

## Familial DNA: a relative success?

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### **Abstract**

This article explains the principles of familial DNA searching and how SIOs can benefit from early consideration of this technique in major crime investigations. It also seeks to dispel the myths surrounding familial DNA investigations by providing a factual summary of both success rates and the routes to success. The authors include a case study where an enhanced prioritisation methodology led to the detection of two linked abductions of young children.

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## **1 History and principles**

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Familial DNA searching is a tactic which often splits the investigative community. Some have tried it and have been unsuccessful and others talk of vast expense for no result. Some describe it as a last resort, or a fishing expedition. The reality is that across the UK since 2003, familial DNA searching has to date been directly responsible for the detection of over 80 of the most serious of offences and we are the envy of the forensic DNA world.

This tactic is available to SIOs in serious crimes where there is a DNA profile attributable to the offender but the offender's DNA is not on the National DNA Database (NDNAD).

The tactic works because DNA is inherited from our parents, half from each. Siblings inherit their DNA from the same two parents and so generally we share more DNA with our siblings than with unrelated strangers. This means that if a parent, child or sibling is on the NDNAD, it may be possible to identify the source of a DNA sample through them.

Familial DNA searching for investigative purposes provides the SIO and the investigation team with two lists of nominals. One list comprises persons who could be either the parent or the child of the unknown offender and all these persons will share half of their DNA with the offender. The other list is made up of persons who could be a sibling of the offender and these persons will share more than an average amount of DNA with the unknown offender.

Within the UK, familial DNA searching became a viable investigative tactic in 2003 when both the Forensic Science Service and Orchid Cellmark developed computerised systems for performing the search of the NDNAD. Prior to 2003, some familial searches had taken place but they were done manually, could only reveal a limited number of potential parents or children of the unknown offender selected from a limited subset of the National database, usually those persons swabbed within the force where the crime occurred. Nonetheless, there was

some success as with Operation Magnum in South Wales where, in 2001 Joseph Kappan was identified as the killer of three women in the early 1970s.

However, in 2003 the process became automated and this provided the opportunity to not only search the whole of the NDNAD but also to identify lists of potential siblings in addition to potential parents and children.

Since 2003, the tactic has developed and been refined from what was originally a somewhat broad brush approach with the DNA similarities being the overriding factor in the search for relatives to what is now a much more focused and streamlined approach which targets only the relatively few nominals most likely to be related to the offender.

## **2 Does it work?**

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Everyone will have their own measure of acceptable success rates but here are the statistics for the UK 2003-2011.

To date, over 200 investigations have commissioned a familial search of the NDNAD. Forty four offenders have been identified as a direct result of those searches. The success rate in these terms is approximately 20%. Of the 44 offenders identified to date;

6	Deceased at the time of identification
38	Prosecuted
35	Convicted
1	Acquitted (a rape case involving consent issues)
2	Sub judice

Many of the 44 offenders committed multiple offences and so the total number of crimes which have been detected as a direct result of familial DNA searching is 83. These are:

15	Murders
52	Rapes
4	Offences relating to child abandonment
2	Abductions
7	Armed robberies
1	GBH
1	Burglary
1	Concealment of birth

These facts often come as a surprise to those who have questioned the use of familial DNA searching as a viable tactic. Many of the ethical and political concerns about it seemed to diminish following a Parliamentary question by David Davies MP when these success rates were revealed publicly for the first time (Hansard 2010).

From an SIOs point of view, the technique can be considered to be highly efficient at identifying parents, children or siblings who are on the NDNAD. Early indications from research being carried out by the authors suggests that where a familial search is negative but the case is later detected in others ways, it is very rare for a parent, child or sibling to have been on the NDNAD at the time of the familial search. Put another way, the current evidence suggests that SIOs can be confident that if a relative is on the database, a familial search is likely to find them.

### **3 History of methodologies**

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From 2003 until 2007 familial DNA searching utilised a method known as the 'allele count' method. This method looked purely at how much DNA potential siblings shared and ranked them accordingly. Potential parents and children all shared half of their DNA with the offender and were of equal ranking. It was

therefore difficult to know where to start with the parent/child list. Since 2007 a different method has been utilised known as likelihood ratio. This system looks not only at how much DNA is shared with the offender but how common the pieces of shared DNA are within the population, thus raising nominals who share rare DNA components with the offender towards the top of the list.

The question of whether 'likelihood ratio' is an improvement on 'allele counting' has been debated and there is now academic research (Hicks et al) to show that it is, but more importantly, the success rate has improved since its introduction. It is also true that likelihood ratio is used elsewhere in the world by countries seeking to develop a familial DNA search capability although it should be noted that many of these have taken good practice from the UK.

#### **4     How do you make it work for you?**

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The most important question when discussing familial DNA searching is: "How do I achieve success?"

The first thing to say is that on occasions, the DNA will do it for you on the day you run the search. Six of the 44 offenders referred to above were the MOST genetically similar to the offender and appeared at the top of the list. When conducting a familial DNA search you examine the whole of the national database. Therefore, persons sharing DNA with the offender can come from any part of the UK. When you run a search and the person most similar also comes from the town where the crime was committed you are entitled to get excited. If you are lucky enough to have this situation your familial DNA search will potentially solve your crime very quickly because the relative leaps off the page at you.

More often though, there will not be an obvious relative and you will have to prioritise the lists. Genetics are the keystone to doing this, but they are not the only consideration. You are looking for a relative of the offender. You know where the crime was committed. In basic statistical terms if two people live 150 miles away from each other, are they less likely to be related than two people

living 10 miles apart? Yes they are (Champion, 2005). Similarly, if two people are born 15 years apart are they less likely to be siblings than two people born 2 years apart? Yes they are (National Statistics, 2004). So we make use of this. It is of course possible that someone could live 150 miles away from a sibling who is 15 years younger than themselves. But this tactic is not about finding the impossible, it's about finding the offender because their sibling or parent or child is on the NDNAD, is the right age to be their relative and lives reasonably near to crime scene as a result of that family cluster. In those cases, familial DNA can identify the offender.

So, both geography and age are utilised to supplement the original genetic based lists. The most advanced methodology for utilising genetics, age and geography together is the NPJA system described by Gregory and Rainbow (Journal of Homicide and Major Incident Investigation Vol. 7, Issue, 1). It is important to recognise that the location recorded on the NDNAD is where the individual was swabbed. The PNC contains more geographic data and the case study within this paper highlights the value of using that additional information.

## **5 Once the genetic lists are re-prioritised using geography and age what do you do next?**

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In most cases seeking to utilise familial DNA searching, the offender is male and so it may be possible to obtain a Y-STR DNA profile from the crime scene stain. The Y-STR profile is generally inherited unaltered from father to son. Thus, if a male appears on the familial lists as a possible parent, child or sibling of the offender, he, together with his biological father, his sons and his siblings, can be eliminated if his Y-STR does not match that of the offender. This method is commonly used to scientifically and in a very cost effective manner eliminate, or hopefully highlight families of interest. Where the nominal on the list is female and the Y-STR tactic is therefore unavailable, or a male nominal matches the crime scene Y-STR, further research of that individual is required.

The debate around online research of family trees and histories has continued since 2003. Experience to date has shown that online enquiries or covert

enquiries with births, deaths and marriages are not 100% reliable and it is often necessary, in the end, to visit the nominal on the results list to properly establish their family tree. These persons are then visited and voluntary swabbed. The circumstances in Operation Elegant described below, whilst highlighting the point about the unreliability of covert research, also lent themselves to an overall covert strategy. Each case is different and the SIO will need to consider the best approach for their investigation.

## **6 How many nominal do you need to research?**

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When familial DNA searching was first considered as a tactic we had no idea how far down the lists it would be necessary to look in order to find the offender's relative. Now, eight years on and over 200 investigations later, we have a very good idea. The combinations of potential prioritisation factors change from investigation to investigation but as a guide, all but 2 of the 48 relatives identified to date were within the top 30 of a list **prioritised** by the application of geography and age alongside the original genetic ranking. This means that, although the list of potential relatives first produced by the familial search may be large, the prioritised list is much more manageable.

This knowledge allows us to dispel one of the biggest myths and often the most inhibiting factor around commissioning a familial DNA search, i.e. that the SIO will be committed to researching and funding DNA analysis for potentially hundreds of nominals. Further research is being conducted by the authors of this paper which will provide SIOs with further empirical based advice regarding the most cost effective and value for money use of familial DNA searching.

## **7 When do you consider using a familial DNA search?**

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This is a much debated question. It is often seen as a 'last resort' tactic to be kept back until all other lines of investigation are exhausted. Yet, some SIOs have used the tactic early in an investigation and achieved a quick resolution to the investigation as a result. In May 2010 a 10 year old girl was abducted and

raped in Lancashire. DNA was obtained which related to the offender and he was not on the NDNAD. The SIO commissioned a familial DNA search almost immediately and after some fast track prioritisation of the results lists by the NPIA and excellent work by the investigation team the offender was identified within a couple of weeks. He was not immediately local to the area (although he did have a previous address there). He may otherwise have remained at large for a considerable period of time, potentially committing further serious offences. The use of the tactic in this case also demonstrates the sometimes unseen value for money aspect of using familial DNA searching at an early stage.

## **8 Golden rules**

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There are some rules to consider when embarking upon a familial DNA search:

*Golden Rule 1: If the offender does not have a relative on the NDNAD this will NOT work.*

This is a frustrating situation to be aware of and to be in because you never find out whether the offender has a relative on the database until you catch him or her and of course, there is absolutely nothing you can do to influence it. There has been consideration in the past to researching which type of offenders are likely to have a relative on the database, for example is a burglar more likely to be from a criminal family than a rapist?

Instinctively police officers may answer a hesitant yes to this question, but the research is not there to confirm or refute this theory and in any event, there are a number of relatives who have been identified and led to the identification of the offender for a serious crime who were loaded to the database for relatively minor offences such as public order or possess cannabis or for offences not obviously connected with a criminal family such as driving over the prescribed limit. This tends to suggest that this consideration should not influence the decision about whether to use familial DNA searching or not.

*Golden Rule 2: Everybody on the results lists definitely did not do it.*

This may seem obvious but it's easy to forget at times as many who have pored over the results lists and studied the names looking for a flicker of recognition will testify. Remember, the results lists comprise persons with half the DNA of the offender (parent/child) or those who share more than the average amount of DNA with the offender (siblings).

*Golden Rule 3: You cannot be the same age as your parents or children.*

The age of potential relatives of an unknown offender is referred to within this paper as a relevant factor when prioritising the familial search results lists. The absolute importance and use of this is highlighted in cases where there is a reliable indication of the offender's approximate age. For example, if you are investigating a rapist who is believed to be in his 20s, persons who are genetically very similar and therefore appear capable of being his parents or children but are 25 years of age are actually very UNLIKELY to be related.

*Golden Rule 4: The investigation team need to take time to understand the science and what the search results lists are giving them.*

This can be a complex tactic at first sight and it's easy to lose the understanding of how the lists were compiled initially and also what the best method of using the lists should be. Advice is available from both your Forensic Service Provider (FSP) and the NPIA Crime Operations Support (COS) and you should seek their expertise.

The following case study demonstrates how the theory and practical advice described above led to the detection of two attacks on children.

## **9 Background and initial investigation**

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One evening in December 1999, fifteen year old 'Clare' was walking along a main road near to an exit slip road from the M62 motorway in North Manchester. The driver of a white box van stopped on the pretext of asking for directions. He forced her into the rear of the van, where he tied her hands behind her back and bound her feet using a ratchet-type strap. He then drove off, stopping to refuel the vehicle, before continuing his journey. A short time later, he stopped the van, climbed into the rear, undressed Clare and forced her to perform oral sex on him before anally raping her.

Following the attack, Clare was driven to Salford, west of Manchester, where she was released and was able to report the incident to the police. After a medical and forensic examination, she provided a description of the offender and his van. Subsequent forensic examination of crime scene samples revealed the offender's full DNA profile. However this did not produce a match on the DNA database.

A second offence occurred three months later on a Wednesday evening in March 2000. On this occasion, the driver of a white box van stopped his vehicle on a main road in east Manchester, purportedly to ask a twelve year old girl, 'Gemma', for directions to a local bread factory. The driver forced Gemma into the cab of the vehicle and drove off. He stopped briefly to place tape around her eyes and mouth, then continued his journey until he parked the van, placed his young victim into the rear, undressed her then indecently assaulted her and attempted to rape her. Following her ordeal, Gemma was placed into a car and the offender released her about a mile away from the abduction site.

Investigating officers immediately suspected that the cases may be linked, by modus operandi, description of vehicle and of the offender, and this was confirmed when a full DNA profile developed from samples taken from Gemma matched the offender from the earlier attack.

Despite this breakthrough and extensive enquiries managed through a major incident room which remained active for a year, no suspect was ever identified and the investigation was shelved, undetected.

## **10 Operation Elegant**

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GMP's Cold Case Review Unit reopened the case in January 2007 and gained authority for a familial search of the DNA database. At that time, the relatively unsophisticated 'allele count' methodology was used to prioritise the list of 1,214 persons on the parent/child list and the 579 names on the sibling list.

Initial enquiries by detectives from the unit concentrated on seven individuals who lived local to the scenes of the abductions. Family trees were drawn up, relatives were swabbed and eliminated one by one.

Meanwhile, the method by which the Forensic Science Service searched and produced lists from the DNA database was being refined, and of course the database itself was growing at the rate of 40,000 profiles a month. A decision was therefore taken in late 2008 to re-run the search. This resulted in even longer lists, containing 9,911 names (parent/child) and 1,443 names (sibling), with a genetic likelihood ratio (LR) assigned to each name.

On this occasion, investigators were tasked with researching and swabbing relatives of the 'top ten' (by genetic likelihood ratio) and a further thirty nominals with a geographic relevance. At this point in the investigation, a Y-STR profile was obtained from the crime scene stain. Both these lines of enquiry failed to bring any resolution to the investigation.

## **11 Breakthrough**

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The SIO had been in regular contact with NPIA advisors throughout the course of the cold case investigation and was acutely aware that Behavioural Investigative Advisors from the Specialist Operations Centre were developing an enhanced prioritisation methodology, using a composite likelihood ratio (as described by Gregory and Rainbow in the Spring 2011 edition of this journal). With this in mind, a further re-run of the search was commissioned in June 2009. On this occasion, the top 400 names on each list were returned to the SIO, prioritised

using this methodology. The table below is extracted from the sibling list and shows the individual genetic, geographic and age LRs, combined to give a total likelihood ratio for the names ranked first ('Smith') and second ('Jones') on the prioritised lists.

Genetic LR	DoB	IC	Sex	FSS swab	Geo LR	Age LR	Total LR	Name
<b>356,215</b>	01-Sep-58	1	M	50EC	63.1	86.9	<b>1,952,579,386</b>	<b>Smith</b>
<b>5,374</b>	15-Jul-59	1	F	06L1	63.1	81.5	<b>27,609,629</b>	<b>Jones</b>

Significantly, Devon and Cornwall (force code 50) where Smith was swabbed for a minor public order offence (for which he received a caution), is 250 miles away from the locations of the offences in Manchester (force code 06). Data which is not shown on this table (for example: place of birth, known addresses, locations of other offences committed) was extracted from the PNC and factored in to reflect Smith's connections to Manchester (place of birth). Without the use of the NPIA methodology, which extracted the PNC geographic data, Smith would have been allocated a significantly smaller LR for geography and potentially appeared much lower down the list.

What is also striking is that Smith has a total LR of 1.9 billion, as opposed to the second placed Jones at 27.6 million. Whilst purists will say the ranking (as opposed to the size of the number itself) is most significant, such a disparity prompted the SIO to concentrate solely on Smith's family members as a priority.

At this point, a decision was taken to progress the investigation in a covert manner. Rather than risk compromise by approaching Smith directly to gain a picture of his family tree, detectives contacted the General Register Office to obtain details of his parents, children and siblings. The initial results focused attention on a brother, who had been born in Greater Manchester, but was now living and working in the south west of England. Further research which revealed his employment history and movements effectively eliminated him as a suspect. Crucially though, a comparison of the Y-STR profiles obtained from the crime stains and from Smith's retained 'B' scrape (buccal swab) showed a match

(albeit the lack of a sizeable UK Y-STR database limits the discrimination factor considerably).

Frustrated by this latest development, but knowing from previous experience that most birth, death and marriage checks are conducted manually rather than electronically, the SIO directed that the Registrar's initial results be double checked. This revealed two more siblings, including a brother who matched the age and general description of the offender as described by Gemma and Clare. Preliminary research into this individual soon raised him to suspect status: he had been employed as a driver in the locality at the time, his vehicle exactly matched the description given by the victims and he lived within minutes of where Clare had been released from her ordeal.

A final check with the Registrar revealed that the suspect had died in 2005. Although he had been cremated, checks of his medical history in life led to the discovery of a tissue sample stored in a paraffin wax block within medical archives. Permission was given to attempt to obtain a DNA profile; this was successful and matched the crime scene stain.

## **12 Resolution**

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At this point the decision was taken not to inform his surviving family members of this conclusion to the case. There are arguments for and against this approach. On the one hand, publicity may have revealed further offences (though none were apparent from police records) or provided public reassurance. Counter balancing this was a recognition that his wife and children may have been caused unnecessary distress or become victimised.

Clare and Gemma however were informed and their reaction to the news proves the value of bringing a successful resolution to such historic cases. Gemma had always believed that her crime would be detected and was very happy to hear the news. Clare was sorry that she was not able to face him in court, but was pleased to hear of his demise. More tellingly, she now felt, for the first time in over ten years, that she could move on with her life: up to this point she could never previously have been alone in a room with a man she did not know. She

had moved home seven times in the intervening period, always afraid that one day she would be confronted by him again.

### **13 Future investigations**

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The successful outcome to this investigation came about through persistence, legitimate and ethical use of the DNA database and the application of an enhanced familial DNA prioritisation methodology. Provisions within the Crime and Security Act 2010 and the Protection of Freedoms Bill, currently before Parliament, threaten to tie the hands of the police in detecting such offences in the future. It has been argued by Chief Constable Chris Sims, ACPO lead on forensic science, that 1,000 DNA matches per year will be lost across all crime categories with the introduction of this legislation (Hansard 2011). This will undoubtedly include some of the most heinous offences committed in this country. The authors are about to embark on a research project which it is envisaged will give SIOs further confidence in the use of the techniques outlined in this article, with the aim of applying them more frequently in appropriate investigations in order to bring more offenders to justice in a timely and cost effective manner.

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