Rapid DNA technologies at the crime scene
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Chapter 2

The Role of DNA in Finding an Offender

The DNA success story as an investigative tool in perspective

Abstract

Based on available statistics, it is not clear how DNA analysis contributes to identifying unknown suspects through a match in the DNA database. To form a picture of the effectiveness of forensic DNA analysis as an investigative tool, all forensic reports of serious crimes (N = 116) and high volume crimes (N = 2791) from the year 2011 at the Kennemerland police district were analysed. DNA profiling results show that for 38% of the traces that were secured for DNA analysis at scenes of serious crimes (N = 384) and for 17% of the traces secured at scenes of high volume crimes (N = 386), no DNA profile could be derived. The turnaround times of DNA traces from the crime scene to DNA report were relatively long: 66 days for serious crimes, and 44 days for high volume crimes. The analysed traces resulted in the identification of an unknown suspect through a match with the Offender DNA database in 3% of serious crime cases and 1% of high volume crime cases. This article argues that the role of DNA for intelligence purposes, to identify a suspect, can be increased by making more use of knowledge regarding the DNA success rates of traces and by further optimising the process of forensic DNA testing in the criminal justice system.

1This chapter is a combination of two comparable complementary articles. One article was published in Dutch as: Mapes A, Poot de C, Kloosterman A. De rol van DNA bij het vinden van een dader. Tijdschrift voor Criminologie, 2014:56(3), 29-46. The other article was published as: Mapes AA, Kloosterman AD, & Poot de CJ. DNA in the criminal justice system: the DNA success story in perspective. Journal of forensic sciences, 2014:60(4), 851-856. This study was designed, performed, analysed and published as an article by the first author. The co-authors advised on the set-up of the study and made suggestions and recommendations for the article.
2.1 Introduction

The use of DNA analysis in the process of criminal investigation and prosecution has grown tremendously in the past decade. This can be attributed to (amongst other things) the unique characteristics of DNA (1-4). Securing biological trace material at a crime scene can be crucial to the success of the criminal investigation and prosecution. DNA analyses of biological traces can contribute to a reconstruction of events and can play an important role in the prosecution of cases. However, DNA analysis can also be used to identify a person who was not previously a suspect. This happens when the DNA profile derived from secured biological traces is compared to profiles of known persons that are stored in the DNA database. The Dutch DNA database contains the DNA profiles of suspected and sentenced persons and of unidentified traces found at a crime scene. While there has been much attention for the role of DNA in the investigation and prosecution process, and for the status of DNA as evidence, not much is known about the role that DNA plays in the process of identifying an unknown suspect through a match in the DNA database. This study concentrates on the contribution of DNA for the intelligence process to identify unknown suspects, so not on the contribution of DNA analyses to the reconstruction of a crime or to the process of presenting evidence, prosecution and sentencing.

Both in the Netherlands and abroad, the national DNA database is seen as an efficient investigative tool (5-12). At the end of 2012, the Dutch DNA database for criminal cases contained 157,864 DNA profiles of individuals and 52,965 profiles of traces (13). In its annual report of early 2013, the Netherlands Forensic Institute (NFI), which manages the DNA database, reported that 50% of the crime traces that are compared to the profiles contained in the database result in a match with the profile of a person registered in the database (13). According to a study in England and Wales it comes to 59% of the submitted traces (8). However, the fact of a match between one or more traces secured at the crime scene with an individual in the DNA database does not mean necessarily that every trace will lead to identifying a yet unknown suspect.

In a study in 2012 it was attempted to clarify to what extent the DNA database contributes to the identification of unknown suspects, in their evaluation of the DNA Testing Convicted Persons Act (in Dutch: Wet DNA onderzoek bij veroordeelden) (11). They did so based on interviews and analyses of fifteen police files. Based on their analyses, they estimate that half of the cases where a trace turns up a match with a person in the DNA database actually results in the identification of an unknown suspect. However, their study still fails to clarify the exact role of the Dutch DNA database in identifying unknown suspects.

Based on the existing statistics, no answer can be offered to the question how often and in how many cases collected biological traces actually lead to the identification of an unknown suspect through a match in the DNA database, and hence what DNA
The Role of DNA in Finding an Offender

contributes to the intelligence phase of a criminal case. It also remains unclear whether and in what way the contribution of the DNA database to the intelligence process could be enhanced. The goal of the current study is to offer a realistic picture of the value of DNA in the intelligence process and of the possible ways of increasing this value.

The extent to which DNA research can play a role in the intelligence process depends on (amongst other things) 1) the quality of the DNA profile from the secured trace, 2) the turnaround time with which trace information can be used in the intelligence process, and 3) the chance that the DNA profile will turn up a match in the DNA database with a yet unknown suspect. This study sets out to examine these factors.

The quality of a trace is relevant to the probability that the trace will yield a suitable DNA profile with which to pursue the criminal investigation. Knowledge regarding the potential value of different types of traces can be used in the process of selecting traces to be submitted for DNA analysis to the laboratory. In theory, selecting the most promising traces will result in more suitable profile results and hence to more traces that are suitable for comparison with the DNA database. This can increase the number of ‘hits’ in the DNA database, which may lead to a previously unknown suspect – generally referred to as ‘cold DNA hits’.

The speed with which a profile can be used in the investigation and serve as intelligence is also important. If the turnaround time for the analysis of biological traces is long, then the obtained profile results may become irrelevant for the intelligence phase, as the suspect may have been identified through other and quicker investigative tools in the meantime.

Finally, the obtained profile must turn up a match with a profile stored in the DNA database. In most studies, the database’s contribution to the identification of unknown suspects, or the ‘cold DNA hits’, is measured from the perspective of individual DNA profiles that are compared with the DNA database. However, in any single case, generally multiple traces are secured and analysed. That is why this approach does not yield an unambiguous insight into the contribution of collected biological trace material to the identification of unknown suspects through a match in the DNA database. In this study we shall examine the contribution of the DNA database to the identification of individual offenders from the perspective of the criminal cases in which this biological trace material was secured and analysed.

By analysing DNA profiling results, turnaround times and database matches, we offer insight into the actual process of DNA based investigations, and into the possible means to improve this process.

In this study, biological traces are followed from the crime scene to the DNA report. The study focuses on police files of serious crimes and high volume crimes in which trace detection was performed by a Scene of Crime Officer (SoCO). In 2012, in one of the former Dutch police districts, the district of Kennemerland, all closed police files
were studied that forensics were involved with in 2011 and for which a SoCO was deployed to the crime scene to collect trace material.

*From crime scene to DNA report*
Biological traces, left at a crime scene, are generally secured by a SoCO from a police forensic department. The SoCO uses an indicative tetra base test to determine whether a blood-like trace actually is blood (14). Other indicative tests, for instance to determine saliva or sperm traces, are usually not performed by the SoCO (15). The secured traces are taken to the police forensic department, and subsequently one or several traces are selected for submission to a forensic laboratory for further analysis, under the authority of a public prosecutor. Most biological traces are submitted to the NFI for further DNA analysis, but traces can also be sent to other accredited forensic labs. At the laboratory, the trace is subjected to a strict protocol for DNA profiling and for the comparison of DNA profiles of traces and individuals stored in the DNA database. At the end of the process, a qualified DNA expert reports the analysis and comparison results.

Traces secured from High Volume Crime cases (HVC cases) follow a different route than traces secured from Serious Crime cases (SC cases). Biological trace material collected at a SC case is usually processed separately, while most of the biological traces collected in an HVC case are submitted to the laboratory for analysis in batches of 28 traces at a time. Only blood and saliva traces are accepted for this HVC route.

### 2.2 Material and Research Method

The selection of closed cases from the Kennemerland district for which a SoCO collected the trace material resulted in 2,907 police files, of which 116 pertained to serious crimes and 2,791 to high volume crimes. A further analysis of these cases was performed based on the forensic reports, including the DNA results that were returned by the forensic laboratory and the (tactical) information about the case that was stored in the police enforcement registration system, *Basisvoorziening Handhaving*, showed that in 243 cases at least one biological trace was secured that was submitted to a forensic laboratory for DNA analysis (see Figure 1). In 67 cases it concerned a serious crime. Specifically, these cases consisted of 29 armed robberies, 8 cases of arson, 8 sexual assaults cases, 5 shooting incidents, 3 stabbing incidents, 3 threats, 3 attempted homicides, 2 thefts with violence, 2 cases involving hard drugs trade, 2 cases of physical abuse, 1 murder and 1 found corpse of an unidentified person. 176 cases involved a high volume crime, specifically: 119 burglaries, 24 investigations into cannabis plantations, 12 attempted burglaries, 15 thefts, 4 cases of vandalism, and 2 cases of arson.
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For all of these 243 cases, the DNA profile results and the turnaround times for each trace that was submitted to a forensic laboratory for further analysis was mapped out. Next, we examined for each case to what extent the DNA analysis contributed to the identification of a previously unknown suspect through a match in the DNA database. The number of DNA typing characteristics analysed, generally known as DNA loci, depends on the DNA analysis system that is used. In the Netherlands, DNA profiles consist of 15 loci plus the sex-specific locus Amelogenin. Complete DNA profiles can always be added to and automatically compared with the profiles in the DNA database. It is also possible to compare an incomplete DNA profile (a profile that has not determined all the donor’s DNA characteristics of the cellular material) with the DNA database (14, 16). For automated comparison, the DNA profile of the crime stain should contain the typing results of at least 6 loci (17).

Although HVC cases follow a different route than SC cases, in 7 of the 176 HVC cases it turned out that another biological trace – other than saliva or blood – was significant (Fig. 1). This usually concerns important contact traces. In these cases, the HVC traces followed the SC route. On the other hand, in 8 SC cases traces were secured that followed the HVC route, because the traces were not complex and because the HVC route generally delivers results more quickly (Fig. 1).

To also gain insight into the route followed by traces that were secured in the selected cases, these two routes were analysed separately. In other words, we analysed the results
of the DNA analysis both from the perspective of the cases and from the perspective of the DNA traces from these cases that were submitted to the laboratory.

All in all, 384 DNA samples followed the SC route and 386 DNA samples followed the HVC route. For both routes the DNA profile results and the turnaround times were analysed separately. We furthermore examined per case whether the DNA profiles that met the criteria for comparison with the DNA database yielded a match with profiles in the DNA database and to what extent that match resulted in the identification of a previously unknown suspect.

### 2.2.1 DNA Results of the Individual Traces

*Following the traces in the SC route*

This study only looked at the standard DNA requests. This concerns requests for a DNA analysis that, in case of a suitable DNA profile as a result, can be used to perform a standard profile comparison with DNA profiles in the DNA database. This means that a number of requests for more specialised DNA analysis were not included in our analysis, such as mitochondrial DNA analysis, low copy number DNA analysis or DNA typing of hairs. In the SC route, the results of 384 samples for standard DNA analysis were analysed.

To map out the DNA profile results, all biological traces that were sent to a forensic laboratory for a standard DNA analysis were included in this study. For instance, the investigation at the scene of one of the shooting incidents mentioned above resulted in the collection of six exhibits that potentially contain DNA traces (specifically, three condom wrappings, one box of peppermints, one cartridge case and one sweater) and one sample of blood, found at the crime scene. Further, three reference samples (suspect, witness and victim) were collected. Five exhibits (three condom wrappings, one box of peppermints and one cartridge case), the blood sample and the three reference samples were sent to the laboratory for DNA analysis. At the laboratory, five DNA samples were secured from the five exhibits. The analysis of these samples of the five exhibits and the blood sample resulted in two complete DNA profiles (of which one matched with the victim and one with the witness) and three mixed DNA profiles (of which one matched with the suspect and one with an unknown male). One sample did not yield a DNA profile.

To calculate the turnaround times, the timeframe of each step in the process, from the crime scene to the DNA report, was analysed. For example, the turnaround time in one of the shooting incidents demonstrates a period of six days from the moment that biological traces were secured at the crime scene to the moment of preparing the DNA requests by the SoCO and six days for the authorisation of the DNA requests by the public prosecutor to perform a standard DNA analysis on these traces. Then, seven days passed until the forensic laboratory received the traces and the authorisation for DNA
analysis. The DNA profiling process at the forensic institute had a turnaround time of 68 days. This example shows an overall turnaround time of 87 days from the crime scene to the DNA report.

Following traces within the HVC route
Crime scene investigation focused on solving high volume crimes primarily concentrates on finding DNA traces such as cigarette ends, blood and saliva stains. These traces are sampled by the SoCO at the crime scene or in a police research laboratory. To analyse such samples, the forensic laboratory uses an automated DNA analysis system. The samples are analysed in batches of 28, and the results are likewise reported per batch. DNA profiles that meet the criteria will be uploaded to the DNA database and are compared with the profiles of the national DNA database. The entire process of the HVC route is strictly regulated. The turnaround times from securing the evidence at the crime scene until the receipt of the trace batches by the forensic laboratory, and from the receipt of the trace batches until the profiling of the traces and the writing of a report per batch, are also prescribed. The results of the 386 DNA samples that followed the HVC route were analysed in the same way as described above for the SC route.

DNA results from the perspective of the case
From the 243 cases (67 SC cases and 176 HVC cases) in which biological traces were sent to a forensic laboratory for analysis, we analysed how often the DNA analysis resulted in a DNA profile and how often these results enabled the successful identification of a suspect. This offers insights into, amongst other things, the number of cases in which an analysed DNA profile leads to a suspect via a match in the DNA database. DNA matches with reference samples of victims or witnesses were not included in this study.

2.3 Results

2.3.1 Profile Results of DNA Traces

SC route
Within the SC route, 384 analysed DNA samples were analysed. The traces that were submitted for DNA analysis mainly concern contact traces (83%). The other traces were from sexual assault (6%), blood (5%), saliva (4%), cigarette ends (0.5%) and nail scrapings (0.5%). Our analyses show that in 38% of all analysed traces (146/384), these DNA analyses did not result in DNA typing information, and that 8% of the DNA analyses (29/384 traces) resulted in a profile that did not meet the criteria to enable comparisons. Looking at these ‘untypable’ traces, it turns out that more than 90% concerns contact traces. See Table 1 for an overview of these results.
Table 1. DNA Profile Results of Traces Analysed in the Serious Crime Route

<table>
<thead>
<tr>
<th>Profile results</th>
<th>SC Traces</th>
<th>Total</th>
<th>Saliva</th>
<th>Contact</th>
<th>Blood</th>
<th>Sexual Related</th>
<th>Cigarette End</th>
<th>Nail Scrapings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complete</td>
<td>94</td>
<td>3</td>
<td>58</td>
<td>15</td>
<td>14</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Incomplete</td>
<td>25</td>
<td>0</td>
<td>22</td>
<td>–</td>
<td>3</td>
<td>–</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Mixed</td>
<td>79</td>
<td>5</td>
<td>67</td>
<td>–</td>
<td>7</td>
<td>–</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Incomplete mixed</td>
<td>11</td>
<td>0</td>
<td>10</td>
<td>1</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>No profile</td>
<td>146</td>
<td>9</td>
<td>132</td>
<td>5</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Unsuitable</td>
<td>29</td>
<td>0</td>
<td>29</td>
<td>0</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>384</td>
<td>17</td>
<td>318</td>
<td>21</td>
<td>24</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

Table 2. DNA Profile Results of Traces Analysed in the HVC Route

<table>
<thead>
<tr>
<th>Profile Results</th>
<th>HVC traces</th>
<th>Total</th>
<th>Saliva Swab</th>
<th>Cigarette End</th>
<th>Blood Swab</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complete</td>
<td>242</td>
<td>59</td>
<td>99</td>
<td>84</td>
<td></td>
</tr>
<tr>
<td>Mixed</td>
<td>6</td>
<td>2</td>
<td>3*</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>No profile</td>
<td>64</td>
<td>55</td>
<td>2</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Unsuitable</td>
<td>74</td>
<td>51</td>
<td>12</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>386</td>
<td>167</td>
<td>116</td>
<td>103</td>
<td></td>
</tr>
</tbody>
</table>

*One mixed profile can only be compare manually.

HVC route

A total of 386 DNA traces were analysed within the HVC route. These traces consisted of saliva samples (43%), cigarette ends (30%) and blood samples (27%). Our analyses show that for 17% of the submitted HVC traces (64/386), the DNA analysis did not result in a DNA profile. For 19% of the submitted HVC traces (74/386) the DNA analysis yielded a profile that did not meet the criteria to enable comparisons. As Table 2 shows, it is mainly saliva samples, not derived from a cigarette end, that often fail to yield a suitable DNA profile for comparison. The chance that cigarette ends and blood samples yield a suitable DNA profile is much higher than the chance that saliva samples, found in other places than on a cigarette end, will yield a suitable DNA profile.

2.3.2 Turnaround Times for DNA Traces

SC route

In the year 2011, 84 DNA requests pertaining to 66 SC cases were submitted to the forensic laboratory by the Kennemerland police district. Eighteen of these requests concerned follow-up requests pertaining to 13 cases. These follow-up requests were only made later in the investigation process and have therefore been analysed separately in this study, in order to obtain a clear picture of the turnaround times from the crime scene to the DNA report. Table 3 gives an overview of the length of turnaround times from the crime scene to the DNA report.
Table 2. DNA Profile Results of Traces Analysed in the HVC Route

<table>
<thead>
<tr>
<th>Profile Results</th>
<th>HVC traces</th>
<th>Total Saliva</th>
<th>Swab Cigarette End</th>
<th>Blood Swab</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complete</td>
<td>242</td>
<td>59</td>
<td>99</td>
<td>84</td>
</tr>
<tr>
<td>Mixed</td>
<td>6</td>
<td>2</td>
<td>3*</td>
<td>1</td>
</tr>
<tr>
<td>No profile</td>
<td>64</td>
<td>55</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>Unsuitable</td>
<td>74</td>
<td>51</td>
<td>12</td>
<td>11</td>
</tr>
<tr>
<td>Total</td>
<td>386</td>
<td>167</td>
<td>116</td>
<td>103</td>
</tr>
</tbody>
</table>

*One mixed profile can only be compared manually.

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Table 3. Turnaround Times of the Traces from the 66 initial DNA Requests Analysed in the Serious Crime Route, in Days

<table>
<thead>
<tr>
<th>Turnaround Time (Days) SC Cases</th>
<th>SC Traces</th>
<th>DNA Profile Results</th>
<th>DNA Request – Authorisation</th>
<th>Public Prosecutor – Received at Forensic Lab</th>
<th>Crime Scene – Forensic Lab (Total)</th>
<th>Forensic Lab – DNA Report</th>
<th>Crime Scene – DNA Report (Total)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median</td>
<td>28</td>
<td>1</td>
<td>6</td>
<td>41</td>
<td>19</td>
<td>66</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>43</td>
<td>5</td>
<td>8</td>
<td>53</td>
<td>26</td>
<td>79</td>
<td></td>
</tr>
<tr>
<td>Min</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Max</td>
<td>184</td>
<td>122</td>
<td>61</td>
<td>189</td>
<td>133</td>
<td>201</td>
<td></td>
</tr>
</tbody>
</table>

Since the mean length of the turnaround times is strongly influenced by a few number of outliers, we decided to give the median values to allow for meaningful comparisons. For biological traces submitted in the SC route, the full turnaround time from crime scene to DNA report has an ‘average’ length of 66 days.

HVC route

In the HVC route, the analysis and reporting process is strictly regulated and the turnaround times are less affected by the specific features of a case. We also analysed the turnaround times per trace here, and there were some outliers. For this reason, again, we chose to measure median values. The biological traces are stored by the SoCOs for about 24 days before they are sent to the laboratory. The analysis process and releasing the DNA report requires an ‘average’ period of 21 days. The total turnaround time for the traces analysed in the HVC cases comes to a median period of 44 days, including a DNA analysis process of 21 days. See Table 4 for an overview of these results.

Table 4. Turnaround Times of the Traces Analysed in the High Volume Crime route, in Days

<table>
<thead>
<tr>
<th>Turnaround Time (Days) HVC Cases</th>
<th>Crime Scene – DNA Request</th>
<th>Crime Scene – DNA Request (Total)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median</td>
<td>24</td>
<td>44</td>
</tr>
<tr>
<td>Mean</td>
<td>34</td>
<td>55</td>
</tr>
<tr>
<td>Min</td>
<td>0</td>
<td>21</td>
</tr>
<tr>
<td>Max</td>
<td>278</td>
<td>298</td>
</tr>
</tbody>
</table>

The total turnaround time from the samples of the follow-up request (N = 18) took a median period of 115 days (including a DNA analysis period of 35 days).

2.3.3 DNA Results from the Perspective of the Case

This study also examines how often biological traces lead to the identification of a suspect from the perspective of the case. To this end we analysed the results of DNA profile comparisons between collected traces and the DNA profiles of individuals. This concerns both profile comparisons with previously identified suspects from whom a reference sample is sent to the laboratory, and profile comparisons with individuals whose DNA profiles are contained in the DNA database. For the HVC cases, the
assumption is that the trace submitted for a profile comparison potentially concerns an offender’s trace. For SC cases, traces are also compared with the DNA profiles of victims or witnesses. These profile comparisons are not considered in this study.

**Serious crimes**

In 2011, the SoCOs of the Kennemerland police district investigated 116 serious crimes. In 58% of these cases (67/116), DNA trace evidence was secured which were subsequently analysed by the forensic laboratory. Figure 2 presents the results of these DNA analyses.

In 79% of these cases (53/67) there was at least one DNA trace that resulted in DNA typing results. In the remainder of cases, the DNA traces that were secured did not result in DNA typing results. In 21% of these cases (11/53), one or more DNA profiles were obtained (totalling 34 DNA profiles) that resulted in a match with a profile in the DNA database. These DNA database comparisons led to the identification of 12 suspects (in

![Diagram](image)

*Figure 2. DNA Analysis in Serious Crime Cases
one case, the DNA profiles led to a match with 2 suspects). In 4 cases, these DNA database matches turned up a ‘cold DNA hit’, enabling the identification of a previously unknown suspect. In 3 cases the matching person in the DNA database had already been identified ‘tactically’ before the database match emerged. In the other 4 cases, the suspect had already been taken into custody before the DNA database match was reported. These last 4 cases involved caught-in-the-act cases, and the profile of the suspect turned out to already be contained in the DNA database for convicted criminals. The 4 cases that yielded a match with the DNA database and where this match actually resulted in the identification of a previously unknown suspect had a turnaround time of 41, 42, 118 and 176 days from the crime scene to the DNA report.

High volume crimes
In 2011, the SoCOs of the Kennemerland police district performed forensic investigation in 2,791 cases of high volume crimes. In 6% of these cases (176/2,791),

![DNA Analysis in High Volume Crime Cases](image-url)
DNA traces were secured that were subsequently analysed by the forensic laboratory. See Figure 3 for the results of these DNA analyses. In 36% of these HVC cases (63/176), not one secured DNA trace resulted in DNA typing results. In 64% of the cases (113/176), the secured DNA evidence resulted in at least one DNA typing result. In 18 of these cases, at least one trace matched another crime sample in the DNA database not yet associated with an individual; these could result in an identification in the future. In 35% (39/113) of the HVC cases with at least one suitable DNA profile, where 96 DNA profiles were generated in total, a suspect was identified through a match between the trace and an individual in the DNA database. This led to the identification of 37 suspects. In most of the cases with multiple traces there were internal matches, resulting in one match with a suspect in the DNA database. Further, in one case two different DNA profiles were found that resulted in the identification of two suspects. Finally, there was a case in which three different DNA profiles were generated, resulting in the identification of three suspects.

In six cases that resulted in a match with the DNA database, the suspect had already been identified through ‘tactical’ investigation. In eight cases, the suspect was caught-in-the-act. The remaining 25 cases with matches with the DNA database were actual ‘cold DNA hits’, so that the suspect could be identified based on this match with the database.

2.4 Conclusions and Discussion

Based on this study, we may conclude that many traces ultimately did not result in a DNA profile. Of the traces that followed the SC route, 38% did not yield a DNA profile; of the traces in the HVC route, this applies for 17%. The fact that HVC traces are more likely to yield a DNA profile than SC traces can probably be attributed to the fact that the HVC batches did not include contact traces. The vast majority of traces analysed in the SC route are contact traces (83%). Of these contact traces, 42% failed to yield a DNA profile. In the HVC route, the DNA analysis did not yield a DNA profile for 33% of the saliva traces, 2% of the cigarette ends, and 7% of the blood traces. The chance that a DNA profile can be derived from saliva traces, not taken from a cigarette end, is relatively small. This has also been shown in other studies (18, 19), and is probably due to the fact that saliva traces, like contact traces, are so-called ‘invisible traces’. This implies that the SoCO, in order to obtain such traces, must sample places where (saliva) contact is likely to have occurred. However, the SoCO is never certain that (saliva) contact actually occurred in the place sampled.

The foregoing results provide some insight into the likelihood that sampled traces will yield a DNA profile, the DNA success rate. This appears to depend on the type of trace. The SoCO can make better decisions based on DNA success rate knowledge as to which traces should or should not be submitted for further DNA analysis. The most promising
traces can be prioritised and selected for further research, increasing the potential contribution of these traces to the further investigative process. It therefore seems worthwhile having a scientifically evidence-based decision-making model for the selection of DNA traces for analysis by making proper use of DNA typing information. This study is a first step towards developing such a model. This model is currently being elaborated in a research project that works with a greater variety of trace exhibits that went for DNA analysis.

The turnaround times from the crime scene to the reporting of the DNA analysis results to the police team are relatively long. Traces are kept at the police bureau for a long time before being forwarded to a forensic laboratory, and the forensic analysis also takes a relatively long time to complete. A turnaround time of 66 days on average for serious crimes and 44 days for high volume crimes can mean that DNA analysis is less suitable for intelligence purposes, to identify a suspect, than it could be in theory. Although we were unable, in this study, to determine whether any communication with the forensic laboratory on the analysis results occurred in the interim, so before these results were reported in writing, there still appears to be a turnaround time of 41 days before a DNA trace secured at the scene of a serious crime is received by a forensic laboratory for further analysis. An acceleration of the entire DNA analysis process, both at the police and at the forensic laboratory, seems essential to making better use of DNA for the investigative process. Improving the prioritisation process – as discussed in the previous section – is also likely to benefit the turnaround times, as it can accelerate the decision-making on the selection of traces for further analysis.

Relatively few unknown suspects were actually identified through analysis of DNA evidence. The results of our analyses show that a DNA database match was reported for 11 of the 116 serious crimes and for 39 of the 2,791 high volume crimes. For four serious crimes (with turnaround times of 41, 42, 118 and 176 days) and 25 high volume crimes (with an average turnaround time of 48 days), this DNA database match actually resulted in the identification of a yet unknown suspect. The long time that elapses before the results of this investigative tool can be used is striking. For three SC cases and six HVC cases, the report on the DNA database match only came in after the suspect had been identified through other, tactical investigative methods. Although this match proved obsolete in terms of using DNA as a means of identifying an unknown suspect, it could of course serve as evidence in court. These obtained matches are registered in the DNA database, but no distinction is made between actual ‘cold DNA hits’ that result in the identification of unknown suspects, and hits that actually lead to a match with a suspect identified previously. This also applies for the matches for suspects caught-in-act who were (therefore) already known from the start of the investigation.

The research results show that in cases with a forensic crime scene investigation just 58% of the SC cases (67/116) and in 6% (176/2,791) of the HVC cases DNA traces are secured and analysed. In a U.S. DNA field experiment on property crimes conducted in
analyses from the perspective of an individual case and of an individual trace. This plays in police investigations into perspective, by considering the results of the DNA

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match in the DNA database. The annual report of the Dutch DNA database concludes

of DNA crime traces resulted in a match with a person in the national DNA database (13). This result is based on the DNA profiles of traces that meet the quality criteria required to be included in the DNA database and to be compared with other traces. The annual report furthermore states that the greater the number of DNA profiles stored in a DNA database, the greater the chances of finding a match.

Unfortunately, the report offers no information about the number of cases in which the DNA match actually resulted in the identification of a previously unknown suspect. However, It is very important for professionals in the criminal justice chain who need to make choices and who need to deploy their scarce resources efficiently to have insight into these figures. After all, the main goal of the DNA database is to solve criminal cases, not to match profiles.

Similar studies on the application of DNA technology in England and Wales (20) also only report on the profiles that were uploaded in the database. Here, a 39% probability of obtaining a match between a crime scene profile and a profile in their national DNA database (resulting in 21,000 cold hits in 2002–2003) is reported. These 21,000 cold hits actually relate to 998,000 attended crime scenes in that year. This comes down to a success rate of 2.1% when the DNA typing and database process are regarded in case perspective. The number of 2.1% corresponds with the results of our study. It is stated that this "attrition process" (21) actually resulted in 1% searchable DNA profiles from all recorded crimes in that year and demonstrates the real efficiency of the use of DNA to actually identify a suspect in a criminal investigation. It is not clear whether the reported 21,000 hits were actual cold hits or that suspects were already identified through other forensic or investigative disciplines or that there are multiple hits within in the same case.

In this article we have sought to put the success story of the role that DNA currently plays in police investigations into perspective, by considering the results of the DNA analyses from the perspective of an individual case and of an individual trace. This
reveals that the role of DNA in the identification of suspects is not as great as might be expected on theoretical grounds. On the one hand, this can be attributed to the fact that a considerable amount of trace material is analysed that contains too little DNA material to yield a DNA profile, and to the long turnaround times on the other hand. Adjustments to the DNA analysis process but also new techniques could help mitigate both problems in the future, leading to a greater role for DNA analysis in the investigative process. This study offers the SoCOs more knowledge with respect to DNA success rates and creates awareness on the potential of trace DNA in the criminal investigations. This study does not claim that DNA traces cannot meaningfully contribute to the investigative process or to the presentation of evidence. But it does provide the criminal justice system with the true story of DNA analysis.

Future perspectives of DNA analysis
DNA success rates, turnaround times, and the use of DNA results during the intelligence phase of the criminal investigation, can potentially be improved in the future by real-time DNA analysis at the crime scene. A tool currently being developed in the Netherlands and internationally is a DNA presumptive test (22-24) with which to determine whether a trace contains sufficient DNA material to yield a DNA profile. As our research shows, presumed biological traces are secured from the crime scene without the SoCOs knowing whether the traces contain sufficient human DNA to enable a DNA profile. It is expected that the future availability of a fast, accurate, and sensitive presumptive DNA test at the crime scene or the police forensic department will lead to a better selection and prioritisation of traces for DNA analysis. It means that less time and energy will be spent on traces that contain too little DNA material or none at all, and will also encourage SoCOs to continue their efforts in localising additional stains that have a more promising potential. It also will relieve the DNA profiling process at the forensic laboratory from putting effort in analysing samples that contain insufficient DNA, thereby reducing the number of traces that undergo unnecessary the complete DNA analysis processes. It is likely that this will increase the role that DNA can play in the identification of an unknown suspect. The available capacity to perform DNA analysis can also be used more effectively.

Several manufacturers in various places are also working on the development of fully integrated instruments for the analysis of DNA samples at the crime scene. These tools will enable SoCOs to generate DNA profiles from traces directly at the crime scene (25-33). Most of these systems are able to derive a DNA profile from a DNA sample within two hours, which can then be compared to profiles stored in a DNA database. The HVC traces are likely to benefit most from these technologies. HVC traces mainly consist of saliva and blood traces, with high potential for yielding informative DNA profiles. A pre-selection of these traces based on the amount of DNA present in the trace will influence the role that the trace can play in the investigation process. The majority
of traces secured for serious crimes consist of less promising contact traces, however. These traces need to be treated with more care and require more advanced DNA technologies. For the near future, it is therefore expected that the SoCOs at the crime scene will be able to analyse the more promising high-template DNA traces. This will give the forensic laboratories more scope to concentrate on the analysis of minimal and more challenging DNA traces or trace exhibits.

Before altering existing regulations on the integration of new and mobile technologies, it is necessary to get a clear and complete understanding of the present-day existing procedures in the forensic (crime scene) investigation procedures. Knowledge on the DNA success rates of biological traces in their potential to allow for fast mobile analysis or need the expertise from a fully equipped forensic DNA typing laboratory is essential for the justification of a selection process.

Which technologies will be used in the future, how these technologies will influence the investigation process, and what risks these developments pose, remains an open question. That such technologies will be implemented in the future seems clear, however. SoCOs must deal with these new opportunities, and therefore, evidence-based protocols must be established for future crime scene work. Current research is toward creating a safe, correct, and bias-free environment for the integration of a faster DNA analysis process in the criminal justice system. The way forward will inevitably bring more science to the crime scene.

2.5 References

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