



Review article

Evaluation of forensic genetics findings given activity level propositions: A review

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ARTICLE INFO

Keywords:

Evidence evaluation
 Bayesian networks
 Likelihood ratio
 DNA
 Activity level propositions

ABSTRACT

The evaluation of results of forensic genetic analyses given activity level propositions is an emerging discipline in forensic genetics. Although it is a topic with a long history, it has never been considered to be such a critically important topic for the field, as today. With the increasing sensitivity of analysis techniques, and advances in data interpretation using probabilistic models ('probabilistic genotyping'), there is an increasing demand on forensic biologists to share specialised knowledge to help recipients of expert information address mode and timing of transfer and persistence of traces in court. Scientists thereby have a critical role in the assessment of their findings in the context of the case. This helps the judiciary with activity level inferences in a balanced, robust and transparent way, when based on (1) proper case assessment and interpretation respecting the hierarchy of propositions (supported by, for example, the use of Bayesian networks as graphical models), (2) use of appropriate data to inform probabilities, and (3) reporting guidelines by international bodies. This critical review of current literature shows that with certain prerequisites for training and quality assurance, there is a solid foundation for evidence interpretation when propositions of interest are at the 'activity level'.

1. Introduction

1.1. What is an evaluation considering activity level propositions?

When evaluating scientific findings in a forensic context, three fundamental principles should be at the forefront of the scientist's mind, e.g. [1]:

- 1) The findings should be evaluated within a framework of circumstances: this framework is commonly denoted by '*I*', which by convention stands for Information.¹
- 2) The findings should be evaluated given two competing, mutually exclusive propositions: generally, propositions are denoted '*Hp*' for the prosecution proposition and '*Hd*' for the defence proposition.²
- 3) The role of the expert should be to consider the probability of the findings given the propositions and not the probability of the

propositions themselves: findings are commonly denoted '*E*', which by convention stands for Evidence. Note that 'the probability of the evidence, given the proposition' has been referred to as "*the single most important lesson for evaluative forensic science*" [3].

These, principles are based on earlier works by Evett and Weir [4], which in turn are extensions of many published works on probabilistic inference not listed here. These principles naturally lead to the likelihood ratio (LR):

$$LR = \frac{\Pr(E|Hp, I)}{\Pr(E|Hd, I)} \quad (1)$$

Once a likelihood ratio has been assigned, for example in the order of magnitude '*M*', it allows scientists to give statements of the following general form (example):

"My evaluation is based on the information (*I*) that I have been

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¹ Not all available information is necessarily relevant for the evaluation of findings by forensic scientists. Information should be relevant for the evaluative task at hand (e.g. 'task-relevant'; see also [2]).

² The use of these mathematical terms are useful in formal and technical discussions, though in written reports to recipients of expert information it may be preferable to avoid mathematical notation.

Level in the hierarchy	Features or factors to consider	Examples of evaluations at this level in the hierarchy
Offense	<u>Elements of the offence:</u> Consent, intent, pre-meditation, relevance of items to offence, number of offenders	[11, 19-21]
Activity	<u>Properties of DNA samples in general, under case circumstances:</u> Transfer of DNA, persistence of DNA, recovery of DNA, background levels of biological material on items	[6, 8, 19, 22-29]
Source	<u>Extrinsic properties of the DNA extract:</u> Amount of DNA present in sample, level of degradation <u>Other factors:</u> Potential for contamination/pollution in laboratory, results of screening tests, visual appearance	[30-32]
Sub-source	<u>Intrinsic properties of the entire DNA profile:</u> Level of resolution between components, number of loci in the profile	[4, 33-35]
Sub-sub-source	<u>Intrinsic properties of the components of the DNA profile:</u> Alleles present in profile component, population of alternate offenders, genotypes of contributors, proportion of alleles in population	[18]

Fig. 1. Hierarchy of propositions [20,33,35].

provided. Taking this information into account, the probability of obtaining the findings (E) is about M times higher if the prosecution's proposition (Hp) is true rather than if the defence's proposition (Hd) is true."

The general formula for the likelihood ratio given in Eq. (1), and the statement that follows, applies to all forms of evidence evaluation, regardless of the propositions and the nature of the findings being considered. The important point to note is that as the propositions or (I) change, then the findings that should be included within E may also change. For example, if information is provided that accounts for part of the findings, then the results to assess may be different than if the information had not been given.

In the late 1990s, work was carried out that defined several broad categories within which propositions can be formulated, ranging from those that focus on the origin or source of particular physical traces (e.g. glass fragments, biological material, fibres, etc.) to those that address the ultimate issue on which the Court is reaching a decision. This, 'hierarchy of propositions' has proven fundamental for furthering the forensic science community's understanding of the propositional levels that condition the evaluation of scientific findings [5–7]. In particular, it has been realized that the higher up the hierarchy the propositions are, against which the scientists are competent to evaluate their results, the more directly useful the testimony will be to the court, thereby limiting the risk of unwarranted carrying over of forensic findings to conclusions (i.e., other propositional levels) that go beyond the scientist's testimony [8]. The positions within the hierarchy are shown in Fig. 1, and we briefly explain each below, within the context of a hypothetical alleged rape, in order to delineate our field of enquiry to activity level propositions.

1.1.1. Offence level propositions

This propositional level reflects the ultimate issue on which the Court must decide. Offence level propositions typically possess a component that relates to an activity (such as having sexual intercourse, punching someone or shooting a firearm at someone) as well as several legal components such as intent, premeditation, excuses and justifications. Rape is defined differently in various legal systems: usually, it refers to a sexual contact of someone with a person who did not consent to it. Examples of propositions may be: 'The accused raped the victim'

versus 'the accused did not rape the victim'. Note, however, that the simple negation of the first proposition rarely provides a suitable alternative proposition [5]. An alternative proposition needs to be explicit, for example: 'The accused had consensual sex with the victim', 'Someone other than the accused raped the victim', or 'no-one raped the complainant'.

1.1.2. Activity level propositions

Propositions at this level, our main focus in this review, specify activities that putatively took place as part of the defence or prosecution version of the event of interest. In the case of the rape scenario the activity in question would be the sexual activity that is making up part of the prosecution's case. If the defence case is one of consent, then the same activity would be conceded by both parties and so, given this information, DNA results would be of little help³ (except if, for example, different timings are alleged so that considerations of persistence may help in the case). If the sexual activity is not being conceded, then some examples of competing activity level propositions may be: 'The accused had sex with the victim' versus 'The accused only socially interacted with the victim'. Other defence propositions may be 'The accused assisted the victim get into bed' or 'The victim wore clothes loaned to them by the accused'. Any number of possible activity level propositions could apply, depending on the framework of circumstances surrounding the case.

Note that the following are *not* activity level propositions as understood under this framework: 'The recovered DNA is the result of primary transfer' versus 'The DNA is the result of secondary transfer' (or 'The recovered DNA is the result of contamination'). Such formulations are explanations [7], not propositions, and are deficient in at least two ways. First, they factor findings into propositions [9] (i.e. the finding of DNA is part of the proposition). Second, they confuse the phenomenon of transfer (i.e., a variable *conditioning* the evaluation) with the posited activities of interest [8]. Activity level propositions, by definition, must specify alleged activities (by a person). Transfer is an event of interest, about which uncertainty exists, and that is taken into account in the

³ In many jurisdictions no exhibits would be accepted or examined by the forensic science laboratory where consent is an issue. Examinations may still occur with the understanding that a statement given by the defendant during the investigative phase of the case can change by the time the case goes to court.

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