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Interpretation and education: (sub) source and activity issues, similar challenges?

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Abstract

In this paper we present what we believe to be the mechanisms for success in the acquisition skills and competence in evaluation and reporting. We discuss the different means of online and certifying education we developed to tailor the curriculum to the role of the learner. At one extreme, there are Massive Open Online Courses (MOOC) or short single-topic video clips to raise awareness among scientists and the public. At the other end of the spectrum are certifying, in-depth, longer learning courses with individual feedback and tutoring. The latter type of course prepares DNA scientists for the challenges of forensic interpretation in casework, including reporting and testimony, and research.

As practical examples of problems best addressed by the latter type of education, we present theoretical and practical concepts that can help scientists formulate more meaningful propositions. We also discuss problematic examples of reporting that are often observed in the context of alleged activities. More generally, we illustrate the similarities in the challenges DNA scientists face in reporting the value of their findings, regardless of the hierarchical level of the propositions.

Although much progress has been made in recent years with the use of specialised software (particularly probabilistic genotyping), publications and court transcripts indicate that the concept of likelihood ratio used in and produced by such software is still misunderstood by many forensic scientists. This illustrates that education in forensic DNA interpretation by academics specialising in the field is both necessary and timely. We argue that the continuing education of DNA scientists/researchers and the training of key players (investigators, prosecutors, defence lawyers, judges) through the creation of flexible learning pathways should be a central part of tomorrow's forensic science landscape.

Keywords
Evaluative reporting, principles of interpretation, e-learning, MOOC, communication.

Introduction

It is now widely accepted that forensic scientists should reason in the face of uncertainty using a robust framework of logic. Much effort has been devoted to the development of research [1-11] and guidelines/recommendations [12-15] to promote an approach to interpretation that is based on a scientific measure of uncertainty, considers the views of both parties, sustains scrutiny and results in transparent reporting. However, the guidelines are difficult to implement because they require in-depth knowledge and understanding.

In this paper we present our work on different ways to acquire skills and competences in evaluation and reporting that we believe can help to implement current recommendations and guidelines. Our learning opportunities are based on flexible pathways that allow participants to learn at their own pace, depending on their personal and professional constraints. In addition, to meet the needs of the community, different types of courses have been developed so that the curriculum can be tailored according to one's role. At one end of the spectrum, we offer a Massive Open Online Course (MOOC) to raise awareness of the importance of DNA evidence in court. At the other end of the spectrum, we offer in-depth, longer learning courses with individual feedback and tutoring. The latter type of course can prepare DNA scientists for the challenges of forensic interpretation in casework, including reporting and testimony, and research.

A first example of online training: MOOC "Challenging forensic science; how science should speak to court"

The aim of our MOOC "Challenging forensic science; how science should speak to court"[1] is to promote critical thinking about forensic science. It is designed to alert (without alarming) investigators, prosecutors, defence lawyers, judges, scientists and the public (e.g., journalists) to the limitations of forensic science methods and techniques to promote the sound administration of forensic science in the criminal justice system. Through videos about famous cases (causes célèbres), the course emphasises the importance of probabilistic reasoning in forensic science. This 16-hour MOOC is freely available on the Coursera platform

[1] https://www.coursera.org/learn/challenging-forensic-science

and is offered in both in English and French, with subtitles in 21 languages. Since its launch in January 2019, more than 17'000 individuals from all over the world have enrolled.

This MOOC is divided into five modules (e.g., weeks). In the first week, entitled "What is the "DNA" of a good forensic report?", learners explore the criteria that an inferential framework should meet when reasoning in the face of uncertainty. The module highlights the differences between evaluative statements and other types of forensic reports (e.g., technical reports), while introducing the principles of forensic evaluation [e.g., 1-5] and how to assign the value (i.e., LR) of forensic observations and findings. The second week, "Elementary: source is not activity!", covers the distinction between assessing the value of forensic results (e.g., DNA, gunshot residues) when the issue is not only the source of the material but also the activities from which it potentially resulted. Week three, "DNA is not the magic bullet", focuses on DNA-related cases where the meaning of the results has been misunderstood. In week four, "Statistics in Court", participants study cases such as Dreyfus, Clark and Collins, where statistics were misapplied. The course concludes with week five, "The Wonderland of Certainty", which examines cases such as Dallagher (earmarks), Mayfield and McKie (fingermarks). It also discusses what is at stake when an expert decides to conclude to an identification/individualisation (i.e., source attribution determination).

The MOOC is built around high-profile cases and includes interviews with scientists, lawyers and individuals directly involved in these cases.

University-based certifying online courses for reporting forensic scientists

Competence in forensic evaluation and reporting is difficult to acquire. Attending workshops or MOOCs is useful to alert forensic DNA scientists to what to avoid and how to improve. However, exercises and individual tutorials are needed to fully master concepts such as probabilities, likelihood ratios or the formulation of propositions. Over the past 15 years, the University of Lausanne has developed online courses on the evaluation of DNA results given propositions at different hierarchical levels (i.e., at sub-source level and activity level). Since 2009, some 200 students from all continents (Africa, Asia, Europe, North and South America and Oceania) have enrolled. In these courses, participants practise formulating propositions, learn how to evaluate results in complex situations (also with probabilistic graphical models), and how to report their conclusions. Some examples of interpretation and reporting challenges are discussed below.

Why training matters: examples of recurrent interpretation challenges.

a. Formulating propositions

In our experience, DNA forensic scientists often find it difficult to distinguish between propositions and explanations, although there have been many publications on that topic [3,9,11-13]. The key point is that propositions are based on case information and must be formulated so that DNA results can help the court resolve a key issue (e.g., whether Mr Smith is the source of the DNA or if it is an unknown person). In contrast, explanations are based on the results and are appropriate for exploring potential reasons for specific observations (e.g., investigating who could be the source of the DNA). When evaluating YSTR DNA profiles, a common problem is the formulation of propositions such as "The male DNA is from Mr Smith or someone from his paternal line" versus "The male DNA is from an unrelated person". It would be fine to rely on the DNA analysis results and methods to explain the results and provide investigative leads. But if the investigation shows that there is no alternative source of the DNA in the paternal line, then there is no case information to justify this proposition. Also, if one alternate source is a paternal relative, then this should appear in the alternative proposition, not in the main proposition. Propositions are not determined by the method: they are dictated by the (key) issue(s) which in turn direct(s) the choice of method(s). The fact that individuals in the same paternal line can be expected to have certain similarities in their YDNA profile is part of general knowledge. It is worth disclosing and explaining to close (or not) investigation avenues. If the investigation shows that a relative is a viable alternative, then new methods ideally need to be devised (e.g., RM-YSTR). If it is not possible, then one should take into consideration this possibility in the alternative proposition. But, this should not interfere with the formulation of the proposition considering that Mr Smith is the source of the male DNA. Indeed, it is not the paternal line that is on trial, but Mr Smith.

Formulating propositions, when there is disagreement about how or when the DNA was transferred, is also difficult. In such a situation, again, it is often tempting to "explain" the findings *ex post* (i.e., *after* knowing the typing results) by saying, for example, that the DNA was (in)directly deposited by a particular mechanism. However, with such a formulation, it is difficult to evaluate the DNA results, and the probability of the results will be one, if they are perfectly "explained". Moreover, as outlined in [16], if the event "transfer" or "DNA deposition" is woven into the proposition, because the factfinder assesses the probability of propositions (usually informally), this means that the factfinder is left with the task of accounting for the phenomenon of DNA transfer (i.e., they will need to assess the probability of DNA being (in)directly deposited by a particular mechanism). We do not think that laypersons have the knowledge to manage this complex issue. Scientific aspects such as transfer, prevalence, or background, are factors that are part of the evaluation of the results and as such should *not* be part of the proposition. It follows that a proposition must not explicitly state that DNA was deposited (e.g., "The person of interest discarded the knife *and that's how his/her DNA got on the knife*"). A more meaningful proposition is one that includes *only* the alleged activities, for example "stabbing" and not the alleged transfer mechanisms. This also has the advantage of allowing to assess all results, absence of DNA included.

b. Joint evaluation of autosomal and non-autosomal results

It is sometimes thought that DNA forensic scientists should not perform a joint evaluation of autosomal and non-autosomal results. However, it is questionable whether this task should be left to the fact finder. It has been shown that laypersons do not know how to combine probabilities or likelihood ratios obtained from different evaluative reports. Combining different types of forensic biological findings is not trivial and requires special knowledge and skills. Therefore, this task should be the domain of forensic DNA scientists. A meaningful couple of propositions that would allow examiners to jointly evaluate autosomal and non-autosomal DNA results could be: "Mr Smith is the source of the DNA", "An unknown unrelated person is the source of the DNA". As previously outlined, the alternative source (an unrelated person or not) would be based on the available case information.

c. What a likelihood ratio is and what it is not

Publications and court transcripts indicate that the concept of likelihood ratio is still misunderstood by many forensic scientists. It is not uncommon to read confusing statements such as "the LR is basically a division; the likelihood ratio equals proposition one divided by proposition two".[2] However, although it is a ratio, a likelihood ratio (or Bayes Factor) is, in the simplest case, obtained by dividing the probability of the results given one proposition by the probability of the results given the alternative. It is the probability of the findings or results that scientists are concerned with, not the propositions nor their probabilities [6].

At present, many scientists, speak of "sub-source LR" or "activity LR". While this might be seen as a convenient shortcut in informal conversations, it does not help communication. Indeed, if we want to communicate that we can give a pro-

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[2] All examples of problematic statements in this paper are paraphrased from actual examples encountered by the authors in their teaching, casework and research.

fessional opinion on our results, but not on the propositions themselves, then it is confusing, if not misleading, to use language that suggests that the scientist is describing the value of the *propositions* (e.g., "*activity* LR"), rather than the results or findings.

Asserting that a likelihood ratio "supports one proposition more than the other" is another example of misrepresenting the value of the evidence. While it is true that LRs are numbers, it is the *results*, not the LRs, that support one proposition over the other (assuming the LR is different from one).

Another common error, even among experienced forensic scientists, is to say, for example: "The probability of observing this DNA profile is at least a billion times *more likely* if the DNA mixture is from Mr Smith and three unknown, unrelated individuals than if it is from four unknown, unrelated individuals." The problem with this sentence is that it qualifies a probability as "likely", which is confusing. It amounts to placing a probability on a probability. One way to avoid this confusion is to say: "The DNA comparison result is of the order of a billion times more probable if the DNA mixture is from Mr Smith and three unknown, unrelated individuals than if it is from four unknown, unrelated individuals."

Conclusions

In this paper we have reviewed various educational frameworks and highlighted challenges in interpretation and reporting that we believe reflect a lack of specialised education on this topic.

With our MOOC, we aim to make the recipient of forensic information aware that uncertainty should be managed by using probabilities and applying the principles of interpretation. The "Essentials of DNA Interpretation" course aims to provide DNA forensic scientists with an appropriate theoretical and practical background in probabilistic and statistical reasoning so that they can tackle challenging DNA casework (e.g., formulation of propositions, comparisons of a DNA profile mixture to multiple persons of interest, assess complex DNA profiles) and report the value of their results in a robust manner, taking into account recent publications in DNA interpretation. The course "Advanced DNA Interpretation" enables participants to acquire specialised and up-to-date knowledge in the evaluation of forensic biological results when accounting for transfer, persistence, prevalence and recovery (TPPR) of biological trace material in the context of alleged activities.

Conflict of interest statement

Tacha Hicks is employed part-time by the *Fondation pour la Formation Continue UNIL-EPFL* (Foundation for Continuing Education of the University of Lausanne and the Swiss Federal Institute of Technology, https://www.formation-continue-unil-epfl.ch), which offers several online courses in forensic interpretation.

References

[1] I.W. Evett, B.S. Weir, Interpreting DNA Evidence—Statistical Genetics for Forensic Scientists, Sinauer Associates, Inc., Sunderland, MA, USA, 1998.

[2] C. Aitken, F. Taroni, S. Bozza. Statistics and the Evaluation of Evidence for Forensic Scientists, third ed., John Wiley & Sons, Chichester, UK, 2021.

[3] G. Jackson, The Development of Case Assessment and Interpretation (CAI) in Forensic Science. Ph.D. Thesis, University of Abertay, Dundee, UK, 2011.

[4] J.S. Buckleton, J.-A. Bright, D. Taylor, Forensic DNA Evidence Interpretation, second ed., CRC Press, Boca Raton, FL, USA, 2016.

[5] B. Robertson, G.A. Vignaux, C.E.H. Berger, Interpreting Evidence, second ed., Wiley & Sons, Chichester, UK, 2016.

[6] I.W. Evett, Avoiding the transposed conditional, Sci. Justice. 35 (1995) 127–131.

[7] R. Cook, I.W. Evett, G. Jackson, et al., A hierarchy of propositions: Deciding which level to address in casework. Sci. Justice. 38 (1998) 231–240.

[8] I.W. Evett, G. Jackson, J.A. Lambert et al., The impact of the principles of evidence interpretation on the structure and content of statements. Sci. Justice. 40 (2000) 233–239.

[9] I.W. Evett, G. Jackson, J.A. Lambert, More on the hierarchy of propositions: Exploring the distinction between explanations and propositions. Sci. Justice. 40 (2000) 3–10.

[10] G. Jackson, S. Jones, G. Booth et al., The nature of forensic science opinion—A possible framework to guide thinking and practice in investigations and in court proceedings. Sci. Justice. 46 (2006) 33–44.

[11] T. Hicks, J. Buckleton, Vincent Castella, et al., A logical framework for forensic DNA interpretation. Genes, 13 (2022) 957. https://doi.org/10.3390/genes13060957.

[12] S.M. Willis, L. McKenna, S.D. McDermott, et al., ENFSI Guideline for Evaluative Reporting in Forensic Science: Strengthening the Evaluation of Forensic Results

Across Europe (STEOFRAE). 2015. http://enfsi.eu/wp-content/uploads/2016/09/m1_guideline.pdf, 2015 (accessed 6th of October 2024).

[13] P. Gill, T. Hicks, J.M. Butler et al., DNA commission of the International society for forensic genetics: Assessing the value of forensic biological evidence—Guidelines highlighting the importance of propositions: Part I: Evaluation of DNA profiling comparisons given (sub-) source propositions. Forensic Sci. Int. Genet. 36 (2018) 189–202.

[14] P. Gill, T. Hicks, J.M. Butler et al., DNA commission of the International society for forensic genetics: Assessing the value of forensic biological evidence—Guidelines highlighting the importance of propositions. Part II: Evaluation of biological traces considering activity level propositions. Forensic Sci. Int. Genet. 44 (2020) 102186.

[15] Expert Working Group on Human Factors in Forensic DNA Interpretation (2024). Forensic DNA Interpretation and Human Factors: Improving Practice Through a Systems Approach. National Institute of Standards and Technology, Gaithersburg, MD, NIST IR 8503. https://doi.org/10.6028/NIST.IR.8503

[16] T. Hicks, A. Biedermann, de Koeijer JA, et al., The importance of distinguishing information from evidence/observations when formulating propositions. Sci. Justice. 55(2015) 520-5.