Executive Summary

AI Case Study: Probabilistic Genotyping DNA Tools in Canadian Criminal Courts

June 2021

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The LCO evaluates laws impartially, transparently and broadly. The LCO's analysis is informed by legal analysis; multi-disciplinary research; contemporary social, demographic and economic conditions; and the impact of technology.

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I. INTRODUCTION

This paper is the fourth in a series of Law Commission of Ontario (LCO) reports considering the use of artificial intelligence (AI), automated decision-making (ADM), and algorithms in the Canadian civil, administrative, and criminal justice systems.[1] Each paper identifies a series of important legal, policy and practical issues that Canadian policy makers and justice system stakeholders should consider before these and other AI technologies are widely adopted by Canadian jurisdictions. This paper considers the role and impact of AI-based probabilistic genotyping technology to generate evidence used in the criminal justice system.

Probabilistic genotyping (PG) is the use of artificial intelligence algorithms to analyze DNA samples collected in police investigations or criminal prosecutions. The overarching concern of this report is to examine whether and how AI-based technologies like PG can continue to meet the high standards of due process, accountability, transparency, and fundamental legal rights demanded by the *Canadian Charter of Rights and Freedoms* and, by extension, the criminal justice system.

The primary authors of this report, Jill R. Presser and Kate Robertson, are both practicing criminal defence lawyers with active practices and experience litigating at all levels of courts in Canada. Both are actively engaged with, and have experience in, litigating at the intersection of emerging technologies and the law.[2] The litigation perspective is important to the analysis of probabilistic genotyping tools in Canadian criminal justice. One of the benefits of litigation is that it can expose the flaws and legal uncertainties of new technologies.[3]

PG tools are in widespread use across North America and in other parts of the world.[4] They are extremely significant for the purposes of this report because they are the first artificial intelligence tools in regular use in the criminal courts in a number of Canadian jurisdictions.[5] And yet, while algorithmic risk prediction in bail and sentencing has been studied and challenged, PG has been largely overlooked.[6]

Most significantly, PG tools purport to generate positive evidence that goes to guilt or innocence. As a result, ensuring the accuracy and reliability of evidence that comes out of PG is essential to ensuring that justice is done in individual cases and for these reasons, PG tools present an imminent need for critical review.[7]

This report is intended, in part, to answer the following related questions about PG:

1. How are *Charter*, due process, and common law rights affected by these tools and what do the *Charter*, due process, and the common law say about these tools?
2. What statutory, regulatory, evidentiary, or other changes are necessary to ensure that any use of PG DNA tools complies with law and to protect access to justice?

Ensuring PG regulation is responsive to these issues may help Ontario and Canada develop a regulatory framework for PG tools that maximize their potential benefits, while minimizing harm.

Some of the issues discussed in this paper will likely be familiar, such as well-known "black box" criticisms of algorithmic decision-making, the challenge of explicability, and concerns for biases ingrained in datasets. This paper also considers how legal, technical and operational choices about AI and algorithms can affect due process, access to justice and the fairness of government and justice system decision-making.

Any new technology that purports to generate potentially inculpatory evidence should be carefully reviewed for reliability and accuracy. PG is no exception to this rule. All the more so because PG tools may raise particular reliability and accuracy concerns:[8] For example, it is difficult for defence counsel to obtain meaningful disclosure of how these tools work, which limits counsel's ability to evaluate or challenge them. This is because in most cases, developers/owners assert that their PG programs are proprietary trade secrets that they cannot or will not disclose.[9]

Finally, as discussed at length in LCO's earlier Issue Paper, **The Rise and Fall of Algorithms in the American Justice System: Lessons for Canada**, all AI tools are prone to algorithmic bias. Unreliable, inaccurate, or biased PG DNA evidence that goes unchallenged or is uncritically received in evidence may work great injustice. Litigators would be well advised to avoid such miscarriages of justice by seeking meaningful disclosure, educating themselves, retaining relevant experts, and where appropriate, challenging the admission of PG DNA evidence.

This report is part of the LCO's **AI, Automated Decision-Making and the Justice System** project.

More information about the LCO is available **here**.

II. WHAT IS PROBABILISTIC GENOTYPING AND HOW DOES IT WORK?

DNA evidence has been received in evidence in the justice system for a relatively long time (as new forensic tools go), to great effect in securing convictions and exonerations. It has been routinely accepted as reliable and authoritative in our courts.[10] But the DNA evidence we are accustomed to receiving in the justice system, "old school" DNA evidence, is not the same as the DNA evidence that results from analysis of samples using PG.[11]

The usual method of analyzing DNA is called Random Match Probability ("RMP"). This is the DNA evidence with which most justice system actors are familiar. It is typically and most effectively used to analyze uncomplicated crime scene samples: DNA that came from a single source, with relatively high quantities of DNA, predominantly from bodily fluids like saliva, semen, or blood. In this process, a forensic lab will go through several steps to deduce a reliable DNA profile from a sample, and then report on the rarity of the profile (likelihood of a coincidental match) and on whether two profiles are a match.[12] In this manner, RMP measures the probability that a DNA match was random or

coincidental.[13] This method of analyzing DNA evidence has been called the "gold standard" of forensic evidence. It presents a non-evaluative fact: a description that corresponds to something real, empirical, and objectively true in the world.[14] Unfortunately, RMP works reliably only for uncomplicated DNA samples. It does not work as well in analyzing DNA samples where there are multiple contributors, degraded samples, or small samples.[15]

In contrast to RMP tools, PG tools are algorithmic programs that interpret the results of complex DNA mixtures. They were developed in an attempt to draw out some of the inferences that may be difficult to interpret in "trace" fragmented, mixed, and complex samples. There are a number of different PG programs, some of which are open source while others are proprietary commercial tools.[16] They all use statistical methods and mathematical algorithms in DNA profiling.

Unlike RMP, PG profiles cannot confirm that a particular person is a source of the DNA sample. Rather, PG profiles may reveal the *kind* of suspect you might be looking for. This is because PG tools compare the probability of two different hypotheses or theories of the case that seek to explain the source of the DNA in the sample. The two hypotheses are compared, with a view to determine which is more probable. The AI tool runs the two hypotheses through its algorithm to produce a "Likelihood Ratio" or "LR." The LR is an expression of which of the two hypotheses is said to be more likely.[17]

The LR *appears* to answer the question a jury is asked to determine, namely, whether the defendant was the source of some of the DNA at issue. However, LRs do not actually answer this question. Instead, they only "weigh the relative likelihood of two very specific hypotheses."[18]

LRs do not express the probability that a suspect is the source of some of the crime scene DNA. Recognizing this, the National Research Council has written that "[t]he likelihood ratio is still one step removed from what a judge or jury truly seeks – an estimate of the probability that a suspect was the source of a crime sample, given the observed profile of the DNA extracted from samples."[19] This is a subtle but crucial distinction that is not easy to understand, and for this reason, LRs are easily and likely misunderstood as evidencing the probability of the defendant's guilt.[20] The actual meaning of the evidence produced by PG algorithmic tools is both difficult for expert witnesses to meaningfully convey and for judges and juries to understand.[21]

In order to convert what the trier of fact actually needs and wants to know (which is the probability that the defendant is the source of some of the DNA), a further step is required. This involves complex statistical analysis, known as Bayesian probability analysis. Bayes' theorem requires the making of certain assumptions about the probability of an event occurring. It describes the process by which information relevant to the *prior* probability of an event is combined with new information to produce a *posterior* probability.[22] This analysis is complex, but the conclusion is clear: PG tools or reports cannot stand alone as evidence of probability of guilt or the probability in the real world of the defendant having contributed to the DNA.

In the context of criminal proceedings, PG tools give rise to several important issues and challenges, including:

- The use of PG tools can violate the presumption of innocence.
- PG tools raise serious issues regarding algorithmic bias and the difficulty of understanding how these tools work.
- There has been very little in the way of independent or comparative studies establishing the scientific validity of PG.

- Unknown or mistaken assumptions can be built into PG tools, including assumptions built into code and/or assumptions of the lab or lab technician operating the tool.
- There is a high risk that judges, triers and even experts will not understand LRs and their limitations.
- PG tools raise important disclosure and due process issues, including but not limited to:
  - Uncertain accuracy and reliability.
  - Difficulty in obtaining disclosure and challenging PG tools in court.
  - "Black box" problems.[23]

The disclosure issue is particularly significant for PG tools. Without such disclosure, it can be impossible to evaluate how a system does or doesn't work, whether it is or isn't reliable or accurate. In addition to making it impossible to test PG tools for reliability and accuracy, inadequate or non-existent disclosure may also violate due process and constitutional rights. The right to disclosure facilitates essential procedural and substantive rights for accused people protected under s. 7 of the *Charter*. These include the right to know the case against them, and the right to make full answer and defence.

Even with disclosure, PG tools can raise other significant issues. For example, the DNA evidence generated by PG is often confidently received by judges and juries, possibly because it benefits from the high degree of confidence typically associated with both scientific evidence and artificial intelligence. It appears to be methodical, evidence-based, and immune from the individual and unpredictable judgments of subjective human actors. In other words, PG tools can appear to be objective and authoritative.[24] But PG, like all tools built and operated by humans, is susceptible to error.[25] Cognitive bias may affect the reliability of forensic scientific evidence.[26] Subjectivity may be baked into the way an algorithmic tool is built, or may come in through the assumptions of the particular analyst operating it.[27] And, like all algorithmic tools, PG is prone to algorithmic bias.[28]

The potential impact of these issues is significant: Unreliable, inaccurate, or biased PG DNA evidence that goes unchallenged or is uncritically received in evidence may work injustice. It may result in misidentification of the contributors to crime scene DNA, and thereby lead to wrongful convictions or wrongful exonerations.

III. LESSONS FOR THE CANADIAN CRIMINAL JUSTICE SYSTEM

This section summarizes several important issues and observations regarding the use of PG DNA evidence in criminal proceedings in Canada's justice system. These issues and challenges pose critical hindrances and obstacles to the necessary due process safeguards that are paramount in criminal law proceedings.

Issue #1 A New Legal Framework is Needed to Govern PG DNA Evidence

RMP is highly tested and the validation approach is well known, but PG DNA tools are neither well tested nor validated in the same way.[29] PG tools must also be validated for their algorithmic software, a feature that RMP DNA analysis does not share and that will not have been validated for RMP DNA analysis methods. For these reasons, the existing legal framework that governs the admissibility of RMP DNA evidence may not be appropriate for courts' determination of the admissibility of PG DNA evidence.

Issue #2 Data (Il)Literacy, Limitations on Probative Value, and the Risk of Prejudicial Effect

The limited probative value of the LR, discussed above, is worsened by how difficult it is to explain and the potential impact of this misunderstanding on criminal trials. LRs are problematic because they present the relative likelihood that the prosecution's hypothesis is correct, as compared to the defendant's, on the issue of the originating identity of a DNA sample; however, disbelief of a hypothesis does not prove its opposite.[30] The Court of Appeal for Ontario in *R v. A.P.* wrote that "by setting up the whole case as a choice between two competing versions of events and stating that the version that is 'most probable in all of the existing circumstances' will be selected as 'true', the trial judge came dangerously close to deciding the ultimate issue at trial on a balance of probabilities."[31]

Issue #3 Automation Bias

Justice system participants may be inclined to accept the evidence generated by PG DNA tools, without adequate consideration of their scientific validity or accuracy. This is in part because of the well-documented tendency of lay people to be favourably impressed by expert scientific evidence.[32] Since PG purports to analyze DNA evidence using artificial intelligence, it marries two types of tools that are regarded as highly authoritative by lay people.

Issue #4 Algorithmic Bias

All AI tools are prone to algorithmic bias. Unreliable, inaccurate, or biased PG DNA evidence that goes unchallenged or is uncritically received in evidence endangers Canada's justice system and the vulnerable individuals who are affected by it.[33] Without careful attention and study to these issues, PG AI tools might exacerbate data biases or worsen discriminatory impacts within the criminal justice system on racialized and Indigenous individuals, and on other individuals with protected characteristics under section 15 of the *Canadian Charter of Rights and Freedoms*, because of the inferential nature of the method and its presented hypotheses.

Issue #5 Barriers to Transparency and Due Process Arising from Private Sector Involvement

The inner workings of PG AI tools are difficult to discover, evaluate, or litigate because their developers typically resist making meaningful disclosure on the basis that their tools are proprietary trade secrets. One market leading PG tool, STRmix, will make its underlying information, including source code and foundational validation research, available to defence experts for review upon signing a non-disclosure and confidentiality agreement.[34] However, the restrictions placed on this defence access are so extensive that one is left wondering whether there is much utility in it at all.[35]

Issue #6 Barriers to Access to Justice Presented By Complex, Multi-Disciplinary Methods

PG AI tools involve complex and interconnected statistical, biological and algorithmic mathematical models. The complexity and multi-disciplinary nature of PG algorithms has implications for the validation of these tools and for the justice system. Most litigators and adjudicators don't understand the technology well enough to know what to challenge or question when PG tools are used. It may also be difficult to find relevant independent experts (meaning experts outside of government forensic DNA labs) to assist defendants and the court.[36]

Issue #7 Critical Challenges to Due Process Protections

Litigation depending on the admissibility and reliability of PG evidence raise unique challenges that undermine access to due process safeguards. Just as the complexity and lack of transparency of PG evidence can create a danger that unreliable, misleading, or inaccurate evidence may be used to inculpate a defendant, the complexity and lack of transparency of PG evidence can also make it particularly difficult for defendants and their counsel to mount a meaningful challenge to this class of evidence.

Issues relating to due process and access to justice in criminal litigation involving PG evidence include the following:

- Difficulty obtaining meaningful disclosure.
- Navigating the tools' lack of transparency.
- Limited access to independent experts.
- Funding litigation.
- Limited access to opportunity for cross-examination.
- Access to training.

IV. CHOICES AHEAD: KEY LAW REFORM CONSIDERATIONS

Building on the LCO's earlier report, *The Rise and Fall of AI and Algorithms In American Criminal Justice: Lessons for Canada*, the authors make many recommendations tailored to the unique challenges arising from PG DNA methods. When it comes to PG DNA evidence, given that this particular form of algorithmic tool is already being used in criminal trials, the need for action is pressing.

To avoid miscarriages of justice, comprehensive action is required to respond to the risks and due process concerns identified in this report, and to ensure that any continued use of PG DNA evidence in Canadian criminal courts is consistent with the *Charter* and human rights at stake.

The report's recommendations are summarized here. Complete recommendations are listed in Appendix A.

The report recommends **statutory amendments focused on the use of PG DNA analysis as evidence**, including:

- Prescribed limits on the admission of AI-generated evidence.
- Presumptive inadmissibility in the absence of strict scrutiny.
- Amendments to *Criminal Code* provisions applicable to expert evidence.
- Amendments to *Evidence Act* provisions applicable to electronic documents.

The report recommends further **statutory amendments focused on enhancing systemic transparency and accountability**, including:

- Modernizing Canada's system of oversight governing the collection, use, retention, and sharing of DNA information within police investigations and criminal proceedings.
- Enacting regulations requiring transparency and accountability with respect to algorithms that will be used for criminal justice purposes, including openness of source code and source code review.

The report recommends improved **practices and training**, including:

- Establishing prosecutorial guidelines concerning the use of PG DNA evidence in criminal proceedings.
- Developing access to training programs for all justice-system participants.

The report recommends improvements to **legal aid plans and funding**, including:

- Review of legal aid programs to identify and remedy gaps in policies and budgetary constraints.

Finally, the report recommends further **research and evaluation**, including:

- Researching and evaluating PG DNA methods and their potential for bias.
- Evaluating human rights and ethical concerns surrounding the use of DNA phenotyping in criminal investigations.

V. CONCLUSION

The data and data science used at every stage of AI and algorithmic decision-making have human rights, equity, due process, and access to justice consequences. These tools often have built-in and largely hidden biases and discriminatory inferences in their decision-making. While appearing scientific, objective, and authoritative, they may be unreliable and invalid. Failure to study, understand, and regulate these tools can have significant system-wide and individual repercussions.

Absent proper scrutiny, process, legislation, and equal access to participation in decision-making about data and technology, there is a risk that AI tools, including PG DNA algorithms, will lead to wrongful convictions, worsen racism and inequality in Canada's justice system, and put access to justice further out of reach for many Ontarians.

VI. NEXT STEPS AND HOW TO GET INVOLVED

The LCO believes that successful law reform depends on broad and accessible consultations with individuals, communities and organizations across Ontario. As a result, the LCO is seeking comments and advice on this report and recommendations. There are many ways to get involved:

- Learn about the project on the LCO website (***www.lco-cdo.org***);
- Contact us to ask about the project; or,
- Provide written submissions or comments on the report and recommendations.

The LCO can be contacted at:

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APPENDIX A – LIST OF RECOMMENDATIONS

1. Statutory Amendments focused on the use of PG DNA analysis as evidence:

a. Prescribing limits on the admission of AI-generated evidence.
b. Codifying presumptive inadmissibility in the absence of strict scrutiny.
c. Amendments to *Criminal Code* provisions applicable to expert evidence.
d. Amendments to *Evidence Act* provisions applicable to electronic documents.

2. Statutory Amendments focused on enhancing systemic transparency and accountability:

a. Modernizing Canada's system of oversight governing the collection, use, retention, and sharing of DNA information within police investigations and criminal proceedings.

b. Enacting regulations requiring transparency and accountability with respect to algorithms that will be used for criminal justice purposes, including openness of source code and source code review.

3. Practices and Training, including:

a. Establishing prosecutorial guidelines concerning the use of PG DNA evidence in criminal proceedings.

b Developing access to training programs for all justice-system participants.

4. Review of legal aid programs to identify and remedy gaps in policies and budgetary constraints.

5. Further Research and Evaluation, including:

a. Researching and evaluating PG DNA methods and their potential for bias.

b. Evaluating human rights and ethical concerns surrounding the use of DNA phenotyping in criminal investigations.

c. Evaluating the scope of existing *Charter* rights to ensure that fundamental rights and freedoms apply with equal force in circumstances where AI-generated evidence is used in criminal investigations and proceedings.

ENDNOTES

1 The complete series of LCO Issue Papers and more information about the LCO's AI, ADM and Justice System project is available at **https://www.lco-cdo.org/en/our-current-projects/ai-adm-and-the-justice-system/**.

2 As noted above, Jill R. Presser and Kate Robertson are also co-authors of "Algorithmic Technology and Criminal Law in Canada," Chapter 3 in Jill R. Presser, Jesse Beatson, and Gerald Chan eds., *Litigating Artificial Intelligence,* (Toronto: Emond: May 2021). We have drawn extensively on the portion of that chapter relating to PG tools in the writing of this report, with the generous permission of the book's publisher.

3 Law Commission of Ontario, *The Rise and Fall of AI and Algorithms In American Criminal Justice: Lessons for Canada*, (October 2020) [LCO Criminal AI Paper], online: **https://www.lco-cdo.org/wp-content/uploads/2020/10/Criminal-AI-Paper-Final-Oct-28-2020.pdf**; *Ewert v. Canada*, 2018 SCC 30; *R v. Mills*, 2019 SCC 22; *R v. Rogers*, 2016 ONSC 70; *R v. Spencer*, 2014 SCC 43; *State v. Loomis,* 881 N.W.2d 749 (Wisc. 2016).

4 John Buckleton, the developer of market-leading proprietary PG tool STRmix, reports on his website that STRmix is in use at 56 labs in the United States, all nine state and territorial labs in Australasia, and in 14 other labs elsewhere. This includes three labs in Canada, and labs in England, Ireland, Finland, Denmark, Switzerland, China, and Hong Kong. See **https://johnbuckleton.files.wordpress.com/2020/06/labs-live-ii.pdf**.

5 PG tool STRmix has been in use to analyze complex DNA mixtures at the Centre of Forensic Sciences ("CFS") in Ontario since August of 2016 : ". . . the Centre of Forensic Sciences ("CFS") has implemented an improved method for resolving mixed DNA profiles. The method, known as probabilistic genotyping, employs a specialized software application called STRmix™," CFS Technical Information Sheet, *Improving the Interpretation of Complex DNA Mixtures with Probabilistic Genotyping - A Guide to STRmix™ for Clients* (March 2017), online: **https://www.mcscs.jus.gov.on.ca/sites/default/files/content/mcscs/docs/STRmix%20Client%20Guide%20-%20March%202017.pdf**. STRmix has also been in use since February of 2018 in Quebec at the forensic lab in Montreal, the Laboratoire de sciences judiciaires et de médecine légale du Québec and since September of 2018 at the British Columbia Institute of Technology. See Buckleton 2020 at 2.

6 Meghan J. Ryan, *Secret Conviction Programs* (March 23, 2020). Washington and Lee Law Review (2020), Vol. 77, SMU Dedman School of Law Legal Studies Research Paper No. 454 at 17, online: SSRN: **https://ssrn.com/abstract=3496055**.

7 Secret Conviction Programs 2020 at 2-3.

8 President's Council of Advisors on Science and Technology ("PCAST"), *Forensic Science in Criminal Courts: Ensuring Scientific Validity of Feature-Comparison Methods* (September 2016). Report to the President at 8, 14, 75-82, online: **https://obamawhitehouse.archives.gov/blog/2016/09/20/pcast-releases-report-forensic-science-criminal-courts**. Secret Conviction Programs 2020 at 2, 28-29; James Foy, *DNA Analysis in Secret: Proprietary Algorithms and Forensic Science* (February 2019). For the Defence, Vol. 39, No. 3 at 28; Bess Stiffelman, *No Longer the Gold Standard: Probabilistic Genotyping is Changing the Nature of DNA Evidence in Criminal Trials* (November 26 2019). Berkeley Journal of Criminal Law, Vol. 24, (2019) at 125, 130, online: **https://lawcat.berkeley.edu/record/1129186?ln=en**.

9 DNA Analysis in Secret: Proprietary Algorithms and Forensic Science 2019 at 28, 31-32.

10 See *R v Terceira*, 1993 3 SCR 866.

11 No Longer the Gold Standard: Probabilistic Genotyping is Changing the Nature of DNA Evidence in Criminal Trials 2019 at 111.

12 No Longer the Gold Standard: Probabilistic Genotyping is Changing the Nature of DNA Evidence in Criminal Trials 2019 at 114-115, 127-128; For a more in-depth description of analysis of single-source DNA samples through RMP, see Forensic Science in Criminal Courts: Ensuring Scientific Validity of Feature-Comparison Methods 2016 at 68-71; and Cecilia Hageman, *Forensic Biology and DNA* in Caitlin Pakosh, ed., *The Lawyer's Guide to the Forensic Sciences,* (Canada: Irwin Law: 2016).

13 Cecilia Hageman, "Understanding Genotyping for Lawyers" presented to the Law Commission of Ontario (June 19, 2020).

14 Forensic Science in Criminal Courts: Ensuring Scientific Validity of Feature-Comparison Methods 2016 at 70.

15 Forensic Biology and DNA 2016 at 396-398.

16 As of March 2014, there were at least eight different PG tools, including LRmix, Lab Retriever, like LTD, FST, Armed Xpert, TrueAllele, STRmix, and DNA View Mixture Solution. See Forensic Science in Criminal Courts: Ensuring Scientific Validity of Feature-Comparison Methods 2016 at 78. It should be noted that FST has since been largely discredited for being unreliable, see *People v. Collins*, 49 Misc. 3d 595 (2015), 15 N.Y.S. 3d 564, 2015 N.Y. Slip Op. 25227; Lauren Kirchner, *Thousands of Criminal Cases in New York Relied on Disputed DNA Testing Techniques*, ProPublica (September 4, 2017), online: **https://www.propublica.org/article/thousands-of-criminal-cases-in-new-york-relied-on-disputed-dna-testing-techniques**; and Lauren Kirchener, *Federal Judge Unseals NY Crime Lab's Software for Analyzing DNA Evidence*, ProPublica (October 20, 2017), online: **https://www.propublica.org/article/federal-judge-unseals-new-york-crime-labs-software-for-analyzing-dna-evidence**.

17 Improving the Interpretation of Complex DNA Mixtures with Probabilistic Genotyping - A Guide to STRmix™ for Clients 2017 at 4; DNA Analysis in Secret: Proprietary Algorithms and Forensic Science 2019 at 30-31; No Longer the Gold Standard: Probabilistic Genotyping is Changing the Nature of DNA Evidence in Criminal Trials 2019 at 112, 118.

18 No Longer the Gold Standard: Probabilistic Genotyping is Changing the Nature of DNA Evidence in Criminal Trials 2019 at 112.

19 National Research Council, *The Evaluation of Forensic DNA Evidence: An Update 201* (1996) at 201.

20 No Longer the Gold Standard: Probabilistic Genotyping is Changing the Nature of DNA Evidence in Criminal Trials 2019 at 118.

21 Jonathan J. Koehler, *On Conveying the Probative Value of DNA Evidence: Frequencies, Likelihood Ratios, and Error Rates* (1996). University of Colorado Law Review, Vol. 67, at 877-879, online: SSRN: **https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1432149**. See also Ronald Jay Allen and Michael S. Pardo, *The Problematic Value of Mathematical Models of Evidence* (January 2007). Journal of Legal Studies, Vol. 36, Northwestern Public Law Research Paper No. 900910, U of Alabama Public Law Research Paper No. 900910, online: SSRN: **https://ssrn.com/abstract=900910**.

22 The Evaluation of Forensic DNA Evidence: An Update 201 1996 at 31-32, 132-133; No Longer the Gold Standard: Probabilistic Genotyping is Changing the Nature of DNA Evidence in Criminal Trials 2019 at 119, 136.

23 LCO Criminal AI Paper 2020.

24 Secret Conviction Programs 2020 at 8, 17-18.

25 Secret Conviction Programs 2020 at 3, 8-9, 11-12.

26 Forensic Science in Criminal Courts: Ensuring Scientific Validity of Feature-Comparison Methods 2016 at 31.

27 Amy Jeanguenat, Bruce Budowle, and Itiel Dror, *Strengthening Forensic DNA Decision-Making Through a Better Understanding of the Influence of Cognitive Bias* (July 29, 2017), online: SSRN: **https://ssrn.com/abstract=3010738**.

28 LCO Criminal AI Paper 2020 at 20-22.

29 Forensic Science in Criminal Courts: Ensuring Scientific Validity of Feature-Comparison Methods 2016 at 8, 79-82.

30 For example, there must be independent evidence of fabrication before an accused's statement at trial can used be as evidence of guilt: *R v. O'Connor* (2002), 62 O.R. (3d) 263 (C.A.); *R v. Coutts*, [1998] O.J. No. 2555 at para 13 (C.A.); *R v. St. Pierre*, 2017 ONCA 241 at paras 5-7. In *R v. MacIsaac* (2017 ONCA 172), Trotter J.A. held that a trier of fact errs in failing to provide reasons as to whether, or why, the accused's statements may be treated as positive evidence of guilt (at para 49).

31 2013 ONCA 344 at para 40.

32 This phenomenon was recognized by the Supreme Court of Canada in *R v. Mohan*, [1994] 2 SCR 9.

33 LCO Criminal AI Paper 2020 at 3, 22-23.

34 *STRmix Access Policy* (April 2020), online: **https://www.strmix.com/assets/Uploads/Access-to-STRmix-Software-by-Defence-Legal-teams-April-2020.pdf**. See also *STRmix Full Nondisclosure and Confidentiality Agreement* (April 2020), online: **https://www.strmix.com/assets/STRmix/STRmix-PDFs/NonDisclosure-and-Confidentiality-Agreement-Full-NDA-Template-FINAL-April-2020.pdf**.

35 The restrictions on defence expert access imposed by STRmix include that defence experts will be afforded one-time access, in person, at the offices of legal counsel to the company in Akron, Ohio, under the direct supervision of a representative of the company on a standalone inspection computer that is not internet-enabled. See STRmix Access Policy 2020.

36 *United States v. Gissantaner*, 417 F. Supp. 3d 857 (W.D. Mich. 2019); It should be noted that the court in *Gissantaner*, retained independent experts to assist the court of its own motion. While there are some independent experts internationally, there appear to be relatively few in Canada outside of government forensic DNA labs, and these government experts will typically be retained by, and provide evidence for, the prosecution.