F19 Forensic Metrology: An Important Branch of Forensic Science Toward Fair Justice

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After attending this presentation, attendees will better understand the role of metrology in forensic sciences and how the most important concepts in metrology, such as measurement uncertainty, calibration, and traceability, help the trier of facts to better understand the results of scientific tests and render a decision beyond any reasonable doubt.

This presentation will impact the forensic science community by providing clearer insight into the basic concepts of metrology and show how the correct evaluation and expression of measurement uncertainty adds necessary and useful information about the probability that the value of the measured quantity (the measurand) lies inside a given confidence interval about the measured value. As a mathematical consequence, the probability (doubt) that the measurand value lies outside the give interval is also given. This presentation will broaden understanding among triers of facts of how a correctly presented measurement result, including measurement uncertainty, helps them quantify the doubt on how a correct decision is based on an experimental test.

Justice has always sought help in science to ascertain the factual truth. Experimental tests and measurements have become an important part of trials, especially since DNA profiling has been recognized as reliable evidence of someone's presence at the crime scene. The legal community considers science capable of providing fully certain answers, so in the past and in some countries even today, expert testimony expressing doubt is considered professional misconduct.[1]

However, the scientific community is aware that science cannot provide full certainty, since experimental (measurement) results cannot provide the exact value of the measurand, but only incomplete (and hence, useless) information about it.[2] Despite this, metrology shows how to turn this information into useful data by defining and evaluating measurement uncertainty. It is then possible to express a measurement result as a probabilistic interval of confidence about the measured value, within which the value of the measurand is supposed to lie with a given coverage probability.[2]

Uncertainty has recently started to be considered, although generally only in cases where the decision is based on values obtained through direct measurements, such as breath alcohol content or toxicological analysis.[1,3-5] In these cases, the instruments' contribution to measurement uncertainty, called instrumental uncertainty, is predominant and is the easiest to treat.[2] In important cases, namely fingerprint and DNA profiling, uncertainty also depends on another important contribution, originated by the inaccuracy of the employed method; in metrology this is called definitional uncertainty.[2]

Profiling is based on the identification of a number of common patterns in the samples to be profiled and in those belonging to known individuals. These patterns are the minutiae in fingerprint profiling and in the Short Tandem Repeat (STR) alleles in the DNA sequences.[6] Forensic science considers the probability of correct profiling given a number of corresponding patterns and therefore assesses the credibility of an identification on the basis of the number of patterns that have been recognized in both profiles.

The given probability represents, in metrology, only the definitional uncertainty; however, the contributions given by the employed instrument and the experience of the operator (instrumental uncertainty) also play a critical role, especially in DNA profiling. It will be shown that the actual probability of identification is the product of the probability of correct identification given the number of corresponding patterns multiplied by the probability of correct detection of the single patterns. Since this last probability may be, in many cases (latent prints, scarce or partially contaminated biological samples), significantly lower than the former one, uncertainty is much higher than that generally presented.

Two significant cases which occurred in Europe will be considered in which DNA profiling, absent uncertainty evaluation, could have led to a sentence of guilt for murder. The first case is that of bartender in Liverpool, United Kingdom, who was accused for murdering a young Italian woman during a robbery; the second case concerns the murder of a British student, Meredith Kercher, in Perugia, Italy, in which two students, American Amanda Knox and Italian Raffaele Sollecito, were first sentenced on the basis of DNA profiling, then released after measurement uncertainty was considered.

The proposed considerations and examples show how critical uncertainty is, and thus forensic metrology, in providing correct evidence to the trier of facts, and the legal and ethical issues that it poses to everyone involved in assessing the factual truth: judges, lawyers, criminalists, and expert witnesses.[7]

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Forensic Metrology, Measurement Uncertainty, Probability of Wrong Decision