Probabilifying the Scenario Approach to Legal Proof

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Outline

1. Introduction
2. The Scenario Approach
3. Degree of Explanation
4. Fit with General Background Beliefs
5. Internal Coherence
6. Bayes Theorem, Internal Coherence, and Legal Proof
7. Summing Up

Introduction

- The scenario approach is a normative account of legal proof (van Koppen and Mackor, 2020; Mackor, 2021), of the descriptive story-based approach by Pennington and Hastie (1993).
- You should find a defendant guilty iff the best scenario implies that the defendant is guilty *and* the best scenario is much better than any scenario which implies the defendant's innocence.
- Scenario approach provides a set of criteria to evaluate scenarios against.
- It is commonly presented as an incompatible alternative to Bayesian accounts of legal proof (Mackor et al., 2021).

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- Explain which scenario strikes the best balance.

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- Problem: Even if precise criteria available, unclear how to weigh them against each other.
- Solution: Probabilify the scenario approach.
- The most probable scenario is the best.
- Explain which scenario strikes the best balance.
- Upshot: show that Bayesian accounts of legal proofs are not incompatible with the scenario approach.
- Upshot: provide a normative foundation for the scenario approach.

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The Scenario Approach

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- Each scenario either implies that the defendant is guilty or not guilty.
- A scenario is best among the available scenarios if it strikes the best balance between:
  - (i) explaining the available evidence,
  - (ii) fitting to the general background beliefs, and
  - (iii) exhibiting internal coherence.

Simonshaven case

A Dutch criminal case provided by Mackor (2021). The defendant Ed and his wife Jenny arrived at the Simonshaven forest by car and went for a walk, as eyewitnesses testified. There is evidence that Jenny was hit by a blunt object and died. There are two scenarios. According to the prosecution scenario, Ed killed his wife. On the defense scenario, a madman jumped out of the bushes who beat up both Ed and Jenny. As a result, Ed lost his consciousness for some time and Jenny died.

Comments on the Simonshaven case

- Both scenarios can explain the evidence.
- Both scenarios are internally coherent at least in so far their elements are logically consistent with one another.
- However, the madman scenario fits less well with our background beliefs than a scenario where a husband kills his wife (Mackor, 2021, p. 2414).
- Hence, the prosecution scenario is better than the defense scenario.

Comments on the Simonshaven case

- The scenario approach does not say what it means that a scenario is 'much better' than another.
- The scenario approach does not explain what it means that a scenario strikes the best balance on the three dimensions.

Again: the Scenario Approach

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Explaining the Available Evidence

- Standard explication of explanation: probability raising (Salmon, 1970).
- Applied to the scenario approach, a scenario S explains the available evidence E iff

$$P(E \mid S) > P(E),$$

where $P(E \mid S)$ is the conditional probability of E given that S and $P(E)$ is the probability of E.

Degree of Explanation

$$Exp(S, E) := \frac{P(E \mid S)}{P(E)}, \text{ if } P(E) > 0.$$

- If S explains E, $Exp(S, E) > 1$.
- If S does not bear on E, $Exp(S) = 1$.

Explaining the Available Evidence

- E: available evidence in the Simonshaven case—the eyewitness testimony and the autopsy of Jenny's injuries.
- S_E: scenario in which Ed kills Jenny
- S_M: scenario in which a madman kills Jenny.

$$P(E \mid S_E) \approx P(E \mid S_M).$$

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Fit with General Background Beliefs

The fit of a scenario S with the general background beliefs can be modelled by the probability of S given the background beliefs B.

Fit with General Background Beliefs

$$P_B(S) = P(S \mid B), \text{ if } P(B) > 0$$

Fit with General Background Beliefs

- That Jenny is killed by their partner is more plausible than that Jenny is killed by a madman jumping out of bushes.
- On our model, this comparative plausibility assessment translates into a comparative assessment of probabilities:

$$P(S_E \mid B) > P(S_M \mid B).$$

The Ed scenario fits better to the background beliefs than the madman scenario.

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Internal Coherence

- A scenario S has internal structure.
- $S \equiv S_1, \ldots, S_n$.
- Basic idea: if elements cohere well, they are more likely taken together than individually.
- $P(S_1, S_2) > P(S_1) \cdot P(S_2)$.

Internal Coherence

This idea generalizes to the Shogenji (1999) measure:

Coherence measure

$$Coh(S_1, \ldots, S_n) := \frac{P(S_1, \ldots, S_n)}{P(S_1) \cdot \ldots \cdot P(S_n)}, \text{ if } P(S_1), \ldots, P(S_n) > 0.$$

- If elements are independent, $Coh(S) = 1$.
- If elements cohere well, $Coh(S) > 1$.
- If elements don't cohere well, $Coh(S) < 1$.

Internal Coherence

- S_{E1}: Ed and Jenny go for a walk.
- S_{E2}: Jenny was attacked and died.
- S_{E3}: Ed killed Jenny in the forest.

$$Coh(S_E) = \frac{P(S_{E1}, S_{E2}, S_{E3})}{P(S_{E1}) \cdot P(S_{E2}) \cdot P(S_{E3})}.$$

The scenario coheres because the elements of the scenario are more likely to be true together than individually.

Internal Coherence

- $S_{M1} = S_{E1}$: Ed and Jenny go for a walk in the forest
- $S_{M2} = S_{E2}$: Jenny was attacked and died.
- S_{M3}: A madman jumped out of the bushes and attacked both Ed and Jenny so that Ed lost his consciousness and Jenny died.

$$Coh(S_M) = \frac{P(S_{M1}, S_{M2}, S_{M3})}{P(S_{M1}) \cdot P(S_{M2}) \cdot P(S_{M3})}.$$

The scenario is again coherent.

Internal Coherence

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Comments on Internal Coherence

- Both scenarios are internally coherent to a similar degree.
- Shogenji measure challenged by Fitelson (2003); Schupbach (2011), further developed by Hartmann and Trpin (forthcoming).

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Putting it all together

Bayes Theorem

$$P_B(S \mid E) = \frac{P_B(E \mid S)}{P_B(E)} \cdot P_B(S).$$

Given that a scenario S consists of elements $S_1, \ldots, S_n$:

Bayes Theorem

$$P_B(S \mid E) = \frac{P_B(E \mid S_1, \ldots, S_n)}{P_B(E)} \cdot P_B(S_1, \ldots, S_n).$$

Putting it all together

And, given our definitions of

- explaining the available evidence,
- fitting to the general background beliefs, and
- exhibiting internal coherence

above:

Posterior Probability of a Scenario S

$$P(S \mid E) = \underbrace{Exp(S, E)}_{\text{Degree of explanation}} \cdot \overbrace{\underbrace{Coh(S_1, \ldots, S_n)}_{\text{Internal coherence}} \cdot P(S_1) \cdot \ldots \cdot P(S_n)}^{\text{Fit with background beliefs}}.$$

Conviction

What does this say about the defendant's guilt and obligation to convict?

- The probability of any best scenario coincides with the probability that the defendant is guilty [extended argument, see paper].
- Convict if the probability of guilt is beyond reasonable doubt.
- Standard decision theoretic argument to find threshold.

Conviction

	G	$\neg G$
finding G	TG	FG
finding $\neg G$	FN	TN

Table: Decision matrix for finding guilty (G) or not ($\neg G$).

You should find the defendant guilty iff

$$P_B(G \mid E) > \frac{C(FG)}{C(FN) + C(FG)}$$

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Summing Up

- We have probabilified the scenario approach to legal proof. Internal coherence is a part of the fit with our background beliefs.
- Our probabilistic account makes precise how the three dimensions of the original scenario approach are to be weighted.
- Our account shows that reconciling the scenario approach and the Bayesian approach is possible.

Summing Up

- Inherits the normative justification of Bayesianism in terms of Dutch book arguments and epistemic utility arguments.
- Avoids confirmation biases as well as the base rate and prosecutor's fallacies.
- The most likely scenario strikes the best balance between explaining the evidence and fit to general background beliefs, including being internally coherent.

Open Problems

- Statistical evidence (but see Günther (2025)).
- Availability of of probability function to court of law.

References I

Branden Fitelson. 2003. A Probabilistic Theory of Coherence. *Analysis*, 63(3):194–199. Publisher: [Analysis Committee, Oxford University Press].

Mario Günther. 2025. Probability of Guilt. *Canadian Journal of Philosophy*, pages 1–18.

Stephan Hartmann and Borut Trpin. forthcoming. Why Coherence Matters. *The Journal of Philosophy*.

Peter J. van Koppen and Anne Ruth Mackor. 2020. A Scenario Approach to the Simonshaven Case. *Topics in Cognitive Science*, 12(4):1132–1151.

Anne-Ruth Mackor. 2021. Different Ways of Being Naked.: A Scenario Approach to the Naked Statistical Evidence Problem. *Journal of Applied Logics — IfCoLog Journal of Logics and their Applications*, 8(9):2407–2432. Publisher: College Publications.

References II

Anne Ruth Mackor, Hylke Jellema, and Peter J. van Koppen. 2021. Explanation-Based Approaches to Reasoning about Evidence and Proof in Criminal Trials. In Bartosz Brożek, Jaap Hage, and Nicole Vincent, editors, *Law and Mind: A Survey of Law and the Cognitive Sciences*, Law and the Cognitive Sciences, pages 431–470. Cambridge University Press, Cambridge.

Nancy Pennington and Reid Hastie. 1993. *The Story Model for Juror Decision Making*. Cambridge University Press, Cambridge.

Wesley C. Salmon. 1970. Statistical Explanation. In Robert G. Colodny, editor, *The Nature and Function of Scientific Theories: Essays in Contemporary Science and Philosophy*, pages 173–231. University of Pittsburgh Press.

Jonah N. Schupbach. 2011. New Hope for Shogenji's Coherence Measure. *The British Journal for the Philosophy of Science*, 62(1):125–142.

References III

Tomoji Shogenji. 1999. Is Coherence Truth Conducive? *Analysis*, 59(4):338–345.