Forensic Science for Liberal Arts Majors
Wisconsin State Public Defender Conference
November 8, 2012, Milwaukee, Wisconsin

Overview

- Outline: Forensic Science for Liberal Arts Majors
- 1. THE ISSUE: Using science incorrectly OR calling it science when it is not.
- 2. What is forensic science? The application of science to law.
- 3. When does science or “science” get applied to law?
  - Daubert gives the answer – often the court decides “it comes in because it always has”
- 4. Daubert critera contains aspects of scientific method.
  - (testing, peer review, rate of error)
- 5. Scientific method – definition.
- 6. What is not scientific method?
- 7. Scientific method – steps.
- 8. Other aspects of scientific method.
- 9. The difference between scientific method and forensic science.
- 10. We are lawyers, why does scientific method matter?
- 11. Wrongful convictions – how? One example: base rate fallacy.
- 12. Probabilities: Bayes theorem.
- 13. The limitations of scientific method in forensic science.
- 14. The Forensic Scientific Method.
- 15. Laying the foundation for your challenges to reliability of science or “science.”

The issue

How to avoid:

- Using science incorrectly OR,
- Calling it science when it is not.

The issue

- Who says we use science incorrectly and call it science what it's not.?

- National Academy of Sciences
  - Prestigious
  - Non-partisan
  - Expert
  - Independent
  - Set up by Abraham Lincoln to advise on science. 2,100 members serve for free.
  - NAS members are among the world's most distinguished scientists, engineers, physicians, and researchers.
  - more than 300 members are Nobel laureates.
  - Members are elected in recognition of outstanding achievements, and membership is considered a high honor.

- NAS REPORT “Strengthening Forensic Sciences, A Path Forward”
- https://www.ncjrs.gov/pdffiles1/nij/grants/228091.pdf
  - Or just google “2009 NAS Report”

- “The report finds that the existing legal regime—including the rules governing the admissibility of forensic evidence, the applicable standards governing appellate review of trial court decisions, the limitations of the adversary process, and judges and lawyers who often lack the scientific expertise necessary to comprehend and evaluate forensic evidence—is inadequate to the task of curing the documented ills of the forensic science disciplines.”
  - NAS report page 85

NAS says in criminal court:

- Judges don’t spend the time or have sufficient expertise to adequately address the issues,

NAS says in criminal court:

- Prosecutors overly rely upon this type of evidence and refuse to acknowledge shortcomings, and

NAS says in criminal court:

- Defense attorneys often have not had the resources or expertise to adequately challenge the underlying science nor have they had the ammunition to go after the science.

DEFINITIONS

What is forensic science?

The application of science to law.

How do we apply science to law?

- "[T]here are important differences between the quest for truth in the courtroom and the quest for truth in the laboratory. Scientific conclusions are subject to perpetual revision. Law, on the other hand, must resolve disputes finally and quickly."
- Daubert v. Merrell Dow Pharmaceuticals, Inc., 509 U.S. 579, 596-97 (1993).

When does science get applied to law?

The analysis under the Daubert criteria determines what constitutes forensic science in Wisconsin.

- To determine whether a theory or technique is scientifically valid and will assist the trier of fact, the trial judge should ordinarily consider:
- 1. Whether the theory or technique can (and has been) tested;
- 2. Whether it has been subjected to peer review;
- 3. The theory or technique's known or potential rate of error and the existence and maintenance of standards controlling the technique's operation;
- 4. The theory or technique's general acceptance within the scientific community.
- Daubert, 509 U.S. at 593-94.

DAUBERT criteria contains aspects of scientific method.

Testing

Peer Review

Rate of Error

Scientific Method

- The Scientific Method involves a series of steps that are used to investigate a natural occurrence.

Scientific Method

"a method or procedure that has characterized natural science since the 17th century, consisting in systematic observation, measurement, and experiment, and the formulation, testing and modification of hypotheses."

Oxford English Dictionary

Scientific Method

Takes a hypothesis, conduct experiments to disprove that hypothesis.

Scientific Method

To prove a theory using the scientific method, you must try to disprove it.

NOT scientific method

- You do not prove a theory true by looking for facts that support it.

NOT scientific method

- You do not prove a theory true by looking for facts that support it.
- Confirmation Bias
- Also known as “junk science”

Confirmation bias

Taking a hypothesis prejudged to be correct and attempting to “prove” it using anecdotal evidence .

The misconsception

- Your opinions are the result of years of rational, objective analysis.

The truth

Your opinions are the result of years of paying attention to information which confirmed what you believed while ignoring information which challenged your preconceived notions.

The frequency illusion

- The tendency to notice instances of a particular phenomenon once one starts to look for it, and to therefore believe erroneously that the phenomenon occurs frequently.

The frequency illusion

- The tendency to notice instances of a particular phenomenon once one starts to look for it, and to therefore believe erroneously that the phenomenon occurs frequently.
- For example: *always* seeing the clock at "12:34 p.m."

The frequency illusion

- The tendency to notice instances of a particular phenomenon once one starts to look for it, and to therefore believe erroneously that the phenomenon occurs frequently.
- For example: bedwetting in child abuse cases (or any negative reaction after allegations of any kind are made)

Another way of saying "scientific method"

The elimination of non-scientific concepts of belief formation.

That is, the elimination of bias.

Another way of saying "scientific method"

Our criminal justice system is riddled with decisions being made on the basis of confirmation bias, frequency illusion, and other non-scientific concepts of belief formation.

For example (a very small sample):

Not scientific method

But how we decide:

Ambiguity effect – the tendency to avoid options for which missing information makes the probability seem "unknown."

Not scientific method

But how we decide:

Anchoring – the tendency to rely too heavily, or "anchor," on a past reference or on one trait or piece of information when making decisions (also called "insufficient adjustment").

Not scientific method

But how we decide:

Attentional bias – the tendency of emotionally dominant stimuli in one's environment to preferentially draw and hold attention and to neglect relevant data when making judgments of a correlation or association.

Not scientific method

But how we decide:

Ambiguity effect – the tendency to avoid options for which missing information makes the probability seem "unknown."

Not scientific method

But how we decide:

Backfire effect – when people react to disconfirming evidence by strengthening their beliefs.

Not scientific method

But how we decide:

Bandwagon effect – the tendency to do (or believe) things because many other people do (or believe) the same. Related to groupthink and herd behavior.

Not scientific method

But how we decide:

Base rate fallacy or base rate neglect – the tendency to base judgments on specifics, ignoring general statistical information.

More on this later.

Not scientific method

But how we decide:

Belief bias – an effect where someone's evaluation of the logical strength of an argument is biased by the believability of the conclusion.

Not scientific method

But how we decide:

Bias blind spot – the tendency to see oneself as less biased than other people, or to be able to identify more cognitive biases in others than in oneself.

Not scientific method

But how we decide:

Confirmation bias – the tendency to search for or interpret information in a way that confirms one's preconceptions.

Not scientific method

But how we decide:

Contrast effect – the enhancement or diminishing of a weight or other measurement when compared with a recently observed contrasting object.

Not scientific method

But how we decide:

Endowment effect – the fact that people often demand much more to give up an object than they would be willing to pay to acquire it.

Not scientific method

But how we decide:

Experimenter's or expectation bias – the tendency for experimenters to believe, certify, and publish data that agree with their expectations for the outcome of an experiment, and to disbelieve, discard, or downgrade the corresponding weightings for data that appear to conflict with those expectations.

Not scientific method

But how we decide:

False-consensus effect - the tendency of a person to overestimate how much other people agree with him or her.

Not scientific method

But how we decide:

Gambler's fallacy – the tendency to think that future probabilities are altered by past events, when in reality they are unchanged. Results from an erroneous conceptualization of the law of large numbers. For example, "I've lost 5 black jack hands in a row, so I should be more on the 6th because I am more likely to win.”

Not scientific method

But how we decide:

Hindsight bias – sometimes called the "I-knew-it-all-along" effect, the tendency to see past events as being predictable at the time those events happened. Hindsight gives you really good vision.

Not scientific method

But how we decide:

Mere exposure effect – the tendency to express undue liking for things merely because of familiarity with them.

Not scientific method

But how we decide:

Optimism bias – the tendency to be over-optimistic, overestimating favorable and pleasing outcomes (see also wishful thinking, valence effect, positive outcome bias).

Not scientific method

But how we decide:

Overconfidence effect – excessive confidence in one's own answers to questions. For example, for certain types of questions, answers that people rate as "99% certain" turn out to be wrong 40% of the time.

Not scientific method

But how we decide:

Reactance – the urge to do the opposite of what someone wants you to do out of a need to resist a perceived attempt to constrain your freedom of choice (see also Reverse psychology).

Not scientific method

But how we decide:

Recency bias – a cognitive bias that results from disproportionate salience attributed to recent stimuli or observations – the tendency to weigh recent events more than earlier events (see also peak-end rule, recency effect).

Not scientific method

But how we decide:

Selection bias - the distortion of a statistical analysis, resulting from the method of collecting samples. If the selection bias is not taken into account then certain conclusions drawn may be wrong.

Not scientific method

But how we decide:

Status quo bias – the tendency to like things to stay relatively the same (see also loss aversion, endowment effect, and system justification).

Not scientific method

But how we decide:

Texas sharpshooter fallacy - pieces of information that have no relationship to one another are called out for their similarities, and that similarity is used for claiming the existence of a pattern.

What IS the scientific method?

Step 1

Ask a question – how, what, when, who, which, why, or where?

In order for the scientific method to answer the question, it must be about something that you can measure, preferably with a number.

What IS the scientific method?

Step 2

Gather information – observe – research.

What IS the scientific method?

Step 3

Make a hypothesis – an educated guess about how things work .

What IS the scientific method?

Step 3

Make a hypothesis – an educated guess about how things work .

a. Null hypothesis – the statistical hypothesis is false

b. Alternative hypothesis – the desired outcome

What IS the scientific method?

Step 4

Test your hypothesis by doing an experiment: investigation of whether the real world behaves as predicted by the hypothesis.

What IS the scientific method?

Step 4

The purpose of an experiment is to determine whether observations of the real world agree with or conflict with the predictions derived from a hypothesis.

What IS the scientific method?

Step 5

Analyze your data and draw a conclusion: determining what the results of the experiment show and what next steps.

Predictions of the hypothesis are compared to those of the null hypothesis to determine which is better able to explain the data.

What IS the scientific method?

3 key components to scientific method

1. Replication – if an experiment cannot be repeated to produce the same results, then original results were in error.

The foundation of modern research. How the scientific community enforces itself. A safeguard “for the creep of subjectivity.”

What IS the scientific method?

3 key components to scientific method

2. External review – peer review – evaluation of experiment by experts given anonymously.

What IS the scientific method?

3 key components to scientific method

3. Data recording and sharing – precision of data records, supply data to others who wish to replicate.

Scientific method v. Forensic Sciences

“The scientific method is instrumental to our understanding of the physical world. To scientists, the process is sacrosanct: Research your topic, generate a hypothesis, test the hypothesis, analyze your data and then publish the results for peer review.

Forensic science, however, was not developed by scientists. It was created by cops—often guided by little more than common sense—looking for reliable ways to match patterns from clues with evidence tied to suspects. What research has been done understandably focuses on finding new techniques for putting criminals in jail.”

Read more: “CSI Myths: The Shaky Science Behind Forensics” - Popular Mechanics December 2009

WE ARE LAWYERS, WHY DOES SCIENTIFIC METHOD MATTER?

- Conclusions drawn from testing are reliable only if the scientific method is followed.
- Daubert is, for better or worse, the legal embodiment of that. If you understand the outline of scientific method, you can use it to inform your critiques under Daubert.

Daubert – what is reliable?

- Whether a method can be or has been tested
- The known or potential rate of error
- Whether the methods have been subject to peer review
- Whether there are standards controlling the technique's operation
- The general acceptance of the method within the scientific community

What isn't reliable?

- Chapter 5 of the NAS report helps. It provides a critique of the most common purported disciplines you will encounter.

What isn't reliable?

"Although some of the techniques used by the forensic science disciplines—such as DNA analysis, serology, forensic pathology, toxicology, chemical analysis, and digital and multimedia forensics—are built on solid bases of theory and research, many other techniques have been developed heuristically."

What isn't reliable?

"That is, they are based on observation, experience, and reasoning without an underlying scientific theory, experiments designed to test the uncertainties and reliability of the method, or sufficient data that are collected and analyzed scientifically." NAS report p 128

What can be reliable?

"Among existing forensic science methods, only nuclear DNA analysis has been rigorously shown to have the capacity to consistently, and with a high degree of certainty, demonstrate a connection between an evidentiary sample and a specific individual or source." NSA report, 3-2

- DNA analysis does not even attempt to give us unique probability – that is to say two samples of DNA are the same to the exclusion of any other possible DNA sample in the world.
- DNA science and DNA experts give us statistics

Problems with testimony

Problems

- claims of perfect accuracy
- claims of infallibility
- claims of zero error rate

“I know a match when I see it.”

- “Fingerprint examiners typically testify in the language of absolute certainty,” professor Jennifer Mnookin at the Univ. of California Los Angeles has written. But like many other claims for forensic science, the assertion that fingerprints are unique lacked a solid scientific basis. Now is viewed with new caution.

But new research underway is taking on the fingerprint match probability problem. And preliminary results published in February in Significance, the magazine of the American Statistical Association and the UK's Royal Statistical Society, give a taste of what may one day be a new fingerprint evidence reality. The researchers' report announced the creation of a statistical model that will allow fingerprint evidence to be quantified so it can be accorded appropriate weight in courtrooms.

Cedric Neumann, Pennsylvania State University assistant professor of forensic science and statistics, is its lead author. “It is unthinkable that such valuable evidence should not be reported, effectively hidden from courts on a regular basis,” he said in a statement. “Such is the importance of this wealth of data, we have devised a reliable statistical model to enable the courts to evaluate fingerprint evidence within a framework similar to that which underpins DNA evidence.”

Wrongful convictions

“Invalid Forensic Science Testimony and Wrongful Convictions” Virginia Law Review March 2009 Garrett and Neufeld

Wrongful convictions

“Invalid Forensic Science Testimony and Wrongful Convictions” Virginia Law Review March 2009 Garrett and Neufeld

First study to explore the forensic study testimony by experts in the trials of innocent persons, all convicted of serious crimes, who were later exonerated.

Wrongful convictions

"Invalid Forensic Science Testimony and Wrongful Convictions" Virginia Law Review March 2009 Garrett and Neufeld

First study to explore the forensic study testimony by experts in the trials of innocent persons, all convicted of serious crimes, who were later exonerated. In 60% of these trials (82 cases of 156) forensic analysts provided invalid testimony at trial – testimony with conclusions misstating empirical data or conclusions wholly unsupported by empirical data.

Wrongful convictions

"Invalid Forensic Science Testimony and Wrongful Convictions" Virginia Law Review March 2009 Garrett and Neufeld

First study to explore the forensic study testimony by experts in the trials of innocent persons, all convicted of serious crimes, who were later exonerated. In 60% of these trials (82 cases of 156) forensic analysts provided invalid testimony at trial – testimony with conclusions misstating empirical data or conclusions wholly unsupported by empirical data. Study covered 72 analysts over 25 states.

Wrongful convictions

One way this happens:

Base rate fallacy – aka prosecutor's fallacy

Wrongful convictions

One way this happens:

Base rate fallacy – aka prosecutor's fallacy

Base Rate Fallacy: A base rate fallacy is committed when a person judges that an outcome will occur without considering prior knowledge of the probability that it will occur.

They focus on other information that just happened that is not important.

Base rate fallacy

For example, imagine that I show you a bag of 250 Skittles with equal numbers of 5 different colors. Then, I ask you what the probability is I will pick a red one while my eyes are closed? I also tell you that red Skittles are my favorite and yesterday I picked out twice as many red Skittles than yellow ones. If you ignored the fact that there are 50 of each color, and instead focused on the fact that I picked out twice as many red Skittles than yellow yesterday, you have commited a base rate fallacy because what I did yesterday is irrelevant information.

Base rate fallacy

Another definition of base rate fallacy: Ignoring statistical information in favor of using irrelevant information, that one incorrectly believes to be relevant, to make a judgment.

This usually stems from the irrational belief that statistics don’t apply in a situation, for one reason or another, when in fact they do.

Base rate fallacy

Reliable analysis requires consideration of the base rate – which is “how often does the indicator exist in the general population?”

Failure to consider base rate and reach a conclusion based only upon the accuracy of the test is the base rate fallacy.

Base rate fallacy

Any test that is less than 100% accurate will be wrong some percentage of the time.

Base rate fallacy

Unless you have considered the comparison group of “non-target” cases AND have accurate data concerning base rates then the conclusion may simply be an educated guess and that the odds could well be very high against the conclusion being right in any particular case.

Base rate fallacy

Example:

Only 4% of applicants make it the school I want to attend. But I am brilliant! They are certainly going to accept me!

Base rate fallacy

Example:

Only 4% of applicants make it the school I want to attend. But I am brilliant! They are certainly going to accept me!

Explanation: Statistically speaking, there is a 4% chance they will accept me. The school is for brilliant people, so the fact that I am brilliant is a necessary condition to be part of the 4% who do make it.

Bayes' theorem

This calculates the odds of one event happening given the odds of other related events. Some mathematicians refer to it simply as logical thinking, because Bayesian reasoning is something we do naturally.

Bayes' theorem

Thomas Bayes (/□beɪz/; 1701 – 7 April 1761) was an English mathematician and Presbyterian minister, known for having formulated a specific case of the theorem that bears his name: Bayes' theorem. Bayes never published what would eventually become his most famous accomplishment; his notes were edited and published after his death by Richard Price.

Bayes' theorem

Most common fallacies of statistical reasoning are easily avoided by using the Bayesian approach, which provides what some call "the only rational way to evaluate the weight of evidence."

Bayes' theorem

"How much more likely would it have been for this evidence to occur if A were true than if B were true?"

This question completely captures how strongly the evidence supports A compared to B. It must lead to one of three conclusions:

Bayes' theorem

1. The evidence would have been more likely to occur if A were true than if B were true. This implies the evidence supports A rather than B.

Bayes' theorem

1. The evidence would have been more likely to occur if A were true than if B were true. This implies the evidence supports A rather than B.
2. The evidence would be just as likely to occur if A were true as if B were true. This implies the evidence has no bearing on the question of whether A or B is more probable. Hence, the "evidence" isn't really evidence at all when it comes to evaluating the relative likelihood of these two hypothesis.

Bayes' theorem

1. The evidence would have been more likely to occur if A were true than if B were true. This implies the evidence supports A rather than B.
2. The evidence would be just as likely to occur if A were true as if B were true. This implies the evidence has no bearing on the question of whether A or B is more probable. Hence, the "evidence" isn't really evidence at all when it comes to evaluating the relative likelihood of these two hypothesis.
3. The evidence would have been more likely to occur if B were true than if A were true. This implies the evidence supports B rather than A.

Bayes' theorem

1. The evidence would have been more likely to occur if A were true than if B were true. This implies the evidence supports A rather than B.
2. The evidence would be just as likely to occur if A were true as if B were true. This implies the evidence has no bearing on the question of whether A or B is more probable. Hence, the "evidence" isn't really evidence at all when it comes to evaluating the relative likelihood of these two hypothesis.
3. The evidence would have been more likely to occur if B were true than if A were true. This implies the evidence supports B rather than A.

Bayes' theorem

Our intuition about what is, or is not evidence, and what is strong versus weak evidence, can be terribly wrong (see, for instance, the base rate fallacy).

Bayes' Theorem helps us avoid many thinking errors and biases.

Bayes' theorem

We simply need to get in the habit of asking, "How much more likely would this evidence have been to occur if A were true than if B were true?"

Bayes' theorem

Worried that your cat doesn't like you because she hasn't hung out with you in two days? Ask, "how much more likely would this be to occur if she liked me than if she didn't like me?"

Bayes' theorem

Believe that "an absence of evidence for A is not evidence of absence of A"?

Ask, "how much more likely would this absence of evidence for A be to occur if A were not true versus if A were true?

LIMITATIONS OF SCIENTIFIC METHOD IN FORENSICS

Observation.

We cannot (usually) observe the past. Items in the past may be remembered by some, but they cannot be seen, smelled, heard, tasted, or sensed in any way.

Observation is an activity in the present that requires the use of the senses.

LIMITATIONS OF SCIENTIFIC METHOD IN FORENSICS

Prediction.

Secondly, one cannot predict the past. Prediction is an activity in the present that looks to the future, not the past.

LIMITATIONS OF SCIENTIFIC METHOD IN FORENSICS

Design of experiment.

We cannot design experiments or controlled observations to determine what happened in the past. Experiments or controlled observations might help one see if a situation is possible or not possible under a set of defined circumstances, but we cannot design an experiment that will replicate the complex variety of conditions that existed in the past — conditions that are often not known in full detail.

LIMITATIONS OF SCIENTIFIC METHOD IN FORENSICS

A hypothesis confirmed by multiple experiments and observations in time may become a theory, but forensic science is not and should not be concerned with the formation of theories. Forensic science may use theories derived from the work of natural and physical scientists, but determining what happened and who is responsible are not scientific theories.

LIMITATIONS OF SCIENTIFIC METHOD IN FORENSICS

A hypothesis confirmed by multiple experiments and observations in time may become a theory, but forensic science is not and should not be concerned with the formation of theories. Forensic science may use theories derived from the work of natural and physical scientists, but determining what happened and who is responsible are not scientific theories.

LIMITATIONS OF SCIENTIFIC METHOD IN FORENSICS

A hypothesis confirmed by multiple experiments and observations in time may become a theory, but forensic science is not and should not be concerned with the formation of theories. Forensic science may use theories derived from the work of natural and physical scientists, but determining what happened and who is responsible are not scientific theories.

LIMITATIONS OF SCIENTIFIC METHOD IN FORENSICS

Forensic Sciences Study the Past and Not the Present.

The Forensic Scientific Method

Builds off of scientific method.

The Forensic Scientific Method

Builds off of scientific method.

Step 1

The forensic examiner, forensic pathologist or other consultant first obtains information about the incident of concern — the crime, the assault, the death, etc. The examiner learns the information from primary, “eyewitness” sources and makes initial assessments of the reliability of those witness accounts. The examiner anticipates the questions that others — family members, public health agencies, insurance agencies, law enforcement officers, attorneys, and the courts — will ask in the future.

The Forensic Scientific Method

Builds off of scientific method.

Step 2

Then, the examiner performs scientific procedures — an autopsy, the retrieval of evidence from a crime scene, crime scene photography, or any other forensic science analysis such as toxicology or firearms examination — with a focus on finding answers to the anticipated questions.

The Forensic Scientific Method

Builds off of scientific method.

Step 3

Following the acquisition of physical evidence from procedures, the examiner then compares the anamnestic data — data obtained from a history or the memories of witnesses — to the physical evidence, essentially asking the question, “Are the physical findings consistent with the events related by witnesses?”

The Forensic Scientific Method

Builds off of scientific method.

Step 3 (cont.)

If they are consistent, the witness or witnesses are reliable and truthful, even if and particularly if a witness is a suspect. If the witness accounts do not agree with the physical findings, then the witness or witnesses are not telling the truth.

During the analysis, the examiner may need to obtain more information until the quality and quantity of the information are sufficient to make assessments. Once the assessments are complete, the examiner then can offer opinions but only to a reasonable degree of medical or scientific certainty.

The Forensic Scientific Method

The standard scientific method does not allow for the acquisition of witness information. Scientists using the scientific method generate hypotheses from the observations of physical evidence only. This does not work when dealing with past events. The forensic scientist does not form a hypothesis as a natural or physical scientist would. The witnesses and other anamnestic data provide the hypothesis, and the forensic scientist's role is to test the veracity of that hypothesis.

So what do you do?

Find out everything you can about the process the expert used.

So what do you do?

Find out everything you can about the process the expert used.

Discovery demands – see Tony Rios presentation on Daubert litigation.

Prepare for Daubert hearing, trial cross.

So what do you do?

Find out everything you can about the process the expert used.

Demand:

- Accreditation for the lab
- Certification for the examiner
- Lab audits
- Personnel corrective actions – error rate
- Contamination records
- Written protocols or statement that there is no protocol
- Training guidelines or statement that there is no training guideline
- Quality assurance manual
- Scientific literature that supports the expert opinion -

So what do you do?

Find out everything you can about the process the expert used.

Cut to what should be the heart of the report:

1. Identify each opinion, then,
2. Request the factual basis for the opinion
3. Request the reasoning for the opinion
4. Request the methodology for the opinion

Resources

- 2009 NAS Report, “Strengthening Forensic Sciences, a Path Forward”
- Will have easy to use resources available on our training resources, compiled from public defender agencies throughout the country.

Questions/Comments

Travis Schwantes
(262)723-7922
SchwantesT@opd.wi.gov