

# Chapter XYZ: Weight of Evidence

## 1 Introduction

The aim of legal-fact finding is, quite literally, to find out the facts. To find out the facts—for example, whether or not the defendant embezzled a large sum of money as the prosecution claims—it is necessary to gather, scrutinize and assess evidence from a variety of sources. One side will present evidence against the defendant, and the other side, the defense, will present evidence in favor of the defendant. But this adversarial process must come to an end at some point. A decision about the facts must be made based on the evidence presented up to that point. This decision is preceded by another, namely a decision about whether the process of presenting, scrutinizing and assessing evidence should come to an end.

In principle, more evidence could always be presented about a disputed factual issue: witnesses, forensic experts, telephone conversations, camera recordings, and so on. But, at some point, gathering more evidence will no longer bring value in addition to what the evidence already available could do because the costs of seeking more evidence may become too great.

### 1.1 Epistemic value or informativeness

What does it mean for new evidence to be valuable? Some terminology can help here. New evidence can be *epistemically* or *informationally* valuable. It provides novel information that existing, already available evidence did not provide, where this novel information can be consistent or inconsistent with the existing evidence. New evidence can be valuable even when it does not provide novel information but simply agrees with other evidence, for example, when two witnesses report having seen the same thing. So, new evidence is epistemically valuable if it adds new information or strengthens the credibility of existing evidence. But, at some point, seeking more evidence will become less and less epistemically valuable.

## 1.2 Decisional value

The epistemic value of new evidence need not be the same as its *decisional* value. A new piece of evidence is decisionally valuable if, when added to the existing body of evidence, it would change the trial decision, given whatever decision criterion is used. A new piece of evidence can be epistemically valuable without being decisionally valuable, but not the other way around. Perhaps a new piece of evidence can add novel information or strengthen the credibility of other evidence, but these changes might not be significant enough to change the decision.

## 1.3 Overall value

Besides epistemic and decisional value of new evidence, a third concept is worth singling out: the *overall* value of new evidence. New evidence is valuable, all things considered, whenever it is worth seeking it and thus postponing the trial decision. New evidence is not valuable, all things considered, whenever it is not worth postponing the trial decision to seek it. We should not presuppose that evidence that is decisionally valuable—if added, it would change the trial decision—must be *ipso facto* also overall valuable. This evidence could be too expensive or even impossible to obtain. Having a detailed camera recording of what happened could have great decisional value, but this does not mean a trial judgment must be postponed until the recording is obtained. The costs of obtaining it might be too great.

In general, the question of whether to stop seeking more evidence is a practical question, moral or political. It requires balancing the costs of seeking more evidence with the epistemic and decisional value of the new evidence. These costs can be monetary, but in time and delayed trial decisions. Before performing this balancing act, however, we need an account of when additional evidence is epistemically and decisionally valuable.

We aim to provide an account of the epistemic value of new evidence here.

## 1.4 Prospective and retrospective question

The question of the epistemic value of new evidence need not be confined to evidence that has not yet been obtained. It could also concern evidence that was obtained. Or it could be about evidence that is missing and could no longer be obtained. So, the question about the value of evidence can be both prospective and retrospective. The prospective question should inform what investigators, prosecutors or defense lawyers do as they seek more evidence. The retrospective question assumes that seeking more evidence is impossible, but can still guide the trial decision.

## 1.5 Styled case

A stylized legal case will help fix ideas. A more detailed discussion of realistic legal cases is to be found at the end of this chapter.

The defendant confessed to having killed the victim when he burglarized the victim's apartment and stole cash and other valuables kept in a tin box. The confession was the prosecution's key incriminating evidence, but at trial, the defense raised doubt that the defendant was covering up for his son. This doubt was corroborated by the fact that the defendant was rather short and it would take a tall person to kill the victim. And the defendant's son was much taller. On the other hand, the defendant confessed and provided abundant details all consistent with the findings of the investigators. One piece of evidence is missing: because the defendant confessed right away, the investigators did not examine the tin box for fingerprints. The box was later wiped clean. Had they found the son's fingerprints on it, that would be evidence of the defendant's innocence.

This case raises several questions:

- First, question on the epistemic or informal value of the evidence. Retrospectively—knowing what we know now—what is the value of the missing fingerprint evidence? Prospectively—knowing what the investigators knew back then—what was the value of the fingerprint evidence?
- Second, questions about the decision. Retrospectively, would the fingerprint evidence, if it had been obtained during the investigation, have changed the trial decision? This retrospective question is relevant for another, related yet different question: Should the defendant be acquitted because of the missing fingerprint evidence?
- Third, questions about the overall value of the evidence. Prospectively or retrospectively, what should the investigators have done?

## 1.6 Weight v. balance of evidence

Another bit of terminology is worth mentioning. Sometimes the expression 'weight of evidence' is used, as opposed to 'balance of the evidence'. This distinction goes back to Keynes. The balance tracks whether the evidence presented tips for or against a hypothesis of interest. Weight, for Keynes, tracks the quantity of the evidence. Here both balance and weight are properties of the *total* body of evidence. Instead, the notion of epistemic or informational value of new evidence we are after is a property of a piece of evidence relative to an existing body of other evidence.

Section [2](#)

## 2 First pass

### 2.1 Absolute probability difference

Let's start with the simplest account of the value of new evidence, mostly in terms of a probability change. Formally, the epistemic value of new evidence  $E_n$ , against the background of other evidence  $E_b$ , can be measured by the probability change the new evidence brings about relative to a hypothesis  $H$  of interest. So the epistemic value of  $E_n$  given background evidence  $E_b$  relative to hypothesis  $H$  is the absolute difference

$$|P(H|E_b) - P(H|E_b \wedge E_n)|.$$

The greater this difference, positive or negative, the greater the epistemic or informational value of the new evidence. The smaller the difference, the lesser the value of the new evidence.

Dahlman's account of informativeness closely follows this definition. Nance offers a similar account. For him, the informational value (or weight) of the evidence is the absolute value of the log likelihood ratio

$$\log\left(\frac{P(E_n|H \wedge E_b)}{P(E_n|\neg H \wedge E_b)}\right).$$

As we know, likelihood ratios mirror changes in probabilities: the greater the likelihood ratio, the greater the change upwards, and the lower the likelihood ratio, the greater the change downwards.

### 2.2 Objection

This account, however, is not completely satisfactory, as it may count additional evidence as worthless, while it is instead quite valuable. Suppose two witnesses testify one in favor and another against the defendant, one says they were with the defendant when the crime occurred away from the crime scene, while the other says they saw the defendant around the crime scene at the relevant time. Absent any reason to believe one witness more than the other, assume the chances are 50/50, that is  $P(G|W1 \wedge W2) = .5$ . Next, we consult two other witnesses, and again we find one favoring the defendant and the other incriminating the defendant. So, again,  $P(G|W1 \wedge W2 \wedge W3 \wedge W4) = .5$ . The probabilities have not changed, but the testimonies of the two additional witnesses are not worthless.

### 2.3 Weighted probability difference

Here is a quick fix. True, after listening to the two additional witnesses, we realize their input is worthless. But *before* listening to them, we did not know what they would have said. They could have spoken both against (or in favor) of the defendant, and in that case, the probability of  $G$  would have changed quite dramatically, either upwards or downwards. So, there are three

possible scenarios: ( $S_1$ ) they both speak against the defendant; ( $S_2$ ) they both speak in favor; and ( $S_3$ ) they speak one in favor and the other against. If each scenario is  $1/3$  likely, there is a  $2/3$  chance the new evidence would be epistemically valuable and only a  $1/3$  chance it would not be. So, overall, the new evidence is valuable.

The proposal would be this. The epistemic value of new evidence  $E_n$  given  $E_b$  and relative to  $H$  is the weighted sum of the difference  $P(H|E_b) - P(H|E_b \wedge E_n^i)$ , where the weights are the probabilities of the scenarios  $P(S_i)$  that could materialize and  $i \in \{1, 2, 3, \dots, k\}$ :

$$\sum_1^k P(S_i) \times |P(H|E_b) - P(H|E_b \wedge E_n^i)|$$

## 2.4 Another objection (or recall higher-order probabilities)

This quick fix is still not satisfactory. In the previous chapter, we argued that precise probabilities are not enough because they fail to capture higher-order uncertainty. If precise probabilities are not enough to model uncertainty, then an account of the epistemic or informational value of new evidence that is based on precise probabilities will fall short for similar reasons.

Suppose an expert who listened to a telephone conversation testifies that the voice of the caller matches the defendant's voice. To quantify the uncertainty associated with the voice match, the expert introduces as is customary the random match probability, a number that expresses the likelihood that a random person would still be a match, simply by coincidence. This number is based on a probability model and sample data, so it is itself subject to uncertainty.<sup>1</sup>

Compare the voice expert with a genetic expert who testifies that the defendant genetically matches the crime traces. Suppose the genetic expert and the voice expert both testify, in different trials, that the defendant is a match, and they both give roughly similar random match probability. Should we say that both forms of evidence have the same value? After all, they change the guilt probability to the same extent. But the genetic match is better evidence than the voice match: better sample, better models, etc. Sticking to first-order probabilities neglects this additional layer of uncertainty and the difference between genetic match and voice match. The next section outlines the right account of the epistemic or informational value of the evidence. This account incorporates higher-order uncertainty.

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<sup>1</sup>This uncertainty is higher-order and is best modeled by a higher probability, a probability of a probability. What is the probability that the random match probability is what the expert says it is? Since the random match probability can take any value between 0 and 1, each of these values will have a higher-order probability, or in other words, there will be a distribution over the first-order probabilities (in this case, a distribution over the possible random match probabilities).

### **3 Our proposal**

### **4 Legal cases**

#### **4.1 Tin box**

#### **4.2 Missing fingers**