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When does absence of evidence constitute evidence of absence?

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Abstract

Negative forensic evidence can be defined as the failure to find a trace after looking for it. Such evidence is often dismissed by referring to the aphorism “absence of evidence is not evidence of absence.” However, this reasoning can be misleading in the context of forensic science. This commentary is designed to help forensic scientists understand the probative value of negative forensic evidence.

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When does absence of evidence constitute evidence of absence?☆

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ABSTRACT

Negative forensic evidence can be defined as the failure to find a trace after looking for it. Such evidence is often dismissed by referring to the aphorism "absence of evidence is not evidence of absence." However, this reasoning can be misleading in the context of forensic science. This commentary is designed to help forensic scientists understand the probative value of negative forensic evidence.

Forensic science is sometimes said to be the science of traces. It involves detection and interpretation of the vestiges of past events, typically for the purpose of solving crime. One of the founders of forensic science, Edmond Locard, argued that "[i]t is impossible for a criminal to act, especially considering the intensity of a crime, without leaving traces of this presence" [1]. Locard's work gave rise to the exchange principle, which asserts that *every contact leaves a trace*.

The exchange principle cannot be entirely true, however, because not every contact leaves a trace, at least not a trace that can be detected. A criminal may handle a gun without leaving a fingerprint; fire the gun without having detectable amounts of gunshot residue on his person; and so on. Uncertainty about whether traces will be found is the basis for the common expression "absence of evidence is not evidence of absence." According to this expression, one should not infer the absence of contact from the absence of a trace because contact may occur without a trace being found.

Astute investigators recognize, however, that the absence of evidence can sometimes be highly probative. A famous passage from A. Conan Doyle's story *The Silver Blaze* [2] makes this point:

> Inspector Gregory: Is there any other point to which you would wish to draw my attention?
>
> Sherlock Holmes: To the curious incident of the dog in the night-time.
>
> Inspector Gregory: The dog did nothing in the night-time.
>
> Holmes: That was the curious incident.

Sherlock Holmes recognized that the dog was likely to have barked upon encountering a stranger during the night-time. From this, Holmes inferred that the perpetrator (who had acted by night) was not a stranger. In this instance the absence of evidence (failure of the dog to bark) was highly probative and, indeed, was the key to solving a difficult case.

This commentary is designed to help forensic scientists understand the probative value of *negative forensic evidence*, which we define as the failure to find a trace after looking for it. We hope to clarify when, why and to what extent the absence of evidence constitutes evidence of absence. Recent research indicates that lay people (such as jurors) do not fully understand the value of negative evidence [3]. Without adequate instruction forensic scientists may be confused as well.

When a particular activity is certain to leave a detectable trace, people generally appreciate that failure to find that trace proves the activity did not occur. For example, the proposition that a decedent was killed by gunshot is disproven definitively by finding no gunshot wound on the body. The absence of evidence (of a gunshot wound on the body) definitively disproves a particular proposition about criminal activity (i.e., that decedent was killed by a gunshot). Similarly, when a particular activity is certain *not* to leave a trace, people generally appreciate that failure to find a trace proves nothing. For example, failure to find semen in a vaginal sample proves nothing about whether a woman engaged in vaginal intercourse two weeks earlier because the chance of detecting semen in a vaginal sample after that

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length of time is nil [4]. In such cases, the absence of evidence is uninformative with regard to the activity.

In the previous examples the probative value of negative evidence is either all or nothing (i.e., definitive proof or worthless) depending on whether there is a 100% or 0% chance of detecting the trace if the proposed activity occurred. Negative evidence is harder to evaluate in cases where the probability of detection falls somewhere between 0% and 100%. Suppose, for example, that a toxicologist fails to detect metabolites of a drug in samples from a person who is alleged to have ingested the drug at a particular time; but the chance of detection under those circumstances is only about 50%. What value does this negative finding have for proving whether or not the person ingested the drug at the time alleged?

It is tempting to think that this negative finding has no value because it fails to distinguish the two alternative hypotheses: H1—that that the person did not ingest the drug; and H2—that the person did ingest the drug. Because the probability of detection is less than 100%, a negative finding could arise under either hypothesis. Those who discount the value of negative evidence in such cases sometimes cite the principle of falsification introduced by philosopher Karl Popper [5]. According to Popper, scientific findings can definitively negate (falsify) a hypothesis, but can never definitively prove that a hypothesis is correct. Hence, in our example, a positive finding of drug metabolites can definitively refute H1 (non-ingestion) but a negative finding cannot definitely affirm H1.

The Popperian argument is correct as far as it goes, but it can be misleading in the context of forensic science because it treats the value of negative evidence as all or nothing—as either definitive or worthless. It fails to recognize that evidence can be probative without being definitive—that evidence can support inferences about the likelihood that a particular hypothesis is true without proving the hypothesis definitively. Such evidence has value for what philosophers call inductive inference [6]. Sherlock Holmes must have recognized that the probability the dog would bark at a stranger was less than 100%. Perhaps the dog was asleep or drugged, or had wandered off. Nevertheless, Holmes thought it likely enough that the dog would have barked at a stranger to support an inference that the alternative hypothesis was true. The failure of the dog to bark thus supported the hypothesis that the perpetrator was known to the dog, even if it did not prove it definitively, because there was at least some chance the dog would have barked at an unknown person.

Statisticians have shown that likelihood ratios can be used to describe the inferential value of evidence—that is, the degree to which the evidence supports a particular hypothesis [7]. A likelihood ratio for negative evidence specifies the relative likelihood of a negative finding under alternative hypotheses about some activity.

Some numeric examples might be helpful. Returning to our toxicology example, suppose that the chance of a negative result will be 100% under H1 (when the person did *not* ingest the drug) because the test never produces false positives; but there is only a 50% chance of a positive results under H2 (when the person did ingest the drug) because the test detects the metabolites only half the time. Under these conditions, the likelihood ratio is:

$$p(\text{negative finding}|H1)/p(\text{negative finding}|H2) = 1.0/0.5 \text{ or } 2.$$

This means that the negative finding supports H1. A rational decision maker applying a Bayesian analysis will judge the odds that the person did not ingest the drug (H1) to be twice as high after learning about the negative finding than before learning about it [7].

The value of negative evidence will be reduced if the test has the potential to produce false positives, but a negative finding may still have substantial value. Suppose, for example, that people who have not ingested the drug falsely test positive 10% of the time (which means that the test correctly produces negative results only 90% of the time). Under these circumstances, the likelihood ratio is 0.9/0.5 = 1.8. The value of the negative finding is reduced, but it still provides some support for H1. A Bayesian decision maker will judge the odds that H1 is correct to be 1.8 times higher after learning about the negative test, than before learning it [7].

As a general matter, negative evidence has inferential value for supporting a particular hypothesis over an alternative hypothesis to the extent a negative result is more likely under the favored hypothesis than under the alternative hypothesis. This means that forensic scientists will need to think about the probability of a negative finding under the relevant hypotheses in order to assess the value of negative evidence. To draw scientifically sound conclusions they will need empirical data on the probability of detecting traces of various kinds under various circumstances.

Fortunately, valuable data of this kind have recently started to emerge—work on the persistence of sperm as a function of time since intercourse being a notable example [4]. If forensic scientists have access to relevant data, and know how to apply those data, they will be able to help legal decision makers draw better conclusions about the value of negative forensic evidence. This will allow legal fact-finders to think more like the astute Sherlock Holmes and less like the clueless Inspector Gregory.

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