E13 The Importance of Asking the Right Question: Framing Competing Hypotheses

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This paper will provide the listener with reference points for framing questions - in making preliminary decisions about performing examinations, in making testing decisions, and in evaluating the results, their implications, significance and reliability. This theme will be explored by applying both formal and informal reasoning structures to case examples. The content is oriented to both technical and legal practitioners.

This presentation will impact the forensic community and/or humanity by demonstrating impact-based decision-making tools such as Bayesian reasoning can be used by scientists and engineers, laboratory management, attorneys and the courts to evaluate the significance and reliability of scientific evidence. This paper explores the power and the sources of error in these tools and offers practical remedies. This would improve our ability to provide reliable information about crimes and their perpetrators and ways to quickly spot reasoning flaws that may lead to charging and convicting innocents.

Working assumptions made at the outset of work on a case, and as the work progresses, influence decisions about examinations, sampling and testing. Whether case management or analytical decisions, these in turn affect the evaluation of the results and their significance. Whether informal evaluation or formal reasoning structures such as Bayesian inference are used, the tools of inference can yield results only as good as the assumptions that the work rests upon.

What to a scientist or engineer are working assumptions can later appear as bias in the eyes of an attorney. Some advocate eliminating bias by restricting information flow about the facts of the case, keeping them from the scientist. This would deprive the scientist of the foundation for hypothesis formation, and thus introduce other errors. A better approach is to clearly articulate the working assumptions, and to use simple conceptual tools to control for bias in evaluation of results. This approach allows for changes in interpretation and additional hypothesis testing as new information comes in. It is both scientifically and legally defensible.

Impact-based decision-making is a current topic in forensic science, and can be applied to questions such as whether laboratory work can make a difference (i.e., whether laboratory resources should be allocated to this work), whether a particular result is significant (i.e., whether it answers case questions), and whether there is information which is germane but of limited significance, or simply does not address the case questions (i.e., can't exclude vs. can't tell). Impact-based reasoning underlies questions such as the following: Is there a small chance of getting results but results would be highly significant? Could examinations add little to what is known regarding a suspect's involvement, but still be potentially exculpatory? If a result confirms the case hypothesis, does it add much to what is already known? If the hypothesis were false, could this be demonstrated by the same testing plan?

A formal structure, Bayesian reasoning, has been advocated for evaluating significance. This approach, grounded in statistics and probability, allows for an evaluation of the impact of evidence or results on the case as a whole. It can also be used to evaluate the impact upon a particular question. The assessment of impact can be translated from the mathematical as a question: What are the chances of the evidence being the way it is if a certain case scenario is correct versus what the chances are if another case scenario – and not the first — is correct? When the chances are about even, the evidence has little impact upon the case as a whole. It is when the chances of one greatly outweigh the chances of another that the evidence has significance. For making case management decisions, the question would be whether laboratory work could have an impact, thus should be done. For completed work, the question would be whether it answers the case questions, and whether additional testing is needed.

It is clear that the statement of hypotheses is critical to the usefulness of Bayesian reasoning. Anything that is critical is a potential source of error. Four common errors are: to weigh the value of associations but not exclusions in case management decisions, to weigh specificity over significance in sampling decisions, to consider suspect involvement rather then type of suspect involvement in deciding which types of tests to perform, and to postulate hypotheses comparing a suspected individual or evidence source only with a randomly occurring individual or source rather than with a non-random but perhaps unknown source.

To control for error from statements of hypotheses, the use of a few checklists can provide the scientist with a useful tool. It can provide laboratory management and the courts with a quality assurance check for the aforementioned sources of error, and could be used by even sciencephobic lawyers in evaluating the evidence in a case. Useful checklists would include: 1.) a simple graph of possible scenarios, possible results, and the likelihood of the evidence being the way it is for each scenario and result (possible results might include positive and negative findings; the likelihood of the evidence might be high, medium or low); 2a.) a suspect involvement checklist featuring the hierarchy of propositions proposed by Cook, Evett et. al., (identification of material, activity and offense); 2b.) a simple graph to compare the significance of more specific testing oriented toward the best identification, vs. less-specific testing oriented toward both identification and a level of activity; 3) an alternative hypotheses checklist including questions incorporating nonrandom alternatives specific to certain types of evidence, such as mixed vs. overlapping stains or deposits; shot fired from a distance vs. through an intermediate target; direct, indirect non-random, or random transfer; this source person, a related person or an unrelated person; and so forth.

Lastly, performing an evaluation of the significance of evidence can itself be a source of error if it is done too soon. Impact-based evaluation of results should be performed only after completion of laboratory testing that can eliminate some of the competing hypotheses. Evaluation is also premature if the evidence has been insufficiently explored to find out what is there, regardless of hypotheses, especially important if some of the initial police information is wrong. Investigative work often takes low priority in crime laboratories because of the pressure of court dates and because it uses time and resources for an uncertain outcome. Yet often, examination of crime scenes by scientists would generate answers to questions that could not be addressed in the laboratory alone, and exploratory clothing examination could provide clues to the nature of a crime and to a perpetrator. If this is not done, and someone who is not the perpetrator was charged with a crime, the scientist will still be able to evaluate the evidence with respect to alternative hypotheses, but may not be alert to unexplored alternatives, and may no longer be in a position to provide information about the true culprit.

Summary: Impact-based decision-making tools such as Bayesian reasoning can be used by scientists and engineers, laboratory management, attorneys and the courts to evaluate the significance and reliability of scientific evidence. The very power of these tools gives rise to concern about sources of error in their use, arising principally from unstated assumptions, but also from premature application of evaluative tools. Conceptual tools using checklists can be used to control for unstated assumptions. Attention to scientific investigative work would control for too soon a weighing of alternative hypotheses, i.e., before exploratory work has been completed and alternatives tested in the laboratory.

Inference, Bayesian Reasoning, Reliability