to particular signals and, in some cases, the acoustic signal itself may then be perceived by the dog as a reward. The dog may also not sniff additional stations after this point, as discussed above.

7. Handling of dogs during trials

The manner of handling dogs during trials and in their kennels, as well as during daily routines, may influence the motivation to work and their effectiveness in performing tasks. It must be kept in mind that dogs work a scent lineup for a reward, i.e., for a positive reinforcement. Dogs should enter the sniffing room willingly in expectation of having an opportunity to fulfill their search and prey drives. Proper handling of dogs may increase their motivation for sniffing, especially in the sniffing room.

7.1. Rewards that may be used for the dog, including treats, toys, etc.

Rewards appealing to dogs vary with their preferences. In contrast to drug or explosives detection dogs, where the dogs should pay no attention to food, in the lineup procedure dogs are sometimes rewarded with treats. This creates a risk of contaminating lineup material, particularly in U.S. scent lineups where the majority of such lineups have been conducted using bloodhounds. For some dogs with a strong prey drive, a toy to throw to be retrieved may provide a greater motivation than a treat. However, throwing a toy in the sniffing room may be inconvenient because a running dog could damage stations in the lineup or hurt itself. Often there is a combination of a treat

reward for a correct indication and a toy at the end of the test to encourage the dog willingly to enter the sniffing room for the next test. The degree to which play is used should take into account the dog's age and whether it expended energy playing before the test began.

7.2. Timing of rewards

Rewards are generally offered during the course of procedures, such as when there is a correct response, often occurring after a clicker sound is made by an experimenter or technician to notify the handler to provide a reward, but also sometimes at the end of work. Timing of rewards should follow precisely the right moment and not involve a long a delay such that the dog may not associate the reward with the correct reaction [34–36]. Although delayed rewarding is well known in practice, in order not to confuse the dogs most rewarding should directly follow a correct indication in the lineup. The sniffing of scent samples in the lineup takes only seconds and an imprecise rewarding technique may confuse the dog (see [37,38], finding that a delay in reinforcement as short as 1 second can impair learning).

8. Dog characteristics and training

The qualities of dogs in terms of their trainability, reliability, calmness, ability to focus on the task (attentiveness), motivation, stamina, good health, and ease of handling are crucial for the lineup procedure.

8.1. Breed preferences for scent lineups

One of the most frequently asked questions concerns which breed is most suitable for working in the lineup. There is no definite answer to this question since not only must breed characteristics be taken into account but also individual predispositions of dogs. Some handlers argue that breeds known for their excellent sense of smell (e.g., bloodhounds, particularly in the U.S.), though it may be doubted whether dogs that work well outside (most judicially reported U.S. lineups were conducted outdoors, often near crime scenes or where tracking led to a suspect) are actually the best candidates for scent lineups generally conducted inside. Work in the lineup is very different from tracking in terrain, and breeds specialized in tracking can quickly become bored with the monotonous work of the lineup and thus become useless. Breed preferences sometimes depend on country traditions and handlers' preferences as well as on availability of particular breeds for police work. Although there is no consensus, German shepherds and mixed shepherd breeds predominate across a number of countries.

8.2. Age requirements for dogs performing scent lineups

Dogs generally begin working after about a year of training, but there is considerable variation between countries as to the length of training programs. Dogs are sometimes required to retire at about 10 years of age. Lineup work requires focusing the dog on the task and the necessity of repeating the trial several times, which requires a strong motivation to earn a reward but to work without overly active and chaotic movement. Therefore, very young dogs are not appropriate, but rather dogs at least a year and a half old with a stable temperament and character are preferred. As the work in the lineup does not require a special physical endurance, even older dogs may work well.

8.3. Period of training before dogs can make an official identification or certification requirement

Since results of canine identification in the lineup are often presented as evidence in courts, attention has to be paid to qualification, sometimes involving a formal certification, of dogs

used. The duration of the training before a dog is considered ready for official identifications depends on the skills of the dog and the handler as well as on the logistical and organizational issues. Retesting or recertification is common at intervals or upon the perceived decline in a dog's abilities.

9. Osmology expert and handler qualifications

Qualification discussions sometimes consider only the requirements for the dog, but it is equally important that persons involved in scent lineup procedures receive adequate training. An osmology expert and dog handler should not only possess knowledge and skills on canine training and behavior, but preferably have at least basic qualifications in forensic techniques because improper handling and use of scent samples as forensic material may affect the usefulness of the outcome of lineup procedures as evidence from a judicial point of view.

9.1. Qualification requirements for handlers

Handlers must generally be trained in specialized facilities before being able to produce official lineup evidence. As with the other forensic procedures, experts in charge of conducting trials and authorized to produce a final identification outcome, as well as the dog handlers who lead and reward the dogs, should have proper and formally documented qualifications to perform their jobs.

9.2. Can handlers have more than one dog?

Handlers in most countries work with more than one dog. It is well known that between the dog and the handler a special bond is created during training and deployment. It is also known that there must be a fit in temperament and character between the dog and the handler. Also, to keep the dog in good physical and mental condition, substantial time and effort is demanded of both the dog and the handler. Therefore, as a best practice, a team of one dog paired with one handler is probably optimal. However, sometimes for organizational reasons, a handler may work with two or more dogs.

9.3. Frequency and length of training sessions after teams begin performing scent lineups

Daily and weekly training sessions are designed to maintain proficiency. For maintaining a good working performance, candidate dogs for lineup identifications require a well-designed initial training regimen, while certified dogs require systematic sustaining training and exercising. The frequency and length of training session may depend on the decision of the handler or on the official regulations for dogs performing forensic tasks.

10. Measures undertaken to decrease judicial skepticism or public mistrust as to reliability and validity of scent lineups in criminal prosecutions

Since identification of perpetrators by dogs is often presented as evidence in courts, it is obvious that lawyers will inquire into the reliability of scent lineups, and how the evidential or diagnostic value of the procedure can be quantified or characterized. Especially in cases of a positive identification by dogs, where there is a minimal amount of other judicially recognized evidence, skepticism and mistrust have been increasingly expressed by some judges.

10.1. Must the probability of a correct indication by chance be estimated, or is such an estimate standard?

When a dog has to match one of scent samples presented in a lineup, there is a certain probability of correct hits of the target

sample occurring by chance alone. The lower this probability is the more valid are the results obtained. The probability of correct hits by chance depends of the number of scents in the lineup, the number of target samples, the number of trials, and the number of dogs. This probability also depends on how correct indications are calculated. For instance, if a correct hit is considered as a choice of one target out of n samples sniffed in the lineup, the probability of correct hits by chance in one trial is $1/n$, but if a correct hit is considered as a single yes/no decision of the dog toward each sample sniffed in the lineup, this probability is 50%.

The following formula has been proposed by Koziol and Sutowski [39] and includes factorials for calculation of the theoretical probability of correct hits by chance, taking into account the number of samples in the lineup, the number of targets, of dogs and of trials:

$$P = \left[\frac{k!(n-k)!}{n!} \right]^{lm}$$

where P = probability of correct indication by chance in repeating trials several times with several dogs; k = number of target samples in the lineup; n = number of stands in the lineup; $!$ = factorial (thus, if $n=6$, $6! = 6 \times 5 \times 4 \times 3 \times 2 \times 1 = 720$); l = number of dogs used; m = number of trials conducted.

Courts are frequently interested in whether there is a significant likelihood that a dog's indication, even if correct, was a "lucky guess." There are limitations to such a formula because consecutive scent lineup trials are not fully independent from each other since the dogs may learn from one trial to another which of the samples in the lineup are target or decoy samples. Also, if the same scent samples are used for more than one dog, an earlier alert may have left cues on a sample that a later dog could respond to, meaning that the lineups are not independent.

10.2. Have experimental studies been undertaken by independent scientific institutions to assess the validity and reliability of scent lineup identifications?

Lineup identifications are performed primarily by police officers who have specialized in canine training and handling. However, in lineup procedures in general there has been a lack of scientific scrutiny, without proper statistical analysis or any inquiry into the validity of procedures used by handlers. Therefore, for forensic and judicial acceptance of the lineup procedure, assessment of a procedure should involve independent scientific analysis with respected scientific tools. In some countries, such scientific studies have been undertaken in independent scientific institutions and published in peer-reviewed scientific journals [7–9,28,40,41], while in others either no such studies have been conducted or any that were became parts of technical reports used for vocational training, mostly lacking proper statistical proofs showing the significance of results. It seems, however, that the results of scientific studies published in peer-reviewed international journals were not sufficiently disseminated in law enforcement units and taken into consideration by officers in charge of osmology procedures, or even by lawyers in courts.

To answer questions by judges about the reliability of the lineup identifications, Schoon [8] proposed two parameters. The first was the *diagnostic ratio of positive identification*, defined as a ratio of percent of correct identifications in suspect = perpetrator cases to percent of false identifications in suspect \neq perpetrator cases. This ratio was experimentally estimated as high as 13.6, meaning that there could be one false identification in every 13–14 positive identifications. A false identification may result in a false accusation of the suspect, if the lineup identification is taken as the only evidence. The second parameter proposed by Schoon [8] was the *diagnostic ratio of negative identification*, defined as the

ratio of percent of correct non-identifications in suspect \neq perpetrator cases to percent of misses in suspect = perpetrator cases. The experimentally obtained diagnostic ratio of negative identification amounted to 2.6, which can be interpreted as one not identified perpetrator (in consequence falsely absolved by scent lineup evidence) in every 2–3 negative identifications using a scent lineup.

However, significant individual differences in dogs' performances in operant conditioning during match-to-sample trials were found by Jeziński et al. [9]. Additionally, the style and time of sniffing the scent samples to be matched, and the number of stations sniffed or omitted were found to influence the percentage of false alerts and false negative indications.

As an alternative to the traditional scent lineup consisting of several scent samples arranged in a line, a different design using scented steel tubes and following an odd–even paradigm was examined by Schoon [28]. Instead of comparing several samples in the lineup, dogs had to compare "odd", when the scent presented to the dog at the starting point was different from the one placed on a platform, or "even", when the scent presented at the starting point was identical with that on the platform. The other station on the platform was always blank. If the trial was "odd" the dog was trained to go to the blank tube and respond to this blank tube. It was found that, in comparison to the customary match-to-sample design, the new design produced a comparable level of matching "even" scents but the level of non-matching "odd" comparisons was substantially higher. This meant there were fewer false alerts, so it was concluded that this new design would be more reliable. However, this proposed design has never been implemented in police osmology praxis.

More recently, it was shown by Marchal et al. [10] that, due a rigorous procedure and continuous training, a high sensitivity of 70% and 100% specificity, i.e., with no false alerts over 200 trials, could be achieved. Interestingly, in this study, sensitivity increased with the number of trials. The authors believed their results could convince law enforcement authorities not to withdraw the identification of humans on the basis of individual scent as official forensic evidence. It has to be noted, however, that in contrast to the claims of Marchal et al. [10], a study by Jeziński et al. [40] found that trained dogs, though easily learning to perform operant conditioning responses in the scent lineup, displayed no significant improvement of identification accuracy, both within particular training phases and during the working phase, despite becoming more experienced as they worked.

In some countries, studies have been conducted that were focused not specifically on demonstrating the reliability of the scent lineup, but on properties of human individual odor that may be of importance for scent lineups as a forensic technique. For example, the results obtained by Vyplelova et al. [41] suggest the existence of human odor fallout, whereby a human scent trace is left by humans even if they do not touch an object. (See also [22] regarding scent collection by placing a sorbent material in contact with an item that has been in contact with an individual.) This finding, if confirmed, would be of importance for extending of application of the scent lineup as a forensic technique. One recent paper suggests that the effectiveness of scent lineups is compromised when certain training techniques are employed with dogs, though the paper contained no experimental evidence that the conceptual framework proposed would lead to better results in canine scent lineups [27].

Generally, it is difficult to determine whether the canine level of performance makes this evidence appropriately admissible in criminal prosecutions [42,43]. Despite a number of studies examining canine detection performance on a diverse array of tasks, it is difficult to make a general comment about detection reliability. This is due to three problems listed by Helton [42]: (1) a

lack of uniformity in reporting performance, (2) a lack of uniformity in testing conditions, and (3) a lack of training information for dogs used in most studies. The results of the present survey generally confirm a lack of uniformity of the lineup procedure among countries from which responses were obtained.

10.3. Has there been a decline or cessation of the use of scent lineups in police practice or judicial acceptance?

The use of scent lineups is either declining or has been terminated in a number of countries. In Germany, due to the federal structure of Germany with 16 federal states, the design of police procedures is a matter for the states, with each state determining how the police service dog system is structured. For several years, the lineup procedure is no longer in use and the method was used in the past in two federal states only. For example, the federal state of Nordrhein-Westfalen had regulations between 1988 and 2011 as to the use of the police in scent lineups. Also, from 1989 to 2012 the police forces in the federal state of Baden-Wuerttemberg used a similar scent lineup procedure. In the past, the scent lineup procedure was used in the former GDR according to Methodological Guide on the use of scent differentiation in the fight against crime, issued by the Ministry of Interior. Currently there are no special regulations for the use of scent lineup. On the other hand, there are efforts to reintroduce the lineup procedure again. In Schleswig-Holstein, for example, two dogs are specially trained and have already been used for criminal investigations.

In The Netherlands, the lineup procedure, despite of being well based on high quality scientific studies, is no longer used by police. The main reason was a lack of strict application of the prescribed methodology and failure to demonstrate the required double-blind character of the procedure. This fact was revealed in criminal cases which caused strong mistrust as to the reliability of the procedure and resulted in official withdrawal of scent lineups from forensic practice.

Scent lineups have been performed in Poland since 1962 [1]. The technique developed rapidly in police work during the period from 1997 to 2005, with dedicated laboratories, training of many dogs and staff, conduct of special workshops for osmology experts, and publishing of experimental results and discussion articles in police and law journals. In 1998 there were 36 police osmological laboratories deploying approximately 118 certified dogs and 936 identification procedures for courts were performed. Due to the verification process and quality control, the number of osmological laboratories decreased to 16 in 2005, performing 1767 procedures. In 2015 the number of laboratories was reduced to 6, but doubts and controversies that emerged as to the reliability of the procedure, especially as evidence for courts, resulted in a decline in the use of this procedure, although it is still performed [44].

In the U.S., scent lineups as performed have been criticized as inadequate to produce judicial evidence almost since the beginning of their intense usage [11]. Even with the development of more advanced techniques in Europe, U.S. procedures remained primitive and well outside such advanced techniques, despite the occasional efforts of respected scientists and even FBI agents to portray them as reliable [16,45]. No court (as of the end of 2018) has issued a decision regarding a scent lineup that was actually performed from 2012 on. Cases on specific handlers began to appear in the 1980s and 1990s, but most cases were issued between 2000 and 2011. Due to a combination of (1) discrepancies between handler claims for the perfection of their dogs and actual results, (2) overturned convictions, and (3) judicial skepticism, with many lawyers now calling scent lineups a "junk science" [12], the future of scent lineups in the U.S. is in considerable doubt. The leading legal critic of scent lineups acknowledged in 2013 that the adoption of European techniques, if widely accepted in the

scientific community, could lead to U.S. scent lineups becoming an acceptable source of judicial evidence [46].

4. Discussion

Scent lineup procedures have been accepted by courts in the countries surveyed, though some of their judicial systems no longer accept such evidence or have considerably reduced the instances where such evidence is allowed in court. There is substantial overlap between most European programs on many aspects of scent lineups, with divergence on certain other aspects. There is a greater degree of separation of U.S. practice from European practice. The approaches in Europe generally follow a similar pattern, though there are significant differences on specific aspects of how scent lineups are conducted. In the U.S., handlers who perform scent lineups adapted their initial approaches from tracking work, only occasionally and usually minimally incorporating concepts from the research literature. Nevertheless, U.S. lineup procedures have sometimes been declared reliable by researchers who have studied scent identification (e.g., [33,45]).

For all countries surveyed here except the U.S., questionnaires could be answered by describing standard practices of specialized, and generally centralized, police units where scent lineups are conducted. Those units establish standards for training dogs and personnel, as well as procedures by which data is produced and evaluated before being provided to prosecutors for use in criminal trials. Magistrates generally have the authority to determine whether the evidence proffered will be admitted in the determination of the guilt or innocence of a defendant.

In the U.S., scent lineups as employed in criminal investigations and prosecutions are not conducted by a centralized police unit but rather by individual handlers who are either employed by local police departments or independent contractors who work on a regular or intermittent basis with a police department or other law enforcement authority. Prosecutors then determine whether the scent lineup results will be proffered as evidence during a trial, though judges may find various grounds for precluding such evidence from being heard by a jury or considered by the judge acting as the trier of fact without a jury. If the evidence is accepted by a court, the judge may issue an opinion or order in which he or she discusses the nature of the scent lineup evidence produced at trial.

Also, for all countries except the U.S., scent lineups are usually conducted in special isolated and regularly cleaned rooms with standardized procedures. In the U.S., in contrast, the vast majority of judicial cases where the location of a scent lineup was specified were outdoors in places like parking lots (e.g., [47]) and open fields (though sometimes this is not specifically stated but rather inferred from statements in an opinion about wind direction or weather conditions or the fact that joggers might have been a distraction for the dog). When conducted indoors, the location was often a room in a police station or a courtroom (e.g., [54]). The reason lineups have so often been conducted outdoors is that tracking dogs (particularly bloodhounds) were often used in scent lineups, sometimes directly or soon after performing a tracking function (e.g., [48,49]). In 20 reported cases involving scent lineups, the dog or dogs used performed an additional function in the investigation, generally tracking.

A further difference between the European countries surveyed here and the U.S. is that in Europe scent lineups are usually conducted with scents on specialized pads or tubes, held in jars or clamped to platforms that are frequently cleaned and in rooms that are also frequently cleaned. In the U.S., the item sniffed is not always specified in judicial cases, but where this has been indicated, 26% were lineups of persons, 17% were lineups of crime scene objects, and 57% were lineups using scent pads or other

items on which scent from a crime scene had been placed by rubbing or some other means. Lineups of persons or objects have been reported in judicial cases even in the last 15 years. Where scent lineups use cotton pads or other objects, it can seldom be said that the lineup was conducted in an environment that is free of other olfactory stimuli, or in an area that had been, or could be, cleaned at all. One U.S. organization SWGDOG (Scientific Working Group on Dog and Orthogonal detector Guidelines), has published "recommended best practice general guidelines for training, certification, and documentation pertaining to canines trained in conducting scent identification lineups." [50]. Although not specifically providing protocols for investigations, the training and certification recommendations contain elements of certain European practices. (The SWGDOG organization has been replaced by the Dogs and Sensors Subcommittee of the National Institute of Standards and Technology in the U.S. Department of Commerce, although the documents issued by SWGDOG remain under that organization's imprint at present.) While such guidelines have been referred to by handlers in courtroom testimony [51]), those guidelines have not been followed by working handlers who have testified in criminal trials. There may be facilities within certain law enforcement organizations, such as the U.S. Federal Bureau of Investigation (FBI), an agency perhaps closer to the centralized police authorities conducting scent lineups in Europe, that could conduct scent lineups in a more sophisticated fashion than has been demonstrated in U.S. case law, but evidence of such procedures is seldom available from U.S. case law. In *Iowa v. Frederiksen* [52], FBI agents used bloodhounds to match scents to attempt to determine whether a suspects' scents could be found at locations associated with a crime. The scents of the suspects were created using "a low airflow vacuum" and a "canine manager keeps the dog handlers 'blind to the case' to eliminate potential claims of bias. The case is notable for establishing that the FBI, as many other agencies in the U.S., uses bloodhounds and scent transfer units (or something close to it) in scent work, and that blindness of handlers is preferred, but it explains little about the agency's overall use of scent identification dogs. One FBI official has testified on behalf of individual handlers even though the techniques of those handlers would likely not satisfy SWGDOG guidelines [16]. Thus, SWGDOG and other guidelines remain theoretical and outside of the cases that have produced U.S. judicial decisions and orders, and only the latter constitute the positive law of the U.S. on scent lineups.

The authors believe it is premature to suggest a list of best practices. Nevertheless, it is possible to describe certain areas where police practices are similar, and certain areas of research consensus that may indicate some starting points for an international effort and discussion toward best practices. There are at least two general approaches to materials that hold scent, i.e., (1) cotton (sometimes blended) and similar materials and (2) steel tubes. There seems some value in continuing research with both types of scent materials. Scent samples in the lineup should only be used once for a dog since they may leave cues when they indicate. Objects holding scent in the lineup should be cleaned or replaced, and the position of target samples randomized, during official trials.

There is variation in both police practice and research traditions about the number of decoy scents in a lineup, but it might be possible to set a minimum number at 4. Decoy scents are usually collected from individuals of the same race, gender, and age as the suspect, but additional similarities may be appropriate. Decoys should ideally not be police officers, but in any case should not be known to the dogs and should have no connection with the investigation or the investigating unit of a case. Scents presented together in a lineup should be collected as closely together in time as possible.

There should likely be disqualifying control trials, as well as zero trials, before an official trial, though this may also be an

appropriate area for further research. There appears to be a consensus from both police and research practice as to how much a dog should work during a day or week. There is variation in the number of stations in both research and police practice and the area needs further research analysis. There should be a minimum number of trials before an identification can be introduced in a criminal trial. Many countries require more than one dog be used for an official identification, which again should receive further research attention.

Alerts should be visible to more than just the handler, so the handler should be able to describe a unique alert for a dog to an observer. To prevent any bias, the person calling the alert should not be aware of the position of the odor of the suspect in the lineup. There is no consensus as to whether all stations should be sniffed after a correct alert. This should receive additional attention as the absence of such a requirement affects the calculation of the statistical probability of a correct hit by chance. Official trials should be videotaped.

The authors believe that trials, except for the early stages of training, should be double-blind, i.e., blind as to the handler as well as anyone whose presence may be perceived or sensed by the dog. Thus, an experimenter who can call a correct alert in control trials should be separated from the lineup area in order not to affect the handler's behavior, which might be a cue to the dog. The use of rewards is highly variable and should be the subject of further research. When rewards are appropriately given, there is a consensus that they should be given immediately after a correct indication through a conditioned behavioral response.

The authors believe that the probability of correct indication by chance should always be calculated in official trials, though we acknowledge that there is not a consensus in actual practice here. There should be a greater connection between research groups around the world and between these groups and police authorities that are implementing scent lineups. There has arisen both public and judicial suspicion regarding lineups in many countries. This concern must be addressed if the technique is to continue in forensic practice and judicial acceptance.

The authors acknowledge that the scent lineup may eventually be superseded by other forensic approaches and specifically by the possibility that individual odors of humans may in time be identified by techniques using gas chromatography/mass spectrometry. Cuzuel et al. [53] noted that forensic profiling of human odor could be useful in supporting information provided by dogs for courts, but in time it may be that such chemical techniques would relegate scent identifications to a secondary function in identifying perpetrators by their odors.

5. Conclusion

The scent lineup, as a forensic procedure, is in serious trouble in some countries, and is experiencing a decline of usage in others. It has to be taken for granted that the scent lineup identification will not show 100% accuracy all the time. However, experimental studies where statistical significance was estimated show that the identification accuracy of the scent lineup significantly surpasses results produced merely by chance. This argues that scent lineup identification of perpetrators can at least produce corroborative evidence so that neither courts nor police should totally reject use of the procedure. On the other hand it has been widely accepted that a scent lineup identification must not be taken as the sole or principal evidence leading to prosecution and sentencing. In view of some controversies and doubt related to the fact that no absolute accuracy of the lineup identification could be proven, there was and will be a tendency to dismiss this method totally from forensic practice. Nevertheless, the authors believe that this technique, conducted with

procedures, developed over the nearly thirty years in which it has been subjected to scientific investigation, can provide valid forensic data for criminal investigations and can be corroborative of other evidence in prosecutions. The authors also believe that specific country experiences and resources can lead to acceptable variations in procedures. In order to have a future as a forensic technique capable of producing such data and evidence, the authors also agree that greater international communication and collaboration should continue to produce research regarding this technique, and that disseminating the results of such research will increase the probability of judicial acceptance in all countries where sophisticated programs can be developed.

Authors' contributions

Barbara Ferry: Conceptualization, Methodology, Discussion, French answers; John Ensminger: Conceptualization, Methodology, Discussion, U.S. answers, graphical abstract; Adeel Schoon: Methodology, Discussion, The Netherlands answers; Zbigniew Bobrovskij: Lithuanian answers; David Cant: Belgian answers; Maciej Gawkowski: Polish answers (with Jezierski); Ilkka Hormila: Finnish answers; Pavel Kos: Czech Republic answers; Ferenc Less: Hungarian answers; Elena Rodionova: Russian answers; Klim T. Sulimov: Russian answers; Leif Woitke: German answers; Tadeusz Jezierski: Conceptualization, Methodology, Discussion, Corresponding author.

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