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Differing perception of DNA evidence and intelligence capabilities in criminal investigations

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ABSTRACT

The ability to predict physical characteristics from DNA presents significant opportunities for forensic science. Giving scientists an ability to make predictions about the donor of genetic material at a crime scene can then give investigators new intelligence leads for cold cases where DNA evidence has not identified any person of interest.

However, the interpretation of this new form of intelligence requires careful analysis. The responses to an online survey, conducted in 2018-19, were used to examine how actors in the criminal justice system assess and interpret different types of DNA evidence and intelligence. The groups of focus for the survey were investigators, legal practitioners and the general public (as potential jurors). Several statistically significant effects were identified based on occupation and whether an individual had prior exposure to new DNA technology. Monitoring how those involved in interpreting reports from different types of DNA evidence and intelligence interpret them helps to ensure that decisions are made based on a sound understanding of their capabilities and limitations and may inform broader training and awareness strategies.

I. INTRODUCTION

Technological advances allow forensic scientists to dive deeper into the human genome than ever before. For decades forensic science has used so-called satellite DNA markers, understood not to be health informative, to compare crime scene samples to the DNA profiles of suspects, or to undertake searches against DNA databases (Frudakis 2010). This approach sought to balance individual privacy with the needs of law enforcement to use technology to identify suspects. Adoption of this technology has not, however, been without its challenges and misinterpreting DNA evidence, however well-intentioned, has led to miscarriages of justice (Gill 2014; Vincent 2010).

This article considers the new field of *forensic DNA phenotyping*, and how it can inform intelligence products. Based on a survey of 260 respondents, the article evaluates how different groups interpret and assess these leads, comparing the perception of forensic DNA phenotyping reports, both text-based and picture-based, with traditional DNA statistical evidence reports. In this study we will demonstrate the potential for DNA intelligence to misdirect investigations and therefore a need for increased training and awareness for law enforcement and the judiciary.

A face from DNA?

New DNA genotyping technologies have allowed scientists to make predictions about the physical characteristics of a donor. Using predictive DNA phenotyping, it is possible to analyse an item of biological evidence from a crime scene and predict certain traits of the donor (Kayser 2015). Predictions can presently be made for characteristics such as skin, eye and hair colour as well as the donor's bio-geographical ancestry (Chaitanya et al. 2018; Cheung, Gahan & McNevin 2017, 2018). These predictions can be presented in written form or, in some cases using commercial algorithms and forensic artistry, a facial composite can be generated predicting the possible appearance of the genetic donor at a predetermined age (Figure 1).

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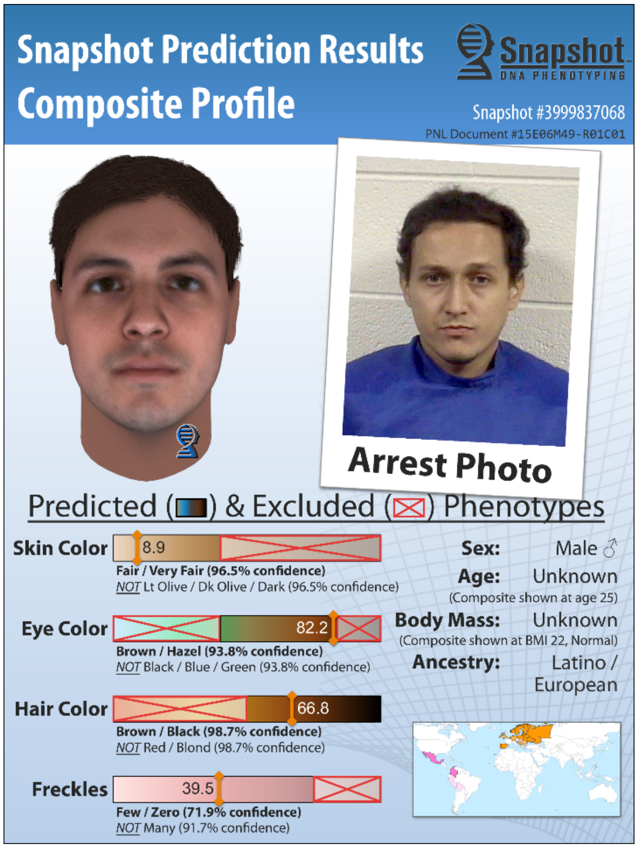

Figure 1: Commercial application of DNA-based facial composite imaging. Superimposed is the arrest photograph of José Alvarez, Jr, who was convicted in 2016 of two murders. Source: Parabon NanoLabs. Reproduced with permission

Investigative significance

Forensic DNA phenotyping is intended as an intelligence lead. Understanding how the various actors engage with different types of DNA evidence and intelligence is critical to developing strategies around the implementation of new technology.

Once a suspect has been identified, a DNA sample can generally be obtained from that individual using a buccal swab and the DNA profile compared directly to the crime scene profile using traditional probabilistic identification processes. Forensic DNA phenotyping is intended to be used primarily to exclude or narrow a wide suspect field, allowing investigators to focus their limited resources on identifying the individual who deposited the genetic material at the scene (Koops & Schellekens 2008).

However, DNA-based intelligence must be treated with some caution. Numerous factors can influence whether written or image-based predictions accurately portray the characteristics of the suspect (MacLean & Lamparello 2014). Flawed DNA intelligence can occur, even with accurate scientific analysis, due to pollution of crime scene evidence or, even more fundamentally, the biological evidence collected at a crime scene not having come from the offender, perhaps not even being deposited at the scene contemporaneously with the crime occurring.

While these risks are not limited to phenotyping, a probabilistic identification using traditional DNA markers will lead investigators to a 'match/no match' situation using a DNA database. A match would yield a name with investigators then seeking to locate and interview the identified individual. That person could then become a suspect in the investigation or could be excluded, for a myriad of reasons.

DNA phenotyping, by its very nature, is less precise. It relies on investigators understanding that the capability sits within an intelligence paradigm and must be assessed in the context of all the evidence in a case (Scudder et al. 2019). If this does not occur then, in future, we may see cases go cold as investigators run down leads based predominantly on DNA intelligence predictions.

Ask, Rebelius and Granhag (2008) assessed the experience of police officers on their assessment of inculpatory and exculpatory evidence. As these new DNA intelligence techniques are only now becoming used operationally, it can be hypothesised that even experienced police have less exposure and understanding of the limitations around this type of intelligence product.

Flawed or misinterpreted DNA intelligence can have potential effects at various stages in the investigative and criminal justice processes. This paper will focus primarily on the effects of misinterpretation of evidence by police and investigators. Some scenarios that could arise include:

- Imprecise or misinterpreted DNA intelligence being relied on by investigators, to the detriment of other viable leads.
- DNA intelligence resulting in an individual being wrongly identified as a suspect based on their physical traits and subjected to privacy-intrusive processes, such as coercively taking a DNA sample.
- Prediction of physical traits or a suspect's appearance being used as a basis for DNA dragnets (Murphy 2007; Skinner 2018).
- Imprecise or misinterpreted DNA intelligence forming the basis for an application to a judicial officer for issue of a warrant, and the execution of that warrant perhaps causing unintended harm.
- Defence counsel highlighting inconsistencies between a DNA intelligence product and the

physical attributes of the defendant, seeking to persuade a jury to put less emphasis on probabilistic-based DNA reports presented as part of a prosecution case.

The presentation of forensic evidence in court has been the subject of analysis and discussion, including detailed consideration of how scientists can accurately convey scientific meaning to non-scientists (Martire, Kristy A 2018; Ribeiro, Tangen & McKimmie 2019). With forensic DNA phenotyping, the importance of the community understanding and interpreting correctly extends far beyond the courtroom.

The readability and complexity of forensic reports, including language, sequencing and format, have all been the subject of academic review (Howes et al. 2014). Researchers have also highlighted the difficulties faced by non-scientists in assessing the probative value of forensic evidence (Biedermann & Kotsoglou 2018). Interpretation challenges have been recorded using both verbal and numerical scales, with proposed ways of resolving this issue including dual verbal and numerical scales, or visual representation (Martire, Kristy A., Kemp & Newell 2013). Statements around prediction of physical traits may be even more difficult to assess, particularly when an individual must consider the probabilities around several different traits together. Further complicating the issue are occurrences of pleiotropy and epistasis. For example, pigmentation traits like eye, hair and skin colour all share genetic markers associated with the melanin synthesis pathway (pleiotropy) and the effects of one marker may be influenced by another (epistasis) (Ducrest, Keller & Roulin 2008; Pośpiech et al. 2014).

The presentation of DNA intelligence through a facial composite is likely to assist in interpretation and understanding, but only if the person receiving the information is also aware of the context and limitations of the information they are assessing. A facial composite can only present a single prediction and needs to take account of the most likely physical characteristics at each point in its creation.

Samuel and Prainsack (2018) conducted qualitative analysis of police interpretation of predictive traits. Their survey showed a distinction between scientists and police, with police more willing to try predictive techniques with less proven reliability and validity, to identify suspects. The authors noted that 'it might be tempting to utilize [predictive DNA] tests even if they are have not yet been validated or if they have low predictive value – just in case they could be helpful' (Samuel & Prainsack 2018, p. 10). Cognitive bias is also relevant, as shown in the work of Charman, Kavetski and Mueller (2017), who examined whether an initial hypothesis of guilt influenced police officer perceptions of evidence in a hypothetical case.

II. Aims, Hypotheses and Study Significance

This study's aim is to assess how individuals from different professional backgrounds understand and assess traditional DNA statistical reports, and text- and image-based DNA phenotyping reports.

The focus of analysis was three different groups of individuals, based on their current or immediate past profession. These groups were: (1) police officers and related professionals, (2) legal practitioners and judicial officers, and (3) other individuals, over 18 years of age, who may be potential jurors.

The study's hypothesis is that occupational background and/or previous exposure to forensic DNA capabilities could impact an individual's assessment of the reliability, trustworthiness and influence of those capabilities and in assessing the ability of the capability to narrow a suspect pool.

III. Methods

Study participants were recruited through paid advertising on the social media platform, Facebook, as well as through retweeted posts on Twitter. An advertisement was also placed in the ACT Law Society's e-mail newsletter. Participants were invited to undertake an online survey, which collected demographic information (Table 1) and then presented each participant with three scenarios.

A total of 260 responses were received. 25 respondents (9.6%) identified their current or last profession as a legal professional or tribunal/judicial officer, and 47 respondents (18.1%) identified their current or last profession as a police officer or related professional. For responses not drawn from the legal or police professions, the largest groups of responses were from students and those working in administration, academia or sales.

Of note, respondents were almost exclusively from countries with adversarial legal systems (refer to Table 1). Further study may be warranted in relation to countries with inquisitorial systems of justice.

Participants were shown three scenarios, each accompanied by three different photographs of individual faces:

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- *Scenario 1:* A DNA evidence statistical report which provided comparative probabilities of a match between the person of interest and a randomly selected member of the community:
  - "The probability of this DNA profile match is 3 billion times more likely if [one of the named individuals] is the donor of the DNA than if a randomly selected member of the community is the donor."
- *Scenario 2:* A DNA phenotyping text-based report containing predictions of the statistical likelihood of hair colour and eye colour:
  - "A new form of forensic DNA analysis makes the following predictions about the person who deposited the sample at the crime scene: Greater than 80% likelihood that the donor has brown hair; Greater than 70% likelihood the donor has blue eyes."
- *Scenario 3:* A DNA phenotyping image-based report which provides a rendered image based on laboratory predictions:
  - "[You have] received an image drawn by a forensic artist, based on the laboratory's predictions of physical features and possible ancestry of the donor of the crime scene sample."

The scenarios were chosen to include both more common use of DNA in criminal investigations (Scenario 1) and two different potential applications of new DNA phenotyping technology (Scenarios 2 and 3). The scenarios were randomly presented in two orders, either with the DNA evidence statistical report (Scenario 1) presented first, or forensic DNA phenotyping reports presented first (Always Scenario 2, followed by Scenario 3).

Participants were asked the following questions, on a scale of 1 to 10, in relation to each of the three scenarios:

1. How reliable do you think the laboratory report is?
2. To what extent does the laboratory report influence your [investigative] decisions?
3. How much do you trust the laboratory report to correctly identify the [person of interest]?
4. To what extent would receiving this laboratory report narrow the focus of your inquiries?

Participants were then asked to order the three scenarios in terms of, firstly, their reliability and, secondly, how well they understood each report.

Participants were asked questions about whether they had seen each DNA report previously, through their employment, study, in the news media or in works of fiction. Finally, participants were given an opportunity to provide final comments in a free text field

IV. Results

Table 1 presents the demographic characteristics of the three groups, including age, gender, country of residence, employment status and education. Table 2 includes participant responses to questions about previous exposure to DNA reports.

Ordering of scenarios

The scenarios were randomly presented in two orders:

1. DNA statistical evidence report (Scenario 1) followed by DNA phenotyping text-based report (Scenario 2) and DNA phenotyping image-based report (Scenario 3); or
2. DNA phenotyping text-based report (Scenario 2) followed by DNA phenotyping image-based report (Scenario 3) and the DNA statistical evidence report (Scenario 1).

A Mann-Whitney analysis (Table 3) revealed a statistically significant difference for ratings of trustworthiness of the DNA statistical report depending on the order of presentation, such that it was rated .60 higher when DNA phenotyping reports were presented before the DNA statistical evidence report (p = .022). Similarly, ratings of the ability to narrow suspects for the DNA statistical report increased by .57 (p = .034) when it was preceded by the DNA phenotyping reports. No other significant differences were observed based on the ordering of the scenarios.

Ratings for different types of DNA evidence/ intelligence

Overall, on scales of 1 to 10, participants rated DNA evidence statistical reports as the most reliable, most influential, most trustworthy and with the greatest ability to narrow the focus of enquiries compared to the two DNA phenotyping reports (Figure 2 and Table 4).

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Table 1: Demographic characteristics

Characteristic - *N* (%)	**Legal Professionals (*N*=25)**	**Police and related professionals (*N*=47)**	**Other (*N*=180)**	**Prefer not to say occupation (*N*=8)**
Age				
18 - 24	5 (20.0%)	1 (2.1%)	54 (30.0%)	3 (37.5%)
25 - 34	9 (36.0%)	11 (23.4%)	46 (25.6%)	4 (50.0%)
35 - 44	4 (16.0%)	17 (36.2%)	25 (13.9%)	0 (0.0%)
45 - 54	4 (16.0%)	15 (31.9%)	19 (10.6%)	0 (0.0%)
55 - 64	2 (8.0%)	3 (6.4%)	21 (11.7%)	1 (12.5%)
65 - 74	0 (0.0%)	0 (0.0%)	13 (7.2%)	0 (0.0%)
75 or older	0 (0.0%)	0 (0.0%)	2 (1.1%)	0 (0.0%)
Over 18 but prefer not to say	1 (4.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Gender				
Female	15 (60.0%)	29 (61.7%)	126 (70.0%)	6 (75.0%)
Male	10 (40.0%)	18 (38.3%)	52 (28.9%)	2 (25.0%)
Agender	0 (0.0%)	0 (0.0%)	1 (0.6%)	0 (0.0%)
Nonbinary	0 (0.0%)	0 (0.0%)	1 (0.6%)	0 (0.0%)
Country of Residence				
Australia	20 (80.0%)	43 (91.5%)	136 (75.6%)	7 (87.5%)
United States of America	2 (8.0%)	0 (0.0%)	9 (5.0%)	1 (12.5%)
United Kingdom	1 (4.0%)	2 (4.3%)	9 (5.0%)	0 (0.0%)
Canada	0 (0.0%)	0 (0.0%)	6 (3.3%)	0 (0.0%)
South Africa	0 (0.0%)	0 (0.0%)	6 (3.3%)	0 (0.0%)
New Zealand	0 (0.0%)	0 (0.0%)	5 (2.8%)	0 (0.0%)
Other	2 (8.0%)	2 (4.3%)	9 (5.0%)	0 (0.0%)

* Number of employees relates only to respondents who indicated they were an employee or contractor (*N*=198).

Characteristic - *N* (%)	**Legal Professionals**	**Police and related professionals**	**Other**	**Prefer not to say occupation**
Employment Status				
Employee or contractor, full-time	18 (72.0%)	44 (93.6%)	57 (31.7%)	3 (37.5%)
Employee or contractor, part-time	7 (28.0%)	1 (2.1%)	68 (37.8%)	0 (0.0%)
Not employed, looking for work	0 (0.0%)	0 (0.0%)	21 (11.7%)	2 (25.0%)
Not employed, not looking for work	0 (0.0%)	1 (2.1%)	13 (7.2%)	1 (12.5%)
Retired	0 (0.0%)	1 (2.1%)	15 (8.3%)	0 (0.0%)
Prefer not to say	0 (0.0%)	0 (0.0%)	6 (3.3%)	2 (25.0%)
*Number of employees**				
0	8 (32.0%)	24 (53.3%)	75 (60.0%)	3 (100.0%)
1-5	13 (52.0%)	8 (17.8%)	34 (27.2%)	0 (0.0%)
6-10	2 (8.0%)	2 (4.4%)	9 (7.2%)	0 (0.0%)
11-20	1 (4.0%)	2 (4.4%)	1 (0.8%)	0 (0.0%)
21-50	0 (0.0%)	4 (8.9%)	2 (1.6%)	0 (0.0%)
50+	1 (4.0%)	4 (8.9%)	2 (1.6%)	0 (0.0%)
Prefer not to say	0 (0.0%)	1 (2.2%)	2 (1.6%)	0 (0.0%)
Highest educational qualification				
Less than high school degree	0 (0.0%)	1 (2.1%)	3 (1.7%)	1 (12.5%)
High school degree or equivalent	0 (0.0%)	4 (8.5%)	15 (8.3%)	3 (37.5%)
Some college/university, but no degree	3 (12.0%)	7 (14.9%)	42 (23.3%)	0 (0.0%)
Associate degree	0 (0.0%)	0 (0.0%)	1 (0.6%)	0 (0.0%)
Bachelors degree	8 (32.0%)	17 (36.2%)	58 (32.2%)	2 (25.0%)
Postgraduate degree	14 (56.0%)	15 (31.9%)	51 (28.3%)	2 (25.0%)
Other	0 (0.0%)	3 (6.4%)	10 (5.6%)	0 (0.0%)
Studying				
Studying full-time	1 (4.0%)	4 (8.5%)	66 (36.7%)	3 (37.5%)
Studying part-time	7 (28.0%)	9 (19.1%)	18 (10.0%)	2 (25.0%)
Not studying	17 (68.0%)	34 (72.3%)	95 (52.8%)	3 (37.5%)
Prefer not to say	0 (0.0%)	0 (0.0%)	1 (0.6%)	0 (0.0%)

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Table 2: Prior exposure to types of DNA evidence and intelligence

	Legal Professionals	Police and related professionals	Other	Prefer not to say occupation
Previously seen a DNA evidence statistical report	***N*** **=23**	***N*** **=43**	***N*** **=166**	***N*** **=6**
Yes	11 (47.8%)	33 (76.7%)	80 (48.2%)	5 (83.3%)
Through my employment	6 (26.1%)	27 (62.8%)	22 (13.3%)	2 (33.3%)
Through my study	5 (21.7%)	10 (23.3%)	49 (29.5%)	1 (16.7%)
On television (documentary or news report)	5 (21.7%)	9 (20.9%)	29 (17.5%)	0 (0.0%)
On television or at the movies (fictional)	4 (17.4%)	7 (16.3%)	25 (15.1%)	1 (16.7%)
Print media (news story or feature)	6 (26.1%)	9 (20.9%)	24 (14.5%)	1 (16.7%)
Print media or a novel (fictional)	4 (17.4%)	4 (9.3%)	23 (13.9%)	0 (0.0%)
Other	0 (0.0%)	3 (7.0%)	5 (3.0%)	0 (0.0%)
Prefer not to say	0 (0.0%)	1 (2.3%)	0 (0.0%)	1 (16.7%)
No	12 (51.2%)	10 (23.3%)	86 (51.8%)	1 (16.7%)
Previously seen a DNA phenotyping text-based report	***N*** **=23**	***N*** **=43**	***N*** **=165**	***N*** **=6**
Yes	9 (39.1%)	12 (27.9%)	74 (44.8%)	2 (33.3%)
Through my employment	1 (4.3%)	8 (18.6%)	8 (4.8%)	0 (0.0%)
Through my study	3 (13.0%)	3 (7.0%)	31 (18.8%)	0 (0.0%)
On television (documentary or news report)	4 (17.4%)	7 (16.3%)	24 (14.5%)	0 (0.0%)
On television or at the movies (fictional)	5 (21.7%)	2 (4.7%)	43 (26.1%)	0 (0.0%)
Print media (news story or feature)	2 (8.7%)	1 (2.3%)	19 (11.5%)	1 (16.7%)
Print media or a novel (fictional)	1 (4.3%)	2 (4.7%)	26 (15.8%)	0 (0.0%)
Other	0 (0.0%)	0 (0.0%)	6 (3.6%)	0 (0.0%)
Prefer not to say	0 (0.0%)	0 (0.0%)	1 (0.6%)	1 (16.7%)
No	14 (60.9%)	31 (72.1%)	91 (55.2%)	4 (66.7%)

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	Legal Professionals	Police and related professionals	Other	Prefer not to say occupation
Previously seen a DNA phenotyping image-based report	***N*** **=23**	***N*** **=43**	***N*** **=165**	***N*** **=6**
Yes	9 (39.1%)	14 (32.6%)	77 (46.7%)	2 (33.3%)
Through my employment	1 (4.3%)	4 (9.3%)	5 (3.0%)	0 (0.0%)
Through my study	1 (4.3%)	2 (4.7%)	15 (9.1%)	1 (16.7%)
On television (documentary or news report)	3 (13.0%)	6 (14.0%)	32 (19.4%)	1 (16.7%)
On television or at the movies (fictional)	4 (17.4%)	7 (16.3%)	53 (32.1%)	1 (16.7%)
Print media (news story or feature)	2 (8.7%)	4 (9.3%)	17 (10.3%)	0 (0.0%)
Print media or a novel (fictional)	1 (4.3%)	5 (11.6%)	28 (17.0%)	1 (16.7%)
Other	1 (4.3%)	2 (4.7%)	6 (3.6%)	0 (0.0%)
Prefer not to say	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
No	14 (60.9%)	29 (67.4%)	88 (53.3%)	4 (66.7%)

Note: Participants who indicated that they had seen the product before were required to at least one response, but could select multiple responses.

Table 3: Analysis of ordering of scenarios

Criterion	DNA statistical evidence report presented first		Forensic DNA phenotyping reports presented first		Mann-Whitney U	Asymp. Sig (2-tailed)	
	Mean	*N*	Mean	*N*			
How reliable							
DNA evidence statistical report	7.23	130	7.78	123	6996.5	.082	
DNA phenotyping text-based report	6.64	128	6.43	127	7500.5	.279	
DNA phenotyping image-based report	6.23	124	6.69	126	6879.0	.097	
How influential							
DNA evidence statistical report	7.71	130	7.89	123	7599.5	.489	
DNA phenotyping text-based report	6.34	128	6.06	127	7484.5	.268	
DNA phenotyping image-based report	6.30	124	6.30	126	7770.5	.941	
How trustworthy							
DNA evidence statistical report	7.12	130	7.72	123	6683.5	.022	*
DNA phenotyping text-based report	5.62	128	5.57	127	7998.0	.810	
DNA phenotyping image-based report	5.77	124	6.07	126	7301.5	.367	
Narrow focus of inquiries							
DNA evidence statistical report	7.12	130	7.69	122	6719.5	.034	*
DNA phenotyping text-based report	5.13	128	4.97	127	7780.5	.552	
DNA phenotyping image-based report	5.75	124	5.97	126	7468.0	.544	

* Statistically significant, p<.05

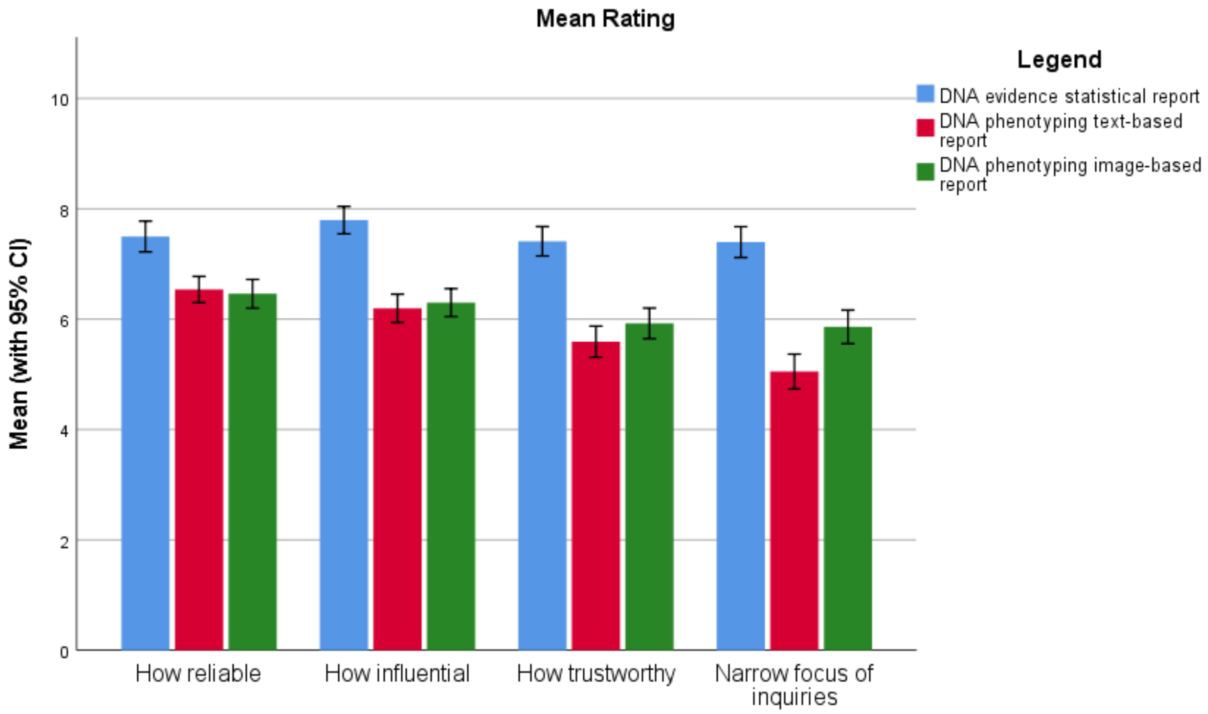

Figure 2: Mean responses to questions for each scenario by occupation group. Error bars represent standard errors

Table 4: Mean ratings

Criterion	**Mean**	***N***	**Std. Dev**	**Std. Error**
How reliable				
DNA evidence statistical report	7.50	253	2.25	.14
DNA phenotyping text-based report	6.54	255	1.93	.12
DNA phenotyping image-based report	6.46	250	2.09	.13
How influential				
DNA evidence statistical report	7.79	253	2.00	.13
DNA phenotyping text-based report	6.20	255	2.08	.13
DNA phenotyping image-based report	6.30	250	2.03	.13
How trustworthy				
DNA evidence statistical report	7.41	253	2.15	.14
DNA phenotyping text-based report	5.59	255	2.29	.14
DNA phenotyping image-based report	5.92	250	2.22	.14
Narrow focus of inquiries				
DNA evidence statistical report	7.40	252	2.25	.14
DNA phenotyping text-based report	5.05	255	2.56	.16
DNA phenotyping image-based report	5.86	250	2.44	.15

Ranking of evidence and intelligence capabilities

When asked to rank each of the scenarios in order from most reliable to least reliable, 69.9% of respondents ranked the DNA evidence statistical report (Scenario 1) as most reliable, but only 43.9% rated it easiest to understand. Image-based DNA phenotyping (Scenario 3) was ranked most reliable by 14.8% of respondents, but easiest to understand by 37.1% of respondents.

Table 5 shows the highest ranked report broken down by occupation group. A chi-square test for independence indicated an association between occupation group (where declared) and whether respondents rated the DNA evidence statistical report highest for reliability, χ^2 (2, n = 202) = 9.06, p = .011. A similar association was observed between declared occupation group and whether respondents rated the DNA evidence statistical report as easiest to understand, χ^2 (2, n = 198) = 12.05, p = .002. A higher proportion of respondents who were police or related professionals or legal professionals rated DNA statistical evidence as the most reliable, or the easiest to understand, compared to the other occupation group.

Occupational background

Analysis was undertaken to compare the ratings given for each question, based on the respondent's declared current, or most recent, occupation (Figure 3).

A Kruskal-Wallis H Test was conducted across occupation groups to predict whether occupation group impacted on the mean. Statistically significant differences were observed in all four questions relating to the DNA statistical evidence report. The differences in the mean between occupation groups are shown in Table 6. Of note, the mean for police officers and related professionals was .93 higher than for legal professionals in their assessment of reliability of the DNA statistical evidence report, and 1.32 higher when compared to individuals who declared an occupation other than in legal or policing fields. Similar trends were observed across influence, trustworthiness and ability to narrow the focus of an enquiry, for DNA statistical evidence reports.

There was no similar trend observed for either the DNA text-based phenotyping report or the DNA image-based phenotyping report, with means not showing any significant differences across occupation groups.

Prior exposure to DNA reports

A Mann-Whitney U Test was conducted to determine whether prior exposure to different types of reports (whether through employment, study, media or fiction), was associated with the ratings respondents provided to each question (Table 7). There was a statistically significant difference between how respondents with and without prior exposure answered all four questions with respect to DNA evidence reports, with those with prior exposure showing higher ratings of reliability (M_{diff} = 1.37, p < .001), how influential (M_{diff} = 1.33, p < .001), trustworthiness (M_{diff} = 1.46, p < .001) and narrowing the focus of inquiries (M_{diff} = 1.17, p < .001).

There was no corresponding effect with respect to the DNA phenotyping text-based report and the DNA phenotyping image-based report responses, with differences in means not statistically significant across exposure groups for these scenarios.

V. Conclusion

This study observed several statistically significant differences in participant responses to the DNA reports, based on occupation and prior exposure.

While the ordering of scenarios also had a statistically significant effect on two questions, trustworthiness and ability to narrow the suspect pool, these differences were not observed with varying the orders of scenarios for any other questions. Further research may be required to assess whether prior exposure to text or image-based DNA phenotyping reports has a systematic, positive effect on respondents' later assessment of more traditional forms of DNA evidence. As this was only observed in two questions, this study does not allow for an attribution of causation.

Overall, nearly three quarters of respondents rated the DNA statistical evidence report as the most reliable report. But over a third rated the image-based DNA phenotyping report as easiest to understand. A higher proportion of police officers and related professionals rated the DNA statistical report as both most reliable and easiest to understand, but

Table 5: Rankings of reliability and ease of understanding by occupation group

Characteristic - *N* (%)	Legal Professionals	Police and related professionals	Other	Prefer not to say occupation
Report ranked as most reliable	***N*** **=20**	***N*** **=37**	***N*** **=145**	***N*** **=7**
DNA evidence statistical reports	15 (75.0%)	33 (89.2%)	93 (64.1%)	5 (71.4%)
DNA phenotyping image-based reports	2 (10.0%)	3 (8.1%)	26 (17.9%)	1 (14.3%)
DNA phenotyping text-based reports	3 (15.0%)	1 (2.7%)	26 (17.9%)	1 (14.3%)
Report ranked as easiest to understand	***N*** **=17**	***N*** **=36**	***N*** **=145**	***N*** **=7**
DNA evidence statistical reports	9 (52.9%)	25 (69.4%)	55 (37.9%)	1 (14.3%)
DNA phenotyping image-based reports	5 (29.4%)	9 (25.0%)	58 (40.0%)	4 (57.1%)
DNA phenotyping text-based reports	3 (17.6%)	2 (5.6%)	32 (22.1%)	2 (28.6%)

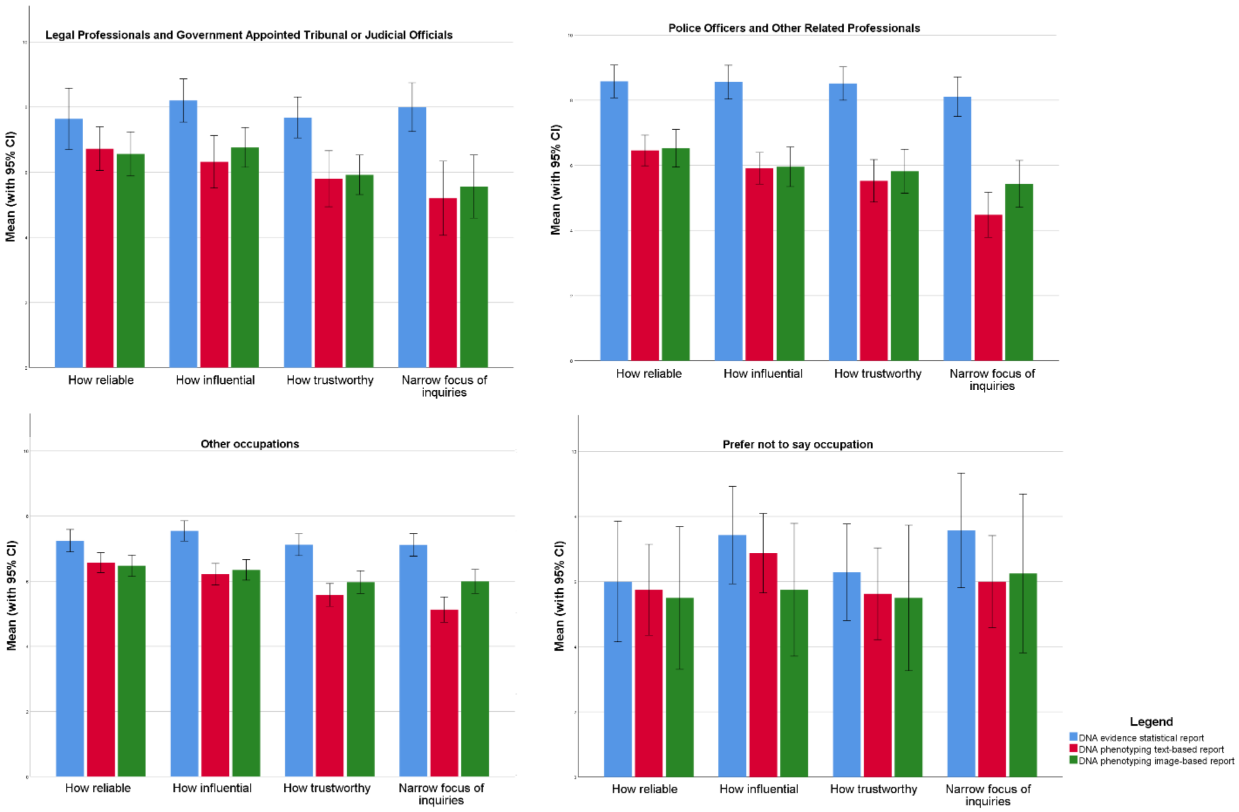

Figure 3: Individual ratings, by scenario and occupation group, for reliability, influence, trustworthiness and ability to narrow suspects).

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Table 6: Kruskal-Wallis H Test analysis by occupation group

Criterion	Legal Professionals		Police and related professionals		Other		Prefer not to say occupation		Sig.	
	Mean	*N*	Mean	*N*	Mean	*N*	Mean	*N*		
How reliable										
DNA evidence statistical report	7.64	25	8.57	47	7.25	174	6.00	7	.000	*
DNA phenotyping text-based report	6.72	25	6.45	44	6.57	178	5.75	8	.492	
DNA phenotyping image-based report	6.56	25	6.52	44	6.47	173	5.50	8	.828	
How influential										
DNA evidence statistical report	8.20	25	8.55	47	7.55	174	7.43	7	.007	*
DNA phenotyping text-based report	6.32	25	5.91	44	6.22	178	6.88	8	.358	
DNA phenotyping image-based report	6.76	25	5.95	44	6.35	173	5.75	8	.361	
How trustworthy										
DNA evidence statistical report	7.68	25	8.51	47	7.12	174	6.29	7	.000	*
DNA phenotyping text-based report	5.80	25	5.52	44	5.58	178	5.63	8	.914	
DNA phenotyping image-based report	5.92	25	5.82	44	5.97	173	5.50	8	.890	
Narrow focus of inquiries										
DNA evidence statistical report	8.00	24	8.11	47	7.11	174	7.57	7	.020	*
DNA phenotyping text-based report	5.20	25	4.48	44	5.13	178	6.00	8	.325	
DNA phenotyping image-based report	5.56	25	5.43	45	5.99	173	6.25	8	.395	

* Statistically significant, $p<.05$

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Table 7: Analysis for previous exposure to DNA evidence or intelligence reports

Criterion	Prior exposure		No prior exposure		Mann-Whitney U	Asymp. Sig (2-tailed)	
	Mean	*N*	Mean	*N*			
How reliable							
DNA evidence statistical report	8.19	129	6.82	109	4524.0	.000	*
DNA phenotyping text-based report	6.62	97	6.63	140	6788.5	.998	
DNA phenotyping image-based report	6.71	102	6.47	135	6335.0	.284	
How influential							
DNA evidence statistical report	8.44	129	7.11	109	4307.0	.000	*
DNA phenotyping text-based report	6.29	97	6.21	140	6648.5	.782	
DNA phenotyping image-based report	6.40	102	6.41	135	6881.5	.995	
How trustworthy							
DNA evidence statistical report	8.12	129	6.66	109	4155.5	.000	*
DNA phenotyping text-based report	5.69	97	5.61	140	6598.5	.710	
DNA phenotyping image-based report	6.12	102	5.99	135	6597.0	.577	
Narrow focus of inquiries							
DNA evidence statistical report	7.96	128	6.79	109	4873.0	.000	*
DNA phenotyping text-based report	5.19	97	4.99	140	6482.0	.550	
DNA phenotyping image-based report	6.14	102	5.88	135	6356.5	.308	

* Statistically significant, $p<.05$

responses from individuals who did not indicate employment in policing or legal professions had a more even distribution, particularly for ease of understanding.

It can be argued that the ability of stakeholders in the criminal justice system - whether investigators, lawyers or potential jurors - to understand different forms of DNA report is critical to effective justice outcomes. As discussed, forensic DNA phenotyping is intended as an input to intelligence, rather than meeting the threshold requirements for admissibility of evidence. Overall, just over 30 per cent of respondents observed either of the DNA intelligence products as more reliable than a DNA statistical evidence report.

A greater understanding of the use of DNA in investigations and in the courts will come as newer technologies are more widespread. The survey results do tend to support increased training and awareness for individuals involved in the criminal justice system, particularly lawyers and police, in the capabilities of forensic DNA phenotyping.

There is a statistically significant difference in the ratings, on a scale of 1 to 10, between occupation groups. Individuals whose current or immediate past occupation was as a police officer or related professional tended to rate the DNA statistical evidence report higher in each question than other respondents. There was a smaller effect observed with legal professionals but, with smaller differences and a small sample size, this effect is not statistically significant. Further analysis of how legal professionals view this technology would be worthwhile.

While there are differences in the way DNA statistical evidence reports are perceived, there is no statistically significant difference in the occupation groups' assessment of newer text or image-based forensic DNA phenotyping reports.

Police and related professionals had the highest prior exposure to DNA evidence statistical reports compared to other groups, but the lowest exposure to DNA phenotyping text-based reports and DNA phenotyping image-based reports. While nearly a third of police respondents had exposure to these newer technologies, the ratings could indicate investigators are still learning about these capabilities. A police officer who has seen DNA evidence presented in court may increase their ratings for that capability, but forensic DNA phenotyping may be too new to have delivered clear operational outcomes to investigators at this time.

Individuals who had previously seen DNA evidence statistical reports also tended to provide higher ratings on the 1-10 scale. Given nearly three quarters of police and related professionals had prior exposure to this type of report, this could help account for the increase in the mean for ratings by this occupation group.

No corresponding increase was observed for individuals who had previously seen either text- or image-based forensic DNA phenotyping reports. Again, this result could arise because the technology is so new. It may also be that the role played by phenotyping in an investigation is overshadowed by the subsequent use of a DNA statistical report, taken once a suspect is identified.

This study observed some statistically significant differences between occupation groups and in relation to prior exposure to DNA statistical evidence. Given these same effects were not observed for phenotyping, and yet a portion of respondents viewed the new capabilities as highly reliable, there is an argument to support further training and awareness in this area, as this technology continues to evolve. However, it is reassuring to see that DNA statistical reports (for identity) are still held as the most reliable form of evidence by all groups as the generation of such a report should be the ultimate goal of an investigation, regardless of any intelligence leading to a suspect (in the form of phenotype reports, for example).

Further study of the impact of forensic DNA phenotyping, and other DNA intelligence capabilities, is also warranted, to assess any impact on investigations, on judicial decision-making, and on court outcomes.

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ETHICS APPROVAL

The survey was approved by the University of Canberra Ethics Committee (HREC18-314).

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