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Touch traces – the challenge for experts and the judiciary

Summary

Thanks to the high sensitivity of modern molecular biology methods, touch trace examination is nowadays one of the most frequently used methods in forensic laboratories. Both forensic genetics experts and representatives of the judiciary are enthusiastic about the dynamic development of DNA examination technology. However, the increase in sensitivity of DNA testing not only means better chances to identify the perpetrator, but also causes more and more potential problems, which have to be faced by both experts and courts, for whom DNA evidence is often the basis for findings that have a significant impact on the resolution of the case.

Key words: touch trace, DNA, forensic genetics, secondary transfer, contamination, sensitivity

A French criminologist Edmond Locard said that „Every contact leaves a trace..." (Locard, 1937, p. 117). This statement takes on particular significance in the light of the sensitivity of modern genetic testing, which is generally regarded as the most reliable and effective method of forensic research. Routine DNA testing requires approximately 1 ng of DNA, which corresponds to approximately 167 cells (Butler, 2005). However, it is possible to carry out genetic tests on the basis of a smaller amount of DNA than generally accepted, i.e. less than 0.2 ng DNA (LTDNA – Low Template DNA; Caddy, Taylor, Linacre, 2008). This means that only a few or a dozen or so cells invisible to the naked eye are enough to determine whether there is a connection between the suspect and the crime scene, based on their DNA content.

Biological traces invisible to the naked eye are commonly referred to as "touch traces" (trace DNA, touch DNA). Such a trace may indicate that the person who left it was connected with the crime scene, e.g. the suspect touched the object with his fingers / hands, thereby depositing a mixture of sebum and sweat (in the form of fingerprints). Touch traces also include invisible, small amounts of biological substances such as nasal secretions or tears, which are transmitted unknowingly from other parts of the body with the hands, or traces deposited as a result of nail biting or scratching (Wickenheiser, 2002, pp. 442–445) as well as microscopic traces of saliva transmitted through the airborne route (as droplets) when speaking, sneezing or coughing or biological traces left on worn clothing, especially in areas in contact with the skin (cuffs, collar). The origin of DNA present within touch traces can be very different. Hence, recent reports define touch traces as biological traces that contain a small amount of DNA and whose source is unspecified (Burrill, Daniel, Frascione, 2019, pp. 8–18).

One of the most frequently asked questions concerning touch traces is: how much DNA do they contain, considering that the circumstances of the trace deposition are usually unknown? The answer to this question is difficult because not every contact (touch) transfers enough DNA to identify the person who left it, as confirmed by the results of many studies. A team of researchers from the UK (Raymond et al., 2009, pp. 136–137) tested 252 samples from contact traces left on various objects, obtaining a negative result for 111 samples (44%). Other study (Lowe et al., 2002, p. 25–34) found that as many as 12 out of 30 objects (i.e. 40%) in the form of sterile tubes held in hand for 10 seconds absorbed too little DNA on their surface for identification. Similar conclusions were also reached by researchers from New Zealand (Phipps, Petricevic, 2007, pp. 162–168), who noted that between 51% and 70% (depending on the hand used) of the study participants failed to deposit enough DNA on the test object – sterile tubes held in hand for 10 seconds – to obtain a profile.

Touch traces can contain between 0 ng and 169 ng DNA (Daly, Murphy, McDermott, 2012, pp. 41–46).

Traces consisting of a single fingerprint contain from 0.04 ng to 0.2 ng DNA (Alessandrini, Carle, Tagliabracci, 2002, pp. 586–592), which corresponds to about 6–30 cells. Traces deposited as a result of multiple and/or prolonged contact with an object, e.g. on the steering wheel surface, tabletop, cup holder, contain more DNA (Burrill, Daniel, Frascione, 2019, pp. 8–18). Although the minimum amount needed to obtain a full DNA profile using most commercially available amplification kits is about 1 nanogram (ng), the so-called partial profiles can be obtained from smaller amounts of starting material. Many laboratories use various techniques to increase the efficiency of their touch trace analysis, e.g., by concentrating the DNA isolate to a volume of about 10–20 µl or by extending the injection time on the capillary electrophoresis device and thus increasing the amount of DNA introduced into the capillary for detection. For example, the volume of amplification reaction can be reduced (to 12.5–25 µl), which improves the sensitivity of the reaction, or the number of PCR cycles can be increased. Each of the above mentioned approaches may increase the reading signal on the electropherogram. However, when using these methods, one should keep in mind that they may cause difficulties in interpretation, such as the occurrence of stochastic effects in the form of unwanted „drop out" (allele falling out) or „drop in" (appearance of additional alleles) phenomena, lack of heterozygous balance or appearance of too high stutters, which make it difficult to interpret DNA profiles (Gill et al., 2000, pp. 17–40).

The size and quality of a trace consisting of sweat and sebum substance, deposited on an object may be determined by many factors, such as: the age and gender of the person who left it, skin conditions (e.g. skin diseases), emotional state (e.g. nervousness and sweating), body overheating, performing hard work at high temperature, eating a spicy meal, taking medications, as well as genetically determined predispositions to deposit DNA (Kamphausen et al., 2012, pp. 179–183). Other factors influence the durability of adhesion of the trace to the surface of the object, e.g. the type of surface on which it was deposited (porous surfaces absorb more DNA than smooth surfaces), environmental conditions to which the trace was exposed (e.g. air temperature, humidity), as well as how long and with what pressure the object was touched, what was the type of contact (static, dynamic), how much time had passed since the last hand wash, or the individual gestural habits of the person leaving the trace, such as frequent rubbing of the forehead, touching the hair, wiping the nose, rubbing the eyes, etc. (Wickenheiser, 2002, pp. 442–445).

The development of genetic techniques, which, in recent years, has become synonymous with innovation and progress in the field of forensic science, also brings with it certain problems of both a forensic and legal nature. First and foremost, the advantage of genetic testing is also its great disadvantage, since when examining a touch trace, not only the biological material of the suspect is examined, but also the entire "background" onto which the suspect's trace was deposited, including the DNA of those who left their marks before the crime was committed, but have no connection with it. In this way, the so-called mixed DNA profiles (DNA mixtures) are obtained and another serious problem arises, namely the determination of the number of people whose DNA is present in the tested sample. This fact affects the later interpretation of the sample and has a huge impact on the result of statistical calculations. A mixture of DNA originating from too many donors may be difficult or even impossible to identify.

Another undesirable phenomenon resulting from DNA properties is the possibility of the so-called DNA secondary transfer (indirect transfer) (van Oorschot et al., 2019, pp. 140–166), i.e. the transfer of a trace from one place to another by an object/hand (vector) completely unrelated to the criminal act. Since there is a tendency to associate DNA directly with crime, a lack of understanding of its transferability carries a high risk of misinterpretation of DNA evidence by the court. The possibility of secondary DNA transfer from the object to the hand was first pointed out by Australian scientists as early as 1997, as reported in the prestigious Nature magazine (van Oorschot, Jones, 1997, p. 767). Many experiments have been carried out to confirm the existence of the phenomenon of secondary transfer. A team of Australian scientists (Goray et al., 2010, pp. 62–67) working on this subject showed that it depends on many factors. The results of their research show that the secondary transfer is significantly affected by both the type of surface and the moisture content of the biological material (trace). Porous surfaces and dry biological material decreased the transfer rate (on average only 0.36% of the biological material was transferred). Approximately 50–95% of the biological material was transferred in the case of a smooth surface, which in turn indicates that such a surface facilitates the transfer of DNA. In addition, the so-called active contact (by friction of two surfaces) significantly increased the transfer compared to passive contact or contact by pressure. A team of researchers from Ireland (Daly, Murphy, McDermott, 2012, pp. 41–46) conducted similar experiments using glass, fabric and wood surfaces. In 10% of the cases tested, they obtained samples of DNA mixtures with a full profile, which also contained DNA resulting from secondary transfer (full or partial profile). Although the authors emphasize that in most cases, the "foreign" DNA is the result of primary transfer (DNA deposited during conversation, sneezing, etc.), the phenomenon of secondary transfer (at a level below 0.03 ng/µl) has made it difficult to analyse the DNA of the person who left the primary trace. The transfer is probably also affected by the physical and chemical properties of the surface, the chemical composition and type of textile

fibres, their weave, thickness, electrical charge, etc. (van Oorschot et al., 2019, pp. 140–166).

Researchers of the phenomenon of secondary transfer also conducted experiments simulating criminal acts. In one of the criminal cases, a woman was murdered and her body was partially burned. The victim's pajamas were used to collect the DNA of her former partner, who claimed that he had not been in contact with the victim nor in her home for several months. The former partner was accused of murder on the basis, among other things, of DNA test evidence. During the trial, the defence proposed to conduct experiments on secondary DNA transfer by simulating the situation of DNA transfer by clothing and children's toys onto the victim's pajamas, in order to clarify the presence of the defendant's DNA on the victim. The experiments confirmed the possibility of DNA transfer (at the level of 13–14% after 24 hours) (Goray, Mitchell, van Oorschot, 2012, pp. 40–46). In another experiment, participants used knives for two consecutive days to simulate a regular use situation. Next, each participant shook hands with another person for 10 seconds and immediately stabbed the foam block several times with a knife for 60 seconds. Subsequently, DNA was collected from each pair of participants from the knife handles at different intervals: immediately after use, after one hour, after one day and after one week. The total amounts of DNA obtained from the knives regularly used by one person were varied (both full DNA profiles and partial profiles were obtained), and the amount of DNA recovered decreased over time. The amount of transferred DNA could be designated as a minority component at a level of about 10% of the dominant profile (Meakin et al., 2017, pp. 38–47). In turn, experiments on touch traces carried out at the Centre for Forensic Science showed that on some of the touched objects profiles of persons close to the subjects were identified, who had not been in contact with the examined object (Stępień, 2018). In another study, a pair of volunteers were asked to hold hands for about 2 minutes, after which each participant was asked to hold a knife. In 85% of the cases, the partner was identified as an "accomplice", and in the remaining 25% cases, his/her DNA was the main or only identified component (Cale et al., 2016, pp. 196–203).

In 2012, a homeless man named Lukis Anderson was accused of murdering a multimillionaire Raveesh Kumra in Silicon Valley, California, on the basis of DNA evidence. A small amount of his DNA was found under the victim's fingernails. It turned out that Anderson could not be the perpetrator of the murder because he had an unquestionable alibi. At the time of the crime, intoxicated to the point of unconsciousness, he was hospitalized for alcohol poisoning. The question was how his DNA got transferred onto the victim's body. It turned out that the same paramedics who had helped him, a few hours later, intervened at the scene of the murder and it was they who transferred his DNA onto the scene (Lee, 2013).

Another problem related to the examination of small amounts of DNA is the phenomenon of contamination, i.e. the transfer of unrelated DNA after a crime has been committed (Gill, 2002, pp. 366–385). The current sensitivity of DNA profiling kits makes it very difficult to prevent this phenomenon, especially when we realize that during a 30-second conversation DNA spreads by the airborne route (carried by droplets) over a distance of up to 115 cm (Port et al., 2006, pp. 157–163), and during sneezing – even up to 8 m (Lok, 2016, pp. 24–26). Contamination is often a reason for erroneous interpretation of genetic test results and a source of the miscarriages of justice (Kloosterman et al., 2014, pp. 77–85). Contaminating DNA may mask the DNA from the crime scene, which in turn may lead to an erroneous resolution of the case or make it impossible to identify a trace. Contamination may occur both at the stage of securing material evidence at the crime scene, packaging, storage and transport, as well as during laboratory tests. Possible sources of contamination with foreign DNA may also include persons involved in the production of consumables, representatives of law enforcement agencies present at the crime scene or paramedics; contamination may also occur between items of material evidence or laboratory samples (Pickrahn et al., 2017, pp. 12–18). Such cases are unavoidable, but procedures are in place to minimise and monitor this undesirable phenomenon (Basset, Castella, 2019, pp. 12–18). Several years ago in Germany, the same female DNA profile was identified in more than 30 traces at various places, including those related to the murder of a policewoman from Heilbronn. The real reason for the repetition of the same profile was the contamination of the cotton swabs used to collect DNA samples by a woman working at the factory where they were made (Neuhuber et al., 2009, pp. 145–146). Researchers report a growing number of such cases, using the example of the Biological Traces Department of the Netherlands Forensics Institute, where the incidents of DNA contamination caused by laboratory staff ranged from 21 to 53 cases in 2008–2011 (Kloosterman et al., 2014, pp. 77–85). Researchers from the Department of Forensic Medicine of the University of Salzburg, Austria have identified as many as 347 cases of contamination caused by police officers over the last 17 years (Pickrahn et al., 2017, pp.12–18). In turn, scientists from the University Center of Legal Medicine, Lausanne, Switzerland (FGU), reported a 70% reduction in laboratory-originated contamination cases after implementing additional anti-contamination procedures. This was due, among other things, to the automation of the process of DNA isolation from standard traces, the ban on bringing external objects such as pens, mobile phones, etc. into laboratory rooms, the use of double gloves, frequent changing of disposable laboratory coats and the implementation of

the principle that the person collecting samples does not perform other activities, such as camera operation, etc. (Basset, Castella, 2019, pp. 12–18).

The above examples show that the analysis of DNA evidence can cause many problems. Moreover, "some argue prematurely that the world of DNA testing is quite unambiguous and ultimately ordered. They express this in bizarre views that this type evidence is so absolutely certain that it should not be subject to a free assessment by the court (Article 7 of the Code of Criminal Procedure)" (Gurgul, 2009, pp. 134–140). DNA analysis is nowadays an essential and extremely effective tool for identifying criminals, but with the constant increase in the sensitivity of the analytical methods used, the margin for error is also increasing. Errors are usually committed by people who examine genetic material and secure evidence. Moreover, not only genetics experts, but above all police technicians, prosecutors, attorneys and, most importantly, judges (because they have the last and decisive "word") have to adopt a new attitude towards DNA evidence. Scepticism and restraint should replace the current enthusiasm and 100% confidence that DNA is the undisputed proof of direct contact. Unfortunately, some prosecutors and judges, who ultimately evaluate evidence originating from genetic testing, often have insufficient knowledge in this field, hence the myth of undisputable DNA evidence still persists. There is therefore a concern that progress in DNA testing technology will paradoxically not result in the elimination of judicial mistakes, and that the need to evaluate increasingly complex and complicated issues, such as the phenomenon of secondary DNA transfer or contamination, may lead to an increase in the number of errors committed. It is also worth noting that, more and more frequently, the typical question asked by the court in relation to DNA evidence is not who left a contact trace, but how and when it was deposited at a crime scene. The issues outlined above show that the answer to this question is not so obvious.

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Examples:

– **one author:**

According to Malinowski (2015)…

In Polish Language Dictionary (Doroszewski, 1961)

– **two authors:**

According to Widacki and Dukała (2015)…

It is stated in Polygraph examinations (Widacki, Dukała 2015)…

– **three and more authors –** all the names are given only in the first instance of referring to a given work in the text; in subsequent references exclusively the name of first author and an abbreviation "et al."

As Bajerlein, Wojterska, Grewling and Kokociński (2015) demonstrated in their article…

In the article mentioned above Bajerlein et al. (2015) demonstrated…

As research has shown (Bajerlein et al., 2015)…

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Arntzen, F. (1989). *Psychologia zeznań świadków*. Warsaw: Państwowe Wydawnictwo Naukowe.

Buller, D.B., Burgoon, J.K. (1996). Interpersonal Deception Theory. *Communication Theory*, 6(3), 203-242.DOI: 10.1111/j.1468-2885.1996.tb00127.x

Sweetser, E.E. (1987). The definition of lie: An examination of the folks models underlying a semantic prototype. W: D. Holland, (ed.), *Cultural models in language and thought*. New York: Cambridge University Press.

Widacki, J. (ed.). (2012). *Kryminalistyka*. Warszawa: C.H. Beck.

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