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Genetics and dactyloscopy – rivals or allies

Summary

For nearly hundred years, dactyloscopy - as the most effective method of human identification, was treated as the queen of all forensic examination. With the emergence of genetic analysis, particularly when a huge progress in molecular biology and genetics resulted in a more extensive scope of application of biological evidence, the rank of dactyloscopy appears to dissipate. Currently the question is whether it will be completely ruled out of practice or could be utilized alongside genetic examination.

For the purpose of verification of theoretical assumptions concerning comprehensive DNA/fingerprint examination opinions and in order to identify potential mistakes which can occur in practice, the analysis of 122 comprehensive opinions from DNA/fingerprint casework examinations was carried out in relation to five police forensic laboratories in Poland in the period between 2010-2013.

Keywords: DNA, dactyloscopy, comprehensive opinion, touch DNA, trace DNA

I. Introduction

In the latter half of the 1990s, with progressing minimalisation of DNA sample required for human identification, the possibility of examination of the so-called contact traces (*trace DNA*, *touch DNA*) has appeared. In the preceding years, the experts in genetic (biological) examination had not taken into consideration the traces of fatty and sebaceous substance, which did not belong to their area of interest due to insufficient sensitivity of analytical techniques applied at that time. Presently, both fingerprint and DNA examination methods allow for corresponding findings as regards the person who left the trace, whether he or she touched a specific item or the surface and if so, at which location and finally, if the suspect can be somehow linked to the crime scene. On one hand, it ensures an increased competitive edge between these two techniques, which stems from a still die-hard belief that application of one technique automatically excludes the other or that it is sufficient to collect one type of examination material for the purpose of identification. On the other hand however, the chance of enhancing the effects of such analyses by a comprehensive application of

both methods in such a way as to utilize all advantages has come up, particularly when involving one method to strengthen the application of the other one.

Undeniably, dactyloscopy is traditionally considered an effective, relatively inexpensive and quick type of forensic casework examination allowing – despite occasionally reported stipulations related to the concept of (*scientific evidence*) (Raport National Research Council, 2009; Raport President's Council of Advisors on Science and Technology, 2016) – even for conclusive opinion being sufficiently good foundation for court ruling (United States Court of Appeals for the Third Circuit, 2004).

Furthermore, it should be kept in mind that not every contact (touch) leaves a sufficient amount of DNA for identification, which is confirmed by findings of numerous research¹, and in such cases there is a need for collecting marks for fingerprint examination.

¹ For instance, Vincent Castella i Patrice Mangin (2008) analysed 1739 contact stains and only 26% of them were qualified as sufficient to be introduced to Swiss DNA database. Likewise, a research team: Raymond, van Oorschot, Gunnb, Walshd, Roux (2009) for total of 252 samples collected from contact stains left on various items,

In turn, a constraint in application of fingerprint examinations (in case of other marks than impressions, e.g. made in blood) is that, as a rule, they cannot be performed after DNA analysis. This is determined by the fact that collection of sample for DNA analysis from contact trace, removes this trace permanently; hence in case of latent mark, the possibility of applying fingerprint examination will be completely abandoned.

A similar risk occurs in a reverse situation; the literature reports on some, not infrequent cases, of undesirable effect of fingerprint detection techniques on subsequent results of DNA analysis (Lee, Gaensslen, 2001). In practice, it is accepted that the least invasive methods should be used in the first place (Wójcikiewicz, 2007). At the same time, there has been a consolidated opinion on fingerprint examination as being destructive, which stems from the fact that the majority of latent fingermarks are invisible and therefore require the treatment with various chemical and physical visualization methods which, in turn, have or could have a negative effect on DNA analysis. This opinion, however, is not prevalent any more, as presently a DNA analysis is possible even after the application of fingerprint detection techniques. This thesis is supported by the analysis conducted for the purpose of a hereby paper and also by the experience of other researchers (Bhoelai, de Jong, de Puit, Sijien, 2011; van Hoofstat, Deforce, De Pauw, van den Eeckhout, 2006; Leemans, Vandeput, Vanderheyen, Cassiman, Decorte, 2006). On the other hand, the adverse effect of fingerprint visualization techniques may be presently sought in a partial loss of typically very small amount of DNA in a trace, and also the risk of the so-called contamination with DNA of the examiner, who is not related to the case but performs casework examination. On top of that, the reagents or powders used for development of ridge skin impressions may contrast not only the mark itself but also colour the underlying surface, which leads the situation when biological trace, other than fatty and sebaceous substance is hard to detect. The location of invisible contact trace and typing the place for collection of sample might pose another problem. A fingerprint expert, when trying to detect a latent mark, is mainly guided by the type and age of

a particular mark and structure of surface in order to adopt appropriate visualization means and methods. In such a scenario (and in absence of other material than blood, saliva, semen or hair) a DNA expert selects a sample for examination basing on his or her experience, from the locations a crime offender could have touched. Sometimes, the locations of contact traces are obvious, however in situations when experts are uncertain as to how a given item was handled or used, dactylscopy can be helpful in predicting the areas of contact. A DNA expert may collect the samples from the location indicated by fingerprint examiner, as the one which allegedly remained in contact with hands of a suspect.

Finally, a factor which should be considered when making the decision as regards the examination choice, is a high sensitivity of DNA analysis, which is a huge asset but sometimes also a huge disadvantage. As this is not only the trace which undergoes examination but also the entire surface, the result of analysis can be either less clear or can prevent the identification due to a mixture of various DNA contributors (i.e. persons related and unrelated with the incident) in examined samples.

All these drawbacks may be eliminated or at least diminished by a **comprehensive approach** towards the detection and examination of *touch DNA*, which means a combination of efforts of DNA and fingerprint experts. Although this approach involves the application of more means and resources, the advantages of comprehensive opinion in supporting the detection of DNA and fingerprints and complementing research options of both disciplines outweigh possible drawbacks. It is important, however, to establish the rules of cooperation between the experts of these two disciplines as well as the mechanisms to prevent adverse outcomes, such as loss or contamination of examination material.

A well-appreciated comprehensive approach principle lies in the assumption that one identification method in specific cases can constitute the substitute of the other one. If a collected fingermark is not suitable for analysis, for instance, due to insufficient number of minutiae to reach a conclusive opinion, then the effort could be made to analyse the mark with molecular genetics method, provided a DNA sample was collected at the same time and relevant principles of fingerprint and DNA examination methodologies are followed.

This is related to the possibility of utilizing the results of fingerprint examination by a DNA expert when dealing with invisible (latent) prints. Thus, the expert can collect a sample for DNA analysis from the locations indicated by a fingerprint examiner as the ones bearing the marks of fatty and sebaceous substance which forms a fingerprint impression

in 111 (44%) samples obtained a negative result. In other types of examinations Lowe, Murray, Whitaker, Tully and Gill (2002) concluded that as many as 12 out of 30 (i.e. 40%) sterile tubes hold for 10 seconds absorbed too low level DNA for identification on their surfaces. Similar conclusions were also reached by M. Phipps and S. Petricevic (2007), who noticed in their research that 51-70% of contributors (depending on the hand used) were not successful in transferring onto surfaces of sterile tubes hold for 10 seconds, the DNA amount sufficient for profiling.

(Bhoelai, de Jong, de Puit, Sijjen, 2011), and which are not suitable for fingerprint examination. It is particularly helpful when a specific item is deprived of surfaces which typically serve for holding (e.g. containers with no handles, plastic bags, sheets of paper, large surface items). Fingerprint visualization aids in making a decision on the location of sampling DNA in such a way as to avoid too excessive areas. Collection of samples from bigger areas carries the risk of obtaining DNA mixtures originating from many contributors (everyone who touched the item at the sampling location). Such DNA mixture is often unsuitable for identification or results in problematic analysis, especially when DNA levels of individual components are quantitatively similar. Therefore, in comprehensive casework examinations, a precise typing of locations with fatty and sebaceous substance by a fingerprint examiner should facilitate a subsequent analysis undertaken by a DNA expert (once such decision is made).

Interaction between DNA and fingerprint experts gains a particular meaning from the perspective of the direction of progress in genetic research. Given that in a not too distant future, a human identification will be possible on the basis of a single cell only, then it would be difficult to link this particular cell to a specific incident as the way it was found on a given location will remain unclear. For instance, it will be problematic to exclude that the cell was deposited on the exhibit as the result of transfer of one object to another, which had been situated elsewhere, in a crime-unrelated location.

Performing comprehensive fingerprint and DNA casework examination requires a tight and good cooperation between forensic experts, which does not leave any space for „competition” between these disciplines. Among others, this interaction comes down to deciding by experts on case-to-case basis what types of examination would be effective, how they complement each other, in which situations they disqualify the other technique or when the application of one method only is sufficient. In such scenarios, experts must always take action in the interest of proceedings, which sometimes mean they resign from examination in the area which is quite likely to yield unproductive results. Although sometimes it is difficult to predict the result of examination *a priori*, nevertheless the experience of forensic experts cannot be overestimated along with their knowledge and ability to communicate and compromise, which is deemed essential in a comprehensive approach towards casework examination.

In case of request for comprehensive DNA/fingerprint casework examination, a sequence of examination of paramount importance; from investigative practice it is often quite difficult to decide

on the location for DNA sampling and fingerprint detection techniques to be used in order to reduce the intervention to a minimum. The many years dispute between DNA and fingerprint experts in that sphere contributed to the formation of two “schools”: the followers of one argue that DNA samples should be collected after fingerprint examination as there is no certainty that the results of DNA analysis would be negative, whereas the representatives of the other “school” support the thesis that DNA samples should not be collected after fingerprint examination as DNA analytical result – if any – can be encumbered with an error in form of e.g. DNA contamination with case-unrelated contributor. The advantage of a comprehensive approach lies in a possibility of reaching the decision jointly as to the tactics of conducting examination from both areas.

Most certainly, it is recommended for DNA expert to collect as many samples as possible prior to fingerprint examination in order to avoid the intervention of chemical and physical reagents for visualization as well as to narrow down the number of persons handling the questioned material. The locations for DNA sampling are typed in a way as to predict the possibility of a positive outcome of analysis with no damage for fingerprint examination to follow. The decision is difficult, principally because evidential stains remain in major part latent prior to chemical treatment. Furthermore, it is not easy to foresee which spot was touched by one person and which – by many possible donors thus contributing to a number of DNA profiles. If a collection of DNA sample involves swabbing the potentially DNA-yielding surface thus eliminating the possibility for subsequent fingerprint examination due to loss of fingerprint, then a fingerprint examiner should, as a rule, detect and lift a fingerprint in the first place. On the other hand, a DNA expert collects traces after fingerprint examination from the locations pointed by fingerprint examiner as having been touched. DNA expert may also, in case of negative result of fingerprint visualization, decide on collection of hypothetical trace basing on his or her experience solely or the information from the investigator in charge. A negative result of fingerprint examination does not prejudice the lack of contact traces as a DNA-originating substance may not necessarily appear in form of skin ridge impressions.

II. Empirical study

For the purpose of verification of theoretical assumptions concerning comprehensive DNA/fingerprint examination opinions and in order to identify potential mistakes which can occur in practice, the analysis of 122 comprehensive opinions from

DNA/fingerprint casework examinations was carried out in relation to five police forensic laboratories in Poland in the period between 2010-2013². The study was conducted in the Central Forensic Laboratory of the Police (67 forensic opinions issued) as well as in 4 other chief police forensic laboratories (Voivodeship Police Forensic Laboratory in Łódź - 23 forensic opinions; Voivodeship Police Forensic Laboratory in Cracow - 11 forensic opinions; Metropolitan Police Forensic Laboratory in Warsaw - 11 forensic opinions; Voivodeship Police Forensic Laboratory in Olsztyn - 10 forensic opinions).

Preliminary results of the research show that in the group of all comprehensive opinions performed in Polish police forensic laboratories, a comprehensive casework opinion in DNA/fingerprint examination belongs to the most frequently requested opinions. Most typically, casework examination in that scope aims to determine a person who touched crime-related items or stayed at the location where crime was had been committed. At the same time however, it was concluded that forensic experts in these two disciplines rarely issue one joint opinion, but there is a clear tendency to drafting separate forensic opinions.

The empirical studies attempted to address the following issues :

1. **Types of criminal offences where comprehensive examinations are requested** in the area of fingerprint and DNA analysis. First of all, it should be reminded that not so long i.e. several years ago, these opinions were issued rather infrequently. It was the outcome of the then limited analytical possibilities of forensic biology as well as the nature of submitted exhibits. Prior to sensitive molecular biology techniques, biological examinations were conducted with use of serological or genetic methods, which required high amounts of good quality material (e.g. RFLP techniques (Branicki, Kupiec, Wolańska-Nowak, 2008)). At that time, examinations of the same item with biological and fingerprint analytical methods solely concerned the cases of visible biological stains (such as blood), or in cases of high probability of occurrence a sufficient amount of DNA for obtaining a positive result (e.g. envelope with a stamp of saliva traces). It should also be pointed out that initially (Kalinowski,

1994). comprehensive casework examinations were mainly requested in complex cases, such as construction disaster or communication accidents, economic crime or criminal offences against life and health. With increasing examination possibilities inherent to forensic biology, there was also a growing number and type of criminal offences which required comprehensive DNA and fingerprint examination. The bodies requesting comprehensive casework examinations however, are not guided by a legal classification of a criminal offence in question, neither the penalty, or high-profile character of the case. In examined cases, issued comprehensive opinions concerned the following types of offences (fig. 1).

2. **Exhibits** which were subject to examination. In the analysed cases, the items bearing subsequently detected marks included most often the following: various implements to commit crime, particularly firearms and ammunition, body wrapping tapes, plastic bags, garbage bags, door and window knobs, cables, envelopes and mail paper, banknotes, bottles, cans, paraphernalia, i.e. the objects the offender could have had contact with. The group of items also contained such untypical objects as stone (Case no. RSD-80/11; it should be added that in this case a DNA profile of a person who used this particular stone to commit crime was determined due to contact traces deposited on its surface). In total, for 122 comprehensive casework examination, 514 exhibits were analysed where fingerprints or touch DNA were detected.
3. **Premises to request the comprehensive casework examination (opinion).** In particular, the study involved analysis whether the surfaces (their size, type and location), which could bear marks are suitable for application of DNA or fingerprint method. Basing on analysed opinions and long-term expert practice of the author who examined the cases in question, it should be accepted with a high level of probability that the bodies requesting comprehensive casework were driven by the research possibilities of particular forensic disciplines. The key reason behind requesting such examination was to try to conclude, by means of these two examination methods, whether crime-related items had been touched by the offender. On the other hand, some cases were noted, when judicial body requested comprehensive examination of very small items, which did not qualify for parallel identification with fingerprint and DNA examination methods, due to too small surface, such as: fragments of thin wire, nails, or even nail heads. It is hard to leave a clear fingerprint on such surfaces. The group of exhibits submitted for comprehensive

² The results of the research have been presented in Ewa Kartasińska's doctoral dissertation: *Identyfikacja osobnicza na przykładzie opinii kompleksowej z zakresu badań daktyloskopijnych i genetycznych (Human identification on the basis of example of comprehensive opinion in scope of fingerprint and DNA examinations)*, Warsaw 2016, carried out at the Warsaw University Faculty of Criminalistics.

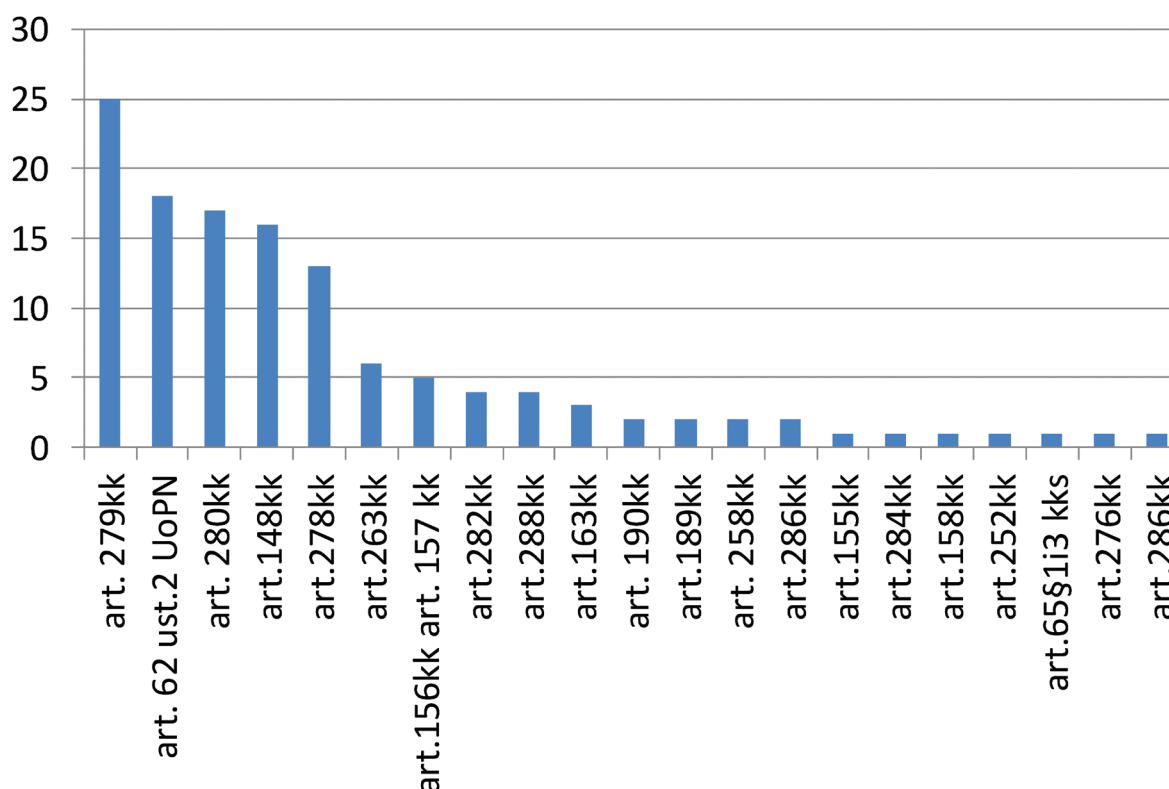


Fig. 1. Number of comprehensive (DNA, fingerprint) opinions depending on legal classification of the offence (art. 279 penal code – burglary, art. 62 ust. 2 possession of significant amounts of narcotic substances; Act of 29 July 2005 on prevention of drug abuse, art. 280kk- robbery, art. 148kk – homicide, art. 278kk – theft, art. 263kk - illegal possession and loss of firearms and ammunition, art. 156kk and 157kk - serious detriment to the health and infringement action against the body, art. 282kk - racketeering and extortion, art. 288kk- property damage, art. 163kk- evoking a dangerous incident, art. 190kk- punishable threats, art. 189kk – detention, art. 258kk- involvement in organised criminal group, art. 286kk- adverse asset disposal, art. 155kk - negligent homicide, art. 286kk - unlawful taking of property, art. 158kk - involvement in a brawl or beating, art. 252kk - hostage taking, art. 65§ 1 and 3 penal fiscal code - carriage of goods without excise, art. 276kk - destruction of documents, art. 286kk – fraud).

examination recurrently contained also big, rough and heterogeneous surfaces, where it is difficult to type the location of contact trace; likewise it is not easy to leave a traditional fingermark on such surfaces. If these exhibits do not bear visible biological stains (such as blood), there is a little chance to find a contact trace which would yield the possibility to determine DNA profile of one person.

4. **The effectiveness of fingerprint and DNA examinations** and the relationship between these two methods in a comprehensive approach. As the criterion of evaluation of effectiveness of DNA and fingerprint examinations performed in a combined approach, it has been accepted that the method allowing for identification a person who left a particular trace is a more effective one. In the analysed empirical material, for total of 122 casework opinions where 514 exhibits were examined, in 60% cases (73 forensic opinions)

DNA examinations yielded a positive result, whereas in case on fingerprint examination, positive results were obtained in 27% cases (33 forensic opinions) (fig. 2). It is worth adding that according to the research conducted in Poland, despite the fact that DNA casework examination does not allow for fully conclusive opinion as this is the case in fingerprint examination, the DNA-based opinions, in the view of judges, constitute a highly reliable evidence. A survey conducted in the group of 76 judges who were asked what casework examination - a sole incriminating evidence would be the basis for conviction of the offender, 100% indicated DNA analysis, whereas fingerprint examinations were pointed by 93% of judges (Wójcikiewicz, 2007). Likewise, a survey research carried out in the Department of Criminalistics of the Warsaw University amongst judges, prosecutors and defense attorneys on the reliability of issuing opinion, demonstrated

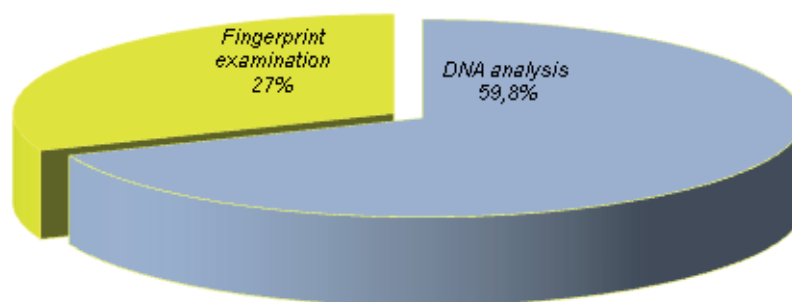


Fig. 2. Comparison of effectiveness of fingerprint and DNA examination methods.

that DNA casework opinion is considered as more credible than fingerprint one and is also characterized by a greater strength of evidence (Achrem, 2013).

5. **Sequence of collection and examination of fingermarks and DNA evidence.** As it was demonstrated earlier, the resolution of that problem poses particular difficulties in practice, as the adoption of inappropriate detection and collection procedures may result in loss or contamination of examination material, which is specifically detrimental in DNA analysis. In the analyzed opinions, a certain inclination towards the collection of fingermarks in the first place can be observed, however DNA samples are collected prior to fingerprints only from the locations which do not give any chances for dactyloscopic identification, in particular surfaces of uneven structures or too small areas to accommodate friction ridge skin impressions. The cases of *a priori* collection of DNA material however, are not too frequent. As typically genetic examination disables a subsequent conduct of fingerprint examination, a DNA expert does not collect samples from smooth surfaces in order to provide the opportunity for collection of fingermarks in the first place and performing a resulting identification. On the other hand, such approach is likely to increase the risk of contamination since the majority of DNA samples are examined after fingerprint visualisation process, meaning that evidential trace is exposed to a multiple contact with personnel responsible for individual stages of examination.
6. **If fingerprint examination in the first place excludes subsequent DNA examination.** It was determined in the analysed cases that DNA examination performed after the treatment of exhibits with chemical or physical reagents/media for the purpose of visualisation, did yield positive identification result in nearly 40% cases (in 39

casework examinations for the total number of 98 examinations which attempted DNA analysis after fingerprint examination). It should be added that in slightly more than 9% cases (9 casework opinions), DNA samples collected after fingerprint examination, were obtained from bloodstains, saliva stains on stamps or bottle mouth (i.e. traces containing high DNA levels), which means that positive DNA examination from contact traces only constituted approx. 30% cases. In 38.7% cases (38 opinions), negative DNA examination result was obtained after visualization, whereas in 21.4% cases (21 opinions), the expert made a decision on abandoning such type of examinations due to a negative result of fingerprint examination. Obtaining DNA profile after fingerprint visualization treatment attests to the fact that fingerprint examinations, as a rule, do not exclude the possibility of conducting subsequent DNA analysis. Hence, the findings corroborate the experiments reported in the literature³. Furthermore, the results validate the fact that the collection of DNA samples after fingerprint examination should be maintained, even if the process of fingermark detection is to reduce further down the amount of DNA in trace. On the other hand, it would be reasonable – in case of

³ For instance, according to the research teams: Leemans et al. (2006) and Norlin, Nilsson, Heden, Allen (2013), despite the loss in amount of biological material following fingerprint treatment with visualization reagents, quite often there is a remaining DNA level allowing for DNA identification of a trace contributor. Team of researchers: Alessandrini, Cecati, Pesaresi, Turchi Carle, Tagliabracci (2002) have tested 374 latent fingermarks in laboratory conditions (marks were deposited on wood, glass and metal) as regards the amount and analytical possibilities of inherent DNA with no application of visualisation techniques. A full DNA profile was obtained for 31.8% samples, whereas in 13.6% - negative results were obtained. The highest percentage involved the so-called partial profiles (54%).

comprehensive casework opinion – to constrain the application of visualisation techniques even to one method (Fingermark Visualization Manual, 2014); in discussed cases, on average 5-7 visualisation methods were utilized each time.

7. **Purpose of conducting DNA examination following a negative result of fingerprint examination.**

In case of comprehensive casework opinion, the problem particularly concerns the collection of samples by DNA experts from the location of the presence of the so-called partial friction ridge skin impressions considered by fingerprint experts as unsuitable for fingerprint identification. At the same time, such impressions contain exceptionally low levels of DNA (approx. 0 - 0.5 ng). In the group of analysed 98 casework opinions, where DNA analysis was undertaken after fingerprint examination whatsoever, only in 16 cases (16%) the samples were collected from these locations. In total, 49 partial impressions were collected and a positive DNA analysis result was obtained in case of 7 marks (nearly 14% cases): a full DNA profile was obtained from impressions on four exhibits (wrapping tape on drug-containing packet, sheet of paper, firearm grip, knife blade); it was possible to obtain DNA mixture from two contributors in case of two exhibits (tape glued on drug-containing packet, sniper telescope) with determination of major profile, and also DNA mixture from two contributors with the possibility for identification in case of one exhibit (plastic bag). In majority of cases, DNA samples collected after fingerprint examination originated from a bigger area than the one with partial skin ridge impression for a fear of insufficient amount of substance for DNA analysis. Collection of sample in such a manner is justified in cases when exhibit itself is of big size and it is difficult to type the locations of contact (touch). On the other hand, collection of samples from too extensive areas touched by many possible contributors, bears the risk of obtaining DNA mixture preventing the identification of these persons. Therefore it should be acknowledged that due to increasing sensitivity of DNA analysing methods, the collection of samples from partial impressions is well-founded, especially in case of negative results of earlier identification.

8. **Is there relationship between the manner the exhibits are examined in the request for comprehensive DNA/fingerprint casework examination and the exhibit type.** The analysis of cases where comprehensive opinions were issued confirmed this dependency; the cases demonstrated in particular that the scope and manner of detection and examination of traces is

determined by the purpose and structure of the surface (smooth, grainy) and physical properties (absorptive or non-absorptive) of the items where contact traces may occur. The list of types of such items is practically unlimited and may encompass anything the offender could have had contact with. Further presented were only these exhibits which in analysed opinions were submitted for examination more frequently than the ones, which posed problems in determining sequence of examinations or predicting their results.

a) Several patches of rugged structure can be found on the surfaces of **firearms**; although these places may frequently be touched during use of a weapon, the uneven surface does not facilitate generation of skin ridges impressions. Only in two out of 12 cases of firearms examination friction ridge impressions suitable for identification were found (on smooth surfaces such as grip lining and magazine). Generally, DNA analyses preceded fingerprint examination and positive results were obtained from 7 firearms (18 samples collected from rifled parts of weapons, mainly from grip lining, lock, hammer, safety lever, slide catch, trigger, etc.) The poorest results, both as regards fingerprint and DNA examinations, were obtained from small calibre ammunition and cartridge cases. These small exhibits of comparatively smooth surfaces were usually first examined for possible latent fingerprints and then for DNA traces, because recovery of biological material required swabbing the entire surface of a cartridge or a case. Fingerprint examinations of 62 cartridge cases and pistol cartridges included in the empirical analysis led to a positive result only in one case (cal. 9 mm *Lugger* cartridge). DNA analysis of traces coming from just one cartridge case (cal. 9 mm *Lugger* cartridge) barely led to, the so-called, a partial profile (11 out of 16 loci), while the preceding fingerprint examination led to a negative result. Traces left on cartridge cases are often degraded. Consequently, it can be concluded that due to the low effectiveness of the examinations discussed above small calibre cartridge cases and ammunition ought to be checked for fingerprints whereas DNA analysis should be only undertaken upon detecting sebaceous deposit during visualization.

b) **Zipper bags** and **plastic bags** were mainly submitted as evidence in drug related cases in order to identify a person or persons who had handled them. The analysed forensic opinions involved examinations of 103 zipper bags including 6 cases (5,8%) of positive fingerprint identifications and 11 cases (10,7%) of positive DNA identifications. It should be added that in

the vast majority of cases, DNA samples were collected regardless the detection of partial fingerprints unsuitable for identification. Out of 41 plastic bags, in 12 cases (29,3%) fingerprint examinations led to detecting marks suitable for identification of persons and DNA analyses proved successful only in one case (2,4%). Better results for DNA examination of zipper bags may be explained by the fact that a sufficient quantity of touch DNA for profiling is usually deposited. At the same time, their small size minimalises the risk of obtaining a mixture of DNA originating from more than one person. On the other hand, regular plastic bags have large and smooth surfaces, so there is a chance a criminal will leave legible fingerprints. Based on the above analysis it is possible to conclude that DNA analysis is more effective than fingerprint examination in case of zipper bags. In addition to that, fingerprint examination is not helpful in subsequent recovery of samples for genetic analysis because DNA examiners usually collect material from the entire surface of a bag and do not take into consideration the results of fingerprint examination. In case of larger exhibits, such as plastic bags, choosing fingerprint examination seems better founded. DNA examination might be carried out only in cases of partial fingerprint impressions not suitable for identification. One should be aware that collecting biological samples from the entire surface of a bag usually leads to obtaining profiles of two or more contributors.

- c) **Adhesive tapes** are used, among others, for restraining victims, wrapping packages containing drugs, or even securing home-made explosive devices (Maynard, Gates, Roux, Lennard, 2001). Literature of the subject reports many chemicals used in fingerprint examination for detecting and enhancing latent marks on adhesive tapes and there is not one all-purpose agent, because selection of the chemical depends on type of adhesive agent on a tape (Brzozowski, Białek, Subik, 2005). Opinions issued on 37 such exhibits were studied (in approx. 30% of cases). Positive results of fingerprint examinations were reached for 47 latent marks recovered from adhesive tapes, whilst DNA profiles were obtained only from 13 traces. This high diversity was related to the fact that there were two cases involving two a comparatively large number of latent marks suitable for identification (in one of the cases a fingerprint expert detected 30 good quality latent fingerprints on 17 zipper bags wrapped with adhesive tape and in the other 12 such marks were found on one drug package wrapped in foil). In the analysed cases all but one DNA analyses

were performed after fingerprint examinations performed most often with use of popular *Wet Powder* developing agent, which allows obtaining positive result of subsequent DNA analysis (Norlin *et al.*, 2013). Therefore a statement can be formulated that in case of traces on adhesive tapes both fingerprint and DNA examination lead to satisfactory results and do not exclude each other. However, it is advisable to suggest an appropriate way of proceeding with exhibits whose outer surface is wrapped with adhesive tape (such as drugs package); DNA sampling from such items should be done before unwrapping the tapes by a fingerprint examiner. This will improve the chance of reaching a positive result by curbing down the surface of collecting biological material and eliminating possible effect of fingerprint developing agents.

- d) In case of **plastic shopping bags** (typically obtained from shops) that have been on many occasions used for transporting narcotics or weapons, selection of spots for collecting biological samples is chiefly determined by the way of carrying, i.e. on the handles. During comprehensive fingerprint/DNA examinations of nine bags, DNA analyses of 3 samples collected from handles led to positive results (mixed profiles from two contributors were obtained from samples collected from two bags prior to fingerprint examination and one profile was obtained in the third case from a sample collected after fingerprint examination). In one case the positive result of DNA analysis was related, among others, to the fact that the fingerprint expert had pointed to detected partial skin ridges impressions. Three such marks were developed and examined. The above analysis and the review of investigative practice allow to conclude that plastic shopping bags are the exhibits where comprehensive fingerprint/DNA examinations are fully justified. Shopping bag handles, which are touched for longer periods of time ought to be examined first for the presence of DNA. Notably, plastic handles are distorted in such a way that there is no chance for depositing a clear skin ridge impressions. On the other hand, applying visualization techniques on the remaining surfaces of a bag can guide a DNA expert to other locations of touch DNA. Collection of samples for DNA analysis from the entire surface of a plastic bag creates a risk of obtaining mixed profiles.
- e) Traces on **bottles** or **cans** in many cases lead to identifying the person who drank from these containers and left his/her saliva on the bottle neck or the top of the can. Also it might be assumed that fingerprints left on remaining smooth surfaces of

bottle or can are easy for developing and further examination. Nevertheless, in a total number of 23 such exhibits positive results of fingerprint examinations were obtained only from two glass bottles and one beer can (13%). On the other hand, DNA examination led to positive results for 15 (65%) of such objects (eight bottles and seven cans). It should be emphasised however, that DNA profiles were obtained from samples recovered from bottle necks or the proximity of can openings. Vast majority of DNA analyses were carried out prior to fingerprint examination. Whenever fingerprint examination was carried out *a priori* DNA analyses of samples collected from smooth bottle neck or can surface, there was no positive result. Typically in those cases, mixtures of biological material unsuitable for identification, trace DNA or negative results were obtained. Such outcome of examinations could be explained either by the fact that more than one person had touched the bottles (mixtures) or that the trace did not contain sufficient quantity of DNA.

- f) In case of visualisation of **paper surfaces** (sheets of paper, envelopes, paper documents, newspapers, etc.) by various techniques it is possible to identify the locations where the paper (which has quite a huge surface in the context of DNA recovery) was touched. Without

prior fingerprint development phase a sample for DNA examination would have to be collected with a swab from the entire surface. This usually results in obtaining a multi-contributor mixture completely unsuitable for profiling. Detailed data about examination of paper substrate are, as follows:

- six of the analysed cases comprised exhibits such as: **paper sheets** and **envelopes** as well as **copy-books** (with a total number of 145 sheets); in four out of six cases fingerprint examinations were concluded with a positive result (detection of as many as 65 skin ridges impressions suitable for identification), while DNA analyses succeeded in one case where a biological sample had been recovered from a partial fingerprint. The unsatisfactory results of DNA analyses of samples collected from partial latent marks may be explained by a fact that paper substrate is absorptive and biological material well penetrates into the structure. Absorptive background, however, facilitates a good preservation of finger ridges impressions which contributes to good results of fingerprint examinations;
- in case of **banknotes** usually touched by many people, fingerprint examinations also proved more effective than DNA analyses.

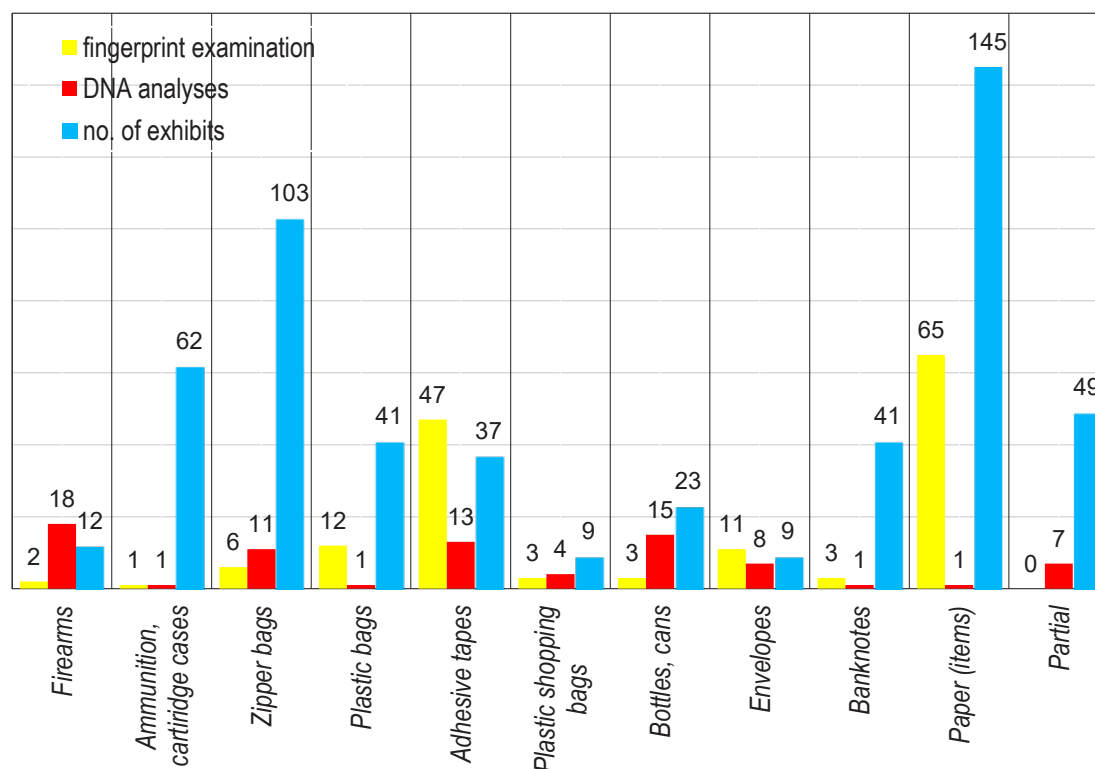


Fig. 3. The bar graph presenting the relationship between the number of exhibits and the number of traces enabling identification of an individual: skin ridges impressions (fingerprint examination)/ DNA samples (DNA analysis).

In the analysed cases, 41 banknotes were examined; in three cases (7,3%) fingerprint examinations led to positive results and DNA analyses yielded a positive result in only one case (2,4%), in which the expert obtained a mixture of DNA originating from at least two contributors;

- very good results of DNA analyses can be obtained by analysing samples collected from the reverse of **postal stamps** and **envelope flaps** (given the presence of saliva). Positive DNA identifications were obtained in six cases (66,7%) out of 9 envelopes with stamps submitted for examination. Additionally, samples were also collected from envelope flaps and positive analyses results were obtained in two cases. Despite a high percentage of identifications performed in this way, lack of results in the remaining cases may seem surprising. It might be explained by a growing level of awareness among criminals derived from TV who do their best to avoid leaving saliva traces on stamps and envelopes; hygienic concerns are also of significance.

The relationship between type of exhibits and the extent of forensic examination, as well as applied methods are presented in the bar graph (fig. 3).

III. Final conclusions

1. Based on the presented analyses of comprehensive fingerprint/DNA casework opinions issued by laboratories in Poland, forensic experts' experience and numerous scientific publications it can be assumed that DNA analysis is generally more effective than fingerprint examination. Since physical and chemical visualization means of fingerprints may cause diminishing the already low quantity of DNA contact traces (*touch DNA*), it is advisable to recover as many samples for DNA analysis as possible prior to carrying out fingerprint examination whilst taking into consideration type of exhibit and background of trace. On the other hand, collection of samples for DNA analysis on a swab prior to fingerprint examination causes irreversible removal of skin ridges impressions and prevents fingerprint identification.
2. At the same time, according to forensic practice it has been confirmed that for some exhibit and surface types fingerprint examination yields better results than DNA analysis. In addition to that, it has been found that initial detection and development of fingerprints does not exclude a possibility of subsequent performance of DNA analysis. DNA profiling is often possible even when the skin ridges impression has been treated with chemicals

used for visualization (approx. 30% effectiveness of DNA profiling of, so-called, touch DNA when performed after fingerprint examination).

3. The cooperation between DNA and fingerprint experts in the process of elaborating a comprehensive fingerprint/DNA casework opinion significantly improves making the effective use of fingermarks and touch DNA in the identification process.

Sources of figures: authors

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