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Standard Human Reasoning Versus Scientific Analysis

Forensic experts have conducted pattern evidence comparisons for over a century. Fingerprint comparisons are perhaps the most well-known type of pattern evidence, though many other types exist: ballistics, bite marks, facial recognition, toolmarks, etc. Across all pattern evidence disciplines, comparisons have been conducted in a similar manner: by observing corresponding and non-corresponding features between a known and an unknown sample. Human reasoning is then used to determine whether these two items originated from a common source.

Generally speaking, pattern evidence conclusions have been accepted as highly reliable by the courts. However, weaknesses in some conclusions and explanations across these disciplines have been revealed, making it now necessary to allow for others to be able to assess the strength behind any pattern evidence conclusion. One way this can be done is to look at the process used to arrive at conclusions and explanations.

The process, human reasoning, may be performed in a variety of ways. For the sake of discussion this article breaks the different methods into two main categories: *standard human reasoning* and *scientific analysis*. Forensic experts may strictly follow one of these methods or use a combination of protocols from each method. Standard human reasoning allows a person to rely on a variety of information sources to arrive at conclusions, including personal factors such as the experience, training, and ability of the expert. Considerable research has shown that relying on personal factors can negatively influence conclusions. With this knowledge, scientific analysis attempts to minimize these influences by relying on data rather than beliefs. A scientific analysis questions common assumptions in order to distinguish solid information from that which lacks an adequate foundation. A thorough understanding of the differences between these methods and analyzing the factors involved in the decision-making process can both assist in determining the strength of a conclusion and flush out weak conclusions.

A side-by-side comparison may be the most helpful way to appreciate the differences between standard human reasoning and a scientific analysis. The differences are sometimes subtle but are also significant, particularly in light of the added scrutiny comparison conclusions now routinely face. The listed protocols show that although all pattern recognition conclusions involve human reasoning, all pattern recognition conclusions are not scientific. Most protocols in the chart are self-explanatory; however, some concepts are discussed further at the end of the table.

Standard Human Reasoning

Goal: to arrive at an accurate conclusion	Goal: to arrive at a well-
Accepts information and concepts from authoritative sources as reliable and valid when gaining knowledge	Doubts and questions
Requires minimal testing to arrive at a conclusion	Require
Seeks confirming data to support beliefs, may discount data that contradicts beliefs (referred to as "ignoring what doesn't fit", "making a conclusion fit the data" or a "leap of faith")	Seeks refuting data (fal
Discounts or disregards opposing views that conflict with beliefs or long-standing views	Va
Relies on the training, experience, and ability of the expert as the deciding factor of sufficiency for acceptance or rejection of data used and conclusions	Relies on tested premis used and conclusio
The threshold of sufficiency is at the discretion of the expert (tolerance level, confidence level, personal beliefs, and opinion)	The threshold of sufficie Necessary conditions f
The expert is certain the conclusion is accurate	The confidence of the
Allows for personal interpretation of data and conclusions (subjectivity)	Disc
Portray concepts and conclusions as proven or conclusive	Portrays concepts and c
Attempt to convince others, perhaps with non data	
Values reproducibility by another expert as sufficient verification -performed blindly is recommended	Values rep
Missed identifications are inevitable and labeled as oversights rather than errors	Establishes a tolerance
False exclusions are tolerated	
Regarding errors: attempts to place blame (incompetent expert)	Regarding errors: atten
Avoids speculating on hypothetical situations	
Trained to competency may be assumed	Kn
Implements quality assurance measures globally without validation (e.g., implementing a point standard, elimination based on the interpretation of a class characteristic, no unexplainable differences)	Implements validated

Well-Supported Conclusions

It may be surprising to see that the goal of a scientific analysis is to have well-supported conclusions instead of accurate conclusions. This is because in most situations the accuracy, or ground truth, cannot be known. With the ground truth unknown it would be impossible to determine the *absolute* accuracy of a conclusion. Generally, the best that can be done is to have overwhelming data to support a conclusion. If a conclusion has overwhelming support behind it, then, scientifically speaking, it is more likely for the conclusion to be accurate.

Scientific Analysis
supported conclusion, based on testing and valid principles, that will stand up to intense scrutiny
s all information, concepts and data; tests assumptions by attempting to refute information (i.e., attempts to find situations where the assumptions are false)
s rigorous testing; all identified alternative possibilities are considered and tested
lsification) in an attempt to disprove assumptions; acknowledges that unknown alternatives cannot be tested
lues opposing views as a means of improving an explanation or conclusion
es, demonstrable data, and correct application of procedures for acceptance or rejection of data ns; values training and experience as essential in order to apply scientific protocols correctly
ency is the ability to diminish doubt in others by satisfactorily demonstrating the basis to the point of general acceptance (to include attorneys and jurors):
for an identification are correlation between the items *and* elimination of alternative explanations (correlation alone is not a sufficient condition to establish causation)
expert comes from knowledge of scientific principles and proper application of those principles
ourages interpretations that cannot be discerned by other reasonable people
conclusions as being supported by testing (e.g., inferences or reasonable assumptions); the only conclusive concepts are those shown to be false
Attempts to dispel doubt in others by showing the supporting data
producibility for physical events; values sound justification for analytical conclusions -justification cannot be reviewed blindly
level for acceptable conclusions (i.e., defines an error, an error rate, and establishes an acceptable error rate)
False exclusions are errors, significance is determined on a case-by-case basis
mpts to find causes and solutions in order to modify suppositions and improve future conclusions
Allows for speculation as a means of educating others
nowledge of protocols and the ability to apply protocols is periodically tested
quality assurance measures specific to a given situation (e.g., additional documentation and/or verification for complex comparisons)

Certainty

Conclusions arrived at using scientific protocols tend to be thought of as the "supreme" form of knowledge. Even so, scientific conclusions are not perfect; regardless of the thoroughness used and the amount of compelling data supporting a conclusion, conclusions can later be found to be incorrect. This is why scientific conclusions are often expressed as tentative and not absolute (e.g., Newton's Law of Gravity stood for 200 years before Einstein determined it was only partially correct). In an effort to be transparent and not embellish the strength of a conclusion (i.e., bolstering), those performing a *scientific* analysis try to demonstrate the amount of uncertainty by stating the amount of research, testing, and data that supports a conclusion and any limitations affecting the conclusion. The chance of error is usually minuscule when conclusions are based on overwhelming data. This overwhelming data, gleaned from testing and properly followed protocols, is where confidence in a conclusion is generated, not from mere opinion or mere observation. The expert's obligation is to also properly convey this information to the courts.

Validated Principles

As stated in the chart, standard human reasoning may rely on principles that have not been validated. It may also include validated principles that are used inappropriately, rather than as research has indicated. Masking all extraneous information in order to prevent bias is one example. Research has shown that extraneous information can influence decisions when the data is vague or limited. Masking information in all situations (i.e., blind verification) instead of only when the data is vague or limited misrepresents the intent of this procedure. This is referred to as dogmatic endorsement or an appeal to scientific authority. Although scientific protocols are generally preferred, using them inappropriately does not provide the same safeguards as using them as intended.

General Acceptance

Perhaps the most striking distinction between conclusions based on standard human reasoning and conclusions arrived at scientifically is determining when that conclusion is final. Non-scientific decision-making allows only those with special knowledge, such as other experts, to endorse a conclusion. Those without this knowledge should simply trust the conclusion presented by the expert. Scientific conclusions, on the other hand, acknowledge that non-experts may not be able to arrive at a similar conclusion on their own, but allows for the non-experts to doubt and question conclusions as well. The expert is required to demonstrate the basis behind a conclusion until experts and non-experts alike are satisfied with the conclusion (e.g., general acceptance). This necessity has neither been suggested nor required of all pattern evidence disciplines and many disciplines have endorsed and authorized conclusions that could only be reached by a select few, those with “an eye” for example. It may be true that some people have abilities others do not possess, however, an ability to see data that cannot be demonstrated to the satisfaction of others does not rise to the level of science. This protocol does require a great deal more concrete data than the non-scientific decision-making process and although the conclusions tend to be more conservative, they are also much more solid. The general acceptance protocol protects against over-interpretation of vague data.

The good news is that the majority of pattern evidence conclusions seem to have met these scientific guidelines without actually making a formal attempt to adhere to them. The bad news is that this has in turn led to an over-confidence in the current methods and that has stifled the call for improvement and has limited change even when needed. Most conclusions that have been found to be in error can also be found to have failed to meet scientific guidelines. Merely stating this, however, does little to advance pattern recognition sciences nor does it move us toward limiting these errors in the future.

Only by striving to thoroughly understand the limits of current thinking and to understand where the weaknesses lie in this thinking, can we truly move forward into the realm of consistently respected science. Those who understand the difference between standard human reasoning and a scientific analysis can assess the strength of conclusions and explanations on appropriate merits instead of on the past precedents of acceptance or on weak data. It is up to us to not only embrace this thinking, but to properly convey this knowledge to those whom we present our findings.

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