doi: 10.17221/8848-CJAS

Resistance of human odours to extremely high temperature as revealed by trained dogs

M. Santariová[1], L. Pinc[1], L. Bartoš[1,2], P. Vyplelová[1], J. Gerneš[3], V. Sekyrová[4]

[1]Canine Behavior Research Center, Department of Animal Science and Ethology, Faculty of Agrobiology, Food and Natural Resources, Czech University of Life Sciences Prague, Prague, Czech Republic
[2]Department of Ethology, Institute of Animal Science Prague-Uhříněves, Czech Republic
[3]Police Canine Training Centre, Czech Republic Police Presidium, Plzeň-Bílá Hora, Czech Republic
[4]Institute of Criminalistics, Prague, Czech Republic

ABSTRACT: Human scent is a complex combination of many chemical substances. Skin is supposed to be one of sources of scent traces. The values of the boiling points of human scent compounds were supposed to be lower than 300°C. The purpose of the study was to determine the temperature at which the human scent is degraded so that a dog would not be able to identify it. In contrast to expectations, eight dogs used in the experiment almost flawlessly identified human scents from five scent donors exposed to temperatures of 100°C, 200°C, 300°C, 400°C, 500°C, 600°C, 700°C, and 800°C. Only two of the dogs were able to identify 5 of 15 scent samples exposed to 900°C. No dog identified a scent exposed to 1000°C. Our study verified heat survivability of human scent far beyond existing expectations. There may be an extremely heat resistant, previously undetected, compound of human scent, unsusceptible to heat which exceeds standard temperatures used for sterilization. We anticipate our results to be a starting point for cardinal change of our view of factors affecting the vulnerability of human scent, resulting in the need to alter the approach of forensic methodology dealing with identification of human scent.

Keywords: human scent; scent identification; scent heat resistance; vulnerability of human scent; evidence in law of court

INTRODUCTION

Human scent is individually specific and distinguishable for trained dogs (Kalmus 1955; Schoon and Debruin 1994; Schoon 1998; Penn et al. 2007). Skin is supposed to be a significant source of scent traces (Prada et al. 2011). Human scent is a complex combination of volatile organic compounds (VOC) such as acids, alcohols, aldehydes, hydrocarbons, esters, and ketones that secret fluids onto the human skin where they interact with skin bacteria (Labows et al. 1982; Stoddart 1999; Syrotuck 2000; Curran et al. 2005, 2007, 2010a). Production of VOCs is managed mainly by the secretion of three types of glands: eccrine, sebaceous, and apocrine (Curran et al. 2007). Using solid phase micro-extraction gas chromatography/mass spectrometry has shown that human scent consists of a great amount of compounds that differ qualitatively and quantitatively from person to person (Curran et al. 2005; Penn et al. 2007). Each person thus has a specific odour profile termed "odour signature" or "odourprint" (Penn et al. 2007).

Supported by the Ministry of the Interior (Project No. VF20102015011), the Ministry of Agriculture (Project No. MZeRO0716), and the Ministry of Education, Youth and Sports (Project No. MŠMT 1321/213206) of the Czech Republic.

doi: 10.17221/8848-CJAS

Overwhelming evidence shows the individual human odour has a genetic base (Syrotuck 2000; Kwak et al. 2008). It is assumed that part of human scent is genetically determined suggesting a strong link between body odour and highly polymorphic major histocompatibility complex (MHC) (Wedekind et al. 1995; Penn and Potts 1999).

The ability of canines to discriminate human scents was reported more than hundred years ago (Romanes 1887). Therefore, human scent is of interest to the forensic community. Its individual character is a useful mean for the scent identification method.

The principle of this method is that dogs match odour of perpetrator, collected on the crime objects with the odour of suspect person. The results of scent identification method are admitted in some countries as evidence in law of court (Brisbin et al. 2000).

The important question for the successful use of scent identification method is which internal and external factors can affect the human odour. For forensic purpose the hand odour is very interesting, because the perpetrator usually touches the object at the crime scene with hands (Curran et al. 2007).

The current study verified that human scent can survive extreme mechanical and thermal conditions associated with an explosion and burning through the ability of canines to correctly identify individuals using scent collected from exploded pipe bomb fragments (Stockham et al. 2004; Curran et al. 2010b). Although these studies have shown that the specially trained dogs can locate and identify individuals, who had been in contact with improvised explosive devices, on the basis of the scent samples collected from items recovered at a post-blast scene (Curran et al. 2010b), it remained to be elucidated which temperature is critical for human scent survival, how long such a temperature has to be in effect, etc. Thus the purpose of the study was to determine the temperature ceiling, which degrades the human scent so that the dog would not be able to identify it. The values of the boiling points of suggested human scent compounds (Curran et al. 2005) are lower than 300°C (Anslyn and Dougherty 2006). Thus the hypothesis was the dogs will be unable to identify individually human scent after exposure of the scent to the heat of 300°C.

MATERIAL AND METHODS

The scent samples of the current study were exposed initially to 100°C and 600°C. We expected the dogs will not identify the scent at 600°C. Heating temperature would be then gradually decreased to reach the point the dog would identify the scent. In case some of the dogs could still identify the scent after heating of the sample at 600°C, the plan was to increase the temperature by increments of 100°C until the dogs would fail to identify the scent.

Method of scent identification. The method, regularly used by the Police in criminal investigations for scent identification in accordance with the Code of Criminal Procedures, Act No. 141/1961 Coll., was applied. The target scent was collected repeatedly from the body of one 20- (n = 25 of different samples collected) and two 25-year-old women (n = 3 each), and 23- (n = 3) and 40-year-old men (n = 3). Other complementary scents, the distractors non-target scents in the line-ups, to supplement the series of seven posts, were collected from the body of 250 female and male students of similar age as the experimental persons, of which we chose at random 230 and applied them in the testing. Each sample was used only once, none being used in training before the experiment.

Animals. Three male and four female German Shepherds, aged between 3 and 6 years, certified by the Police of the Czech Republic for scent identification, and also three 3-year-old females trained at the Czech University of Life Sciences Prague were used in the experiment.

Ethics statement. Data were collected in accordance with the Guide for the Care and Use of Animals of the Czech University of Life Sciences Prague and all experimental protocols were approved by the Faculty of Agrobiology, Food and Natural Resources Licensing Committee (Permit number: MZE 17214, 58176/2013, 16OZ13147/2013-1721).

Materials. The scent for the experiment was collected on stainless steel tubes 100 mm long, 12 mm in diameter, and 2 mm in wall thickness. These tubes were stored in glass jars with twist off lids. Before the human scent collection, all glass jars and tubes were treated by dishwashing detergents and warm water, which appeared to remove the human scent (unpublished). Then they were dried at a temperature of 180°C. All scent samples were absorbed into sterile cotton absorbent ARATEX™ (CHLUM-TEX, s.r.o., Rovensko pod Troskami, Czech Republic) squares, size 30 × 30 cm. These cotton squares were also stored in glass jars with twist off lids.

Collection of human scents. Scent samples, to be exposed to radiant heat, were collected from

doi: 10.17221/8848-CJAS

the palm region of the experimental person. The experimental person removed a steel tube from a glass jar and scented it by holding for 1 min. Then the person put the metal tube back into the glass jar. The assistant opened and then sealed the glass jar wearing latex gloves and using sterile tools. Twenty-five scent samples were transported to the Institute of Criminalistics of Prague, where the tubes were removed from the jars by clean tongs and placed into an electric furnace. Each tube was exposed to one of these temperatures: 100°C, 600°C, 700°C, 800°C, 900°C, and 1000°C for 30 min. When the procedure reached levels beyond the original presumption, to increase control of the heat process, twelve additional scent samples were then heated for 30 min at temperatures of 200°C, 300°C, 500°C, and 700°C in a furnace at the Czech University of Life Sciences Prague. After the exposure process, the assistant removed the metal tube from the furnace to an aluminium foil to cool down for about 15 min. He always used new tongs washed in detergents. Then he inserted the tube into a clean glass jar containing a cotton absorbent square. He rubbed the tube against the cotton absorbent and closed the tube in the jar to transfer the scent from the tube to the absorbent over the next 24 h. Then the tube was removed from the jar. The scented textile in the jar was used as a smeller scent sample. After each experimental sample heating, the furnace was switched to the highest temperature (1200°C) for 30 min in order to get rid of any possible remnants from the experimental heating. Samples of the same person match even if they are collected from different parts of body (Schoon and Debruin 1994). Hence, the comparative odour, which was not exposed to heat, was taken from the belly region of the experimental person. Another assistant (different from the one in the first procedure) opened the glass jar, removed the cotton square, and placed it on the naked skin of the belly region of the experimental person. After 20 min, the assistant returned the cotton square to the glass jar and sealed it with the lid. Distractor samples were collected separately from the collection of the scent of the experimental person to prevent impairment of any sample. All scents were transported to one of the two scent identification police facilities in two cities (Plzeň/Pilsen and Prague) and to the Czech University of Life Sciences Prague, in which the verification of the ability of the dogs to identify odour samples was carried out.

Scent identification. The procedure was described in details in the previous study (Pinc et al. 2011). In brief, glass jars with scent samples were opened and then the experimenter placed them into a line-up (video https://www.youtube.com/watch?v=Vd1M7oyImNA). The line-up contained one scent sample of the experimental person (the scent not exposed to heat), one control scent sample, and six scent samples used as distractors. Distractors were collected from the belly region of human bodies which had not been exposed to heat. Prior to an intrinsic matching procedure, every handler tested "attractiveness" of an experimental person's scent to a dog. The goal of this procedure was to disqualify the possibility that the matching odour itself was not attractive to the dog. The control scents were obtained from the body of persons with no physical contact to the experimental person in the study. One control scent sample was placed in the line-up behind the experimental person scent. A second identical scent sample was given to a dog as a target scent. Each handler stood in front of the line-up with his dog and motioned the dog to sniff the scented cotton squares. The dog then searched for the control scent sample in the line. Next, the dog had to match the target scent sample with the control scent sample without any response to the experimental person scent. After the test of attractiveness, the dog was to sniff at the heated scent of an experimental person and then it was sent to search for the target scent (the scent of the same person, which had not been heated). The heated scent was thus used in all tests as that sniffed by the testing dog before searching for the control scent sample in the line. (In a line-up, there were exclusively the samples not exposed to heat.) The control scent previously used was left in the line-up. The position of the target scent was random and blind to the handlers. After each procedure the positions of scent samples were rearranged at random. Each dog had to go through three different line-ups (trials) for matching each scent exposed to heating with the scent of the same person, which had not been exposed to heating.

Statistical analysis. The data were analyzed using the SAS software (Statistical Analysis System, Version 9.4, 2015). We applied the Generalized Linear Mixed Model (GLMM, PROC GLIMMIX for binary distribution) modelling the probability that the sample will be matched. To account for

doi: 10.17221/8848-CJAS

repeated measures, the mixed model was performed using individual dog's and individual donor's ID as a random effect. Fixed effects were Temperature (100, 200, 300, 500, 600, 700, 800, 900, and 1000°C), Trial (1 to 3), Sex of the scent donor (male or female), Scent donor, Sex of the scent donor, Age of the scent donor, Scent identification facility (Police in Prague or in Plzeň/Pilsen, and the Czech University of Life Sciences Prague), and Furnace (Police or the Czech University of Life Sciences Prague).

RESULTS

All dogs used in the experiment almost flawlessly identified a sample scent exposed to temperatures of 100°C, 600°C, 700°C, and 800°C. The dog, who failed in the initial trial with the temperature of 100°C, correctly matched the level samples during the following two trials and matched all trials with 700°C, 800°C, and 900°C. Only two of the dogs (one male and one female) were able to identify scents exposed to 900°C, the female matching all three trials and the male 2 of 3 trials. No dog identified a scent exposed to 1000°C. The GLMM revealed that the probability for a dog to match a heated scent was affected by the temperature only ($F_{(1, 91)} = 20.06$, $P < 0.001$) (Figure 1), with no other fixed effect significant.

DISCUSSION

Our study verified heat survivability of human scent far beyond existing expectations. Scent samples exposed to the heat of 900°C were still detectable by trained dogs. This suggests there may be an extremely heat resistant, previously undetected, compound of human scent, unsusceptible to heat which exceeds standard temperatures used for sterilization. At this stage, we can only speculate on possible alternatives. However, there is also evidence that organic compounds may resist high temperatures on space bodies during atmosphere deceleration depending on factors such as nature and altitude of the heating, ablation, chemical composition of the space body and of the atmosphere (Jenniskens et al. 1998; Basiuk and Douda 1999), fluid inclusions (Jenniskens et al. 1998; Basiuk and Douda 1999; Wycherley et al. 2004; Zak et al. 2012), hypervelocity (Bowden et al. 2008), etc. Recently Thiel et al. (2014) have shown up to 35% of DNA retained its full biological function on a rocket exterior after being exposed to temperatures of more than 1000°C during the passage through Earth's atmosphere and re-entry. It suggests an existence of not yet fully understood mechanisms which could probably explain our results in the future.

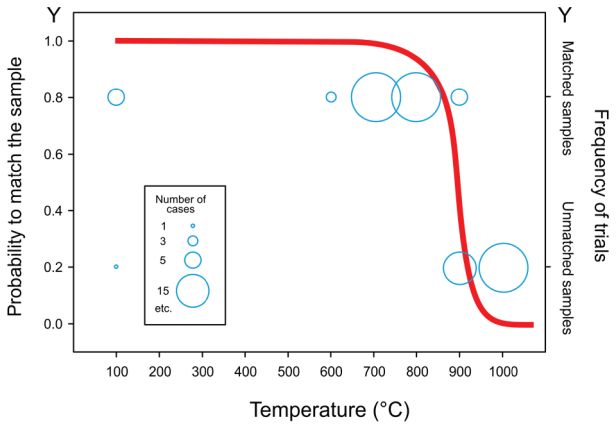

Figure 1. Predicted probability to match the human scent sample plotted against temperature to which the scent sample was exposed for 30 min (left Y axis) and frequency of trials with either matched or unmatched samples (right Y axis)

CONCLUSION

The results of the study change our view of factors affecting the vulnerability of human scent, resulting in the need to alter the approach of forensic methodology dealing with identification of human scent. These findings can be a useful asset in investigating and collecting samples from fires or even bombings, and thus in the war on terror and organized crime.

Acknowledgement. We wish to express our gratitude to the management of the Canine and Mounted Police Section of the Czech Republic Police Presidium for their consent with the use of their police canine teams and to the Police Canine Academy in Plzeň-Bílá Hora and the Scent Identification Canine Unit of the Prague Police Headquarters for their cooperation during the experiment. We would also like to highly acknowledge Hynek Burda, who inspired us to seek supportive evidence to our results in the area of astrobiology.

REFERENCES

Anslyn E.V., Dougherty D.A. (2006): Modern Physical Organic Chemistry. University Science Books, Saualito, USA.

Basiuk V.A., Douda J. (1999): Pyrolysis of simple amino acids and nucleobases: survivability limits and implica-

doi: 10.17221/8848-CJAS

tions for extra-terrestrial delivery. Planetary and Space Science, 47, 577–584.

Bowden S.A., Court R.W., Milner D., Baldwin E.C., Lindgren P., Crawford I.A., Parnell J., Burchell M.J. (2008): The thermal alteration by pyrolysis of the organic component of small projectiles of mudrock during capture at hypervelocity. Journal of Analytical and Applied Pyrolysis, 82, 312–314.

Brisbin I.L., Austad S., Jacobson S.K. (2000): Canine detectives: the nose knows – or does it? Science, 290, 1093.

Curran A.M., Rabin S.I., Prada P.A., Furton K.G. (2005): Comparison of the volatile organic compounds present in human odor using SPME-GC/MS. Journal of Chemical Ecology, 31, 1607–1619.

Curran A.M., Ramirez C.F., Schoon A.A., Furton K.G. (2007): The frequency of occurrence and discriminatory power of compounds found in human scent across a population determined by SPME-GC/MS. Journal of Chromatography B, Analytical Technologies in the Biomedical and Life Sciences, 846, 86–97.

Curran A.M., Prada P.A., Furton K.G. (2010a): Canine human scent identifications with post-blast debris collected from improvised explosive devices. Forensic Science International, 199, 103–108.

Curran A.M., Prada P.A., Furton K.G. (2010b): The differentiation of the volatile organic signatures of individuals through SPME-GC/MS of characteristic human scent compounds. Journal of Forensic Sciences, 55, 50–57.

Jenniskens P., Wilson M.A., Packan D., Laux C.O., Kruger C.H., Boyd I.D., Popova O.P., Fonda M. (1998): Meteors: a delivery mechanism of organic matter to the early Earth. Earth Moon and Planets, 82–3, 57–70.

Kalmus H. (1955): The discrimination by the nose of the dog of individual human odours and in praticular of the odours of twins. British Journal of Animal Behaviour, 3, 25–31.

Kwak J., Willse A., Matsumura K., Opiekun M.C., Yi W.G., Preti G., Yamazaki K., Beauchamp G.K. (2008): Genetically-based olfactory signatures persist despite dietary variation. PLoS ONE, 3, e3591.

Labows J.N., McGinley K.J., Kligman A.M. (1982): Perspectives on axillary odor. Journal of the Society of Cosmetic Chemists, 33, 193–202.

Penn D.J., Potts W.K. (1999): The evolution of mating preferences and major histocompatibility complex genes. American Naturalist, 153, 145–164.

Penn D.J., Oberzaucher E., Grammer K., Fischer G., Soini H.A., Wiesler D., Novotny M.V., Dixon S.J., Xu Y., Brereton R.G. (2007): Individual and gender fingerprints in human body odour. Journal of the Royal Society Interface, 4, 331–340.

Pinc L., Bartos L., Reslova A., Kotrba R. (2011): Dogs discriminate identical twins. PLoS ONE, 6, e20704.

Prada P.A., Curran A.M., Furton K.G. (2011): The evaluation of human hand odor volatiles on various textiles: A comparison between contact and noncontact sampling methods. Journal of Forensic Sciences, 56, 866–881.

Romanes G.J. (1887): Experiments on the sense of smell in dogs. Nature, 36, 273–274.

Schoon G.A. (1998): A first assessment of the reliability of an improved scent identification line-up. Journal of Forensic Sciences, 43, 70–75.

Schoon G.A.A., Debruin J.C. (1994): The ability of dogs to recognize and cross-match human odors. Forensic Science International, 69, 111–118.

Stockham R.A., Slavin D.L., Kift W. (2004): Survivability of human scent. Forensic Science Communications, 6. Available from https://www2.fbi.gov/hq/lab/fsc/backissu/oct2004/research/2004_10_research03.htm (accessed Oct 2004).

Stoddart R.A. (1999): The Scented Ape: The Biology and Culture of Human Odour. Cambridge University Press, Cambridge, UK.

Syrotuck W.G. (2000): Scent and Scenting Dog. Barkleigh Productions, Pensylvania, USA.

Thiel C.S., Tauber S., Schutte A., Schmitz B., Nuesse H., Moeller R., Ullrich O. (2014): Functional activity of plasmid DNA after entry into the atmosphere of Earth investigated by a new biomarker stability assay for ballistic spaceflight experiments. PLoS ONE, 9, e112979.

Wedekind C., Seebeck T., Bettens F., Paepke A.J. (1995): MHC-dependent mate preferences in humans. Proceedings of the Royal Society B, Biological Sciences, 260, 245–249.

Wycherley H.L., Parnell J., Baron M.L. (2004): Survival of organic matter after high temperature events (meteorite impacts, igneous intrusions). In: Proc. 35th Lunar and Planetary Science Conference, League City, USA, 1149.

Zak K., Skala R., Randa Z., Mizera J. (2012): A review of volatile compounds in tektites, and carbon content and isotopic composition of moldavite glass. Meteoritics and Planetary Science, 47, 1010–1028.

Received: 2015–11–01
Accepted after corrections: 2015–12–18

Corresponding Author

Prof. Ing. Luděk Bartoš, DrSc., Institute of Animal Science, Department of Ethology, Přátelství 815, 104 00 Prague 10-Uhříněves, Czech Republic
Phone: +420 731 650 801, e-mail: bartos@vuzv.cz