Spring School on Argumentation in Artificial Intelligence and Law

Day 3 Thursday April 12

Evidence

8:30	Burdens of proof in the law (Giovanni Sartor)
10:00	*Break*
10:30	Three approaches to rational proof in criminal cases (Henry Prakken)
12:00	*Break*
14:30	Hybrid models of rational legal proof (Bart Verheij)
16:00	*Break*
16:30	Discussion
17:30	

Hybrid models of rational legal proof

Bart Verheij

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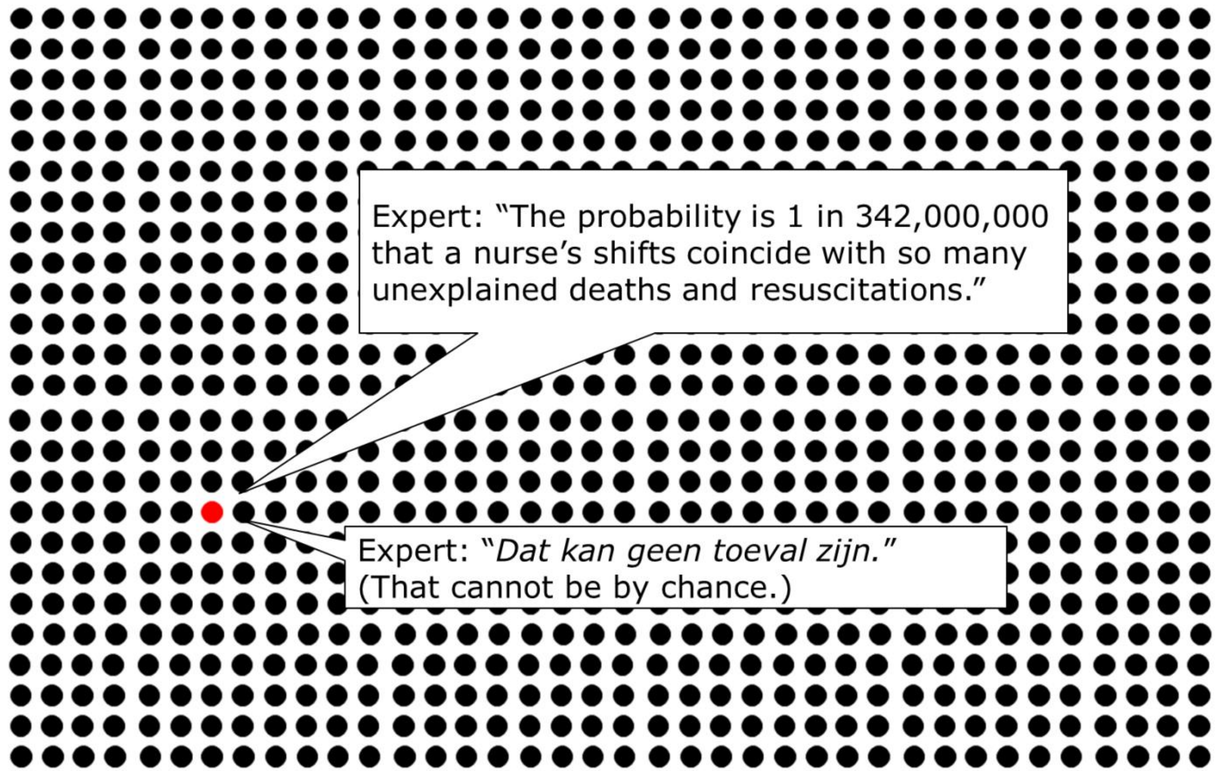
university of groningen

faculty of mathematics and natural sciences

How can forensic evidence be handled effectively and safely?



Analyses of what went wrong

1. The statistical calculations were erroneous.
   - Wrongly combining p-values

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   Biased data collection

Analyses of what went wrong

1. The statistical calculations were erroneous.
   Wrongly combining p-values

2. The statistics were erroneous.
   Biased data collection

3. The statistics only show that what happened is rare.
   Lack of context

What makes a suspect’s guilt convincing?

When the context speaks for itself.

E.g.,

- The murder weapon is found.
- Fingerprints found on the gun match the suspect’s.
- The suspect has `shooting hands’.
- The suspect is a known hitman.
- The victim was a drug dealer involved in a gang war.
- …

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- Fingerprints fo... ...e gun match the suspect's.
- The susp... ...hooting hands'.
- The ... a known hitman.
- ... was a drug dealer involved in a gang

...

Concrete facts in context

Goal:

promote rational handling of evidence in courts

Tool needed:

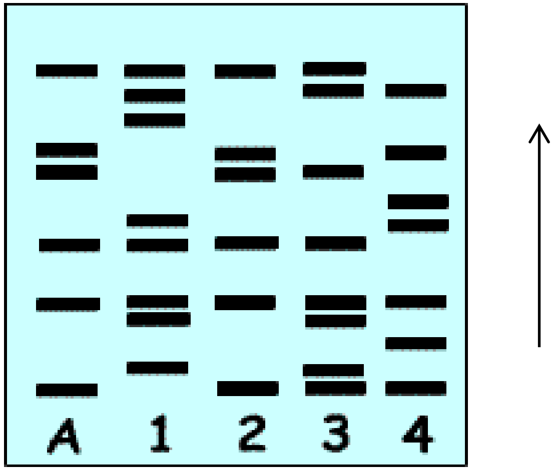
a normative framework

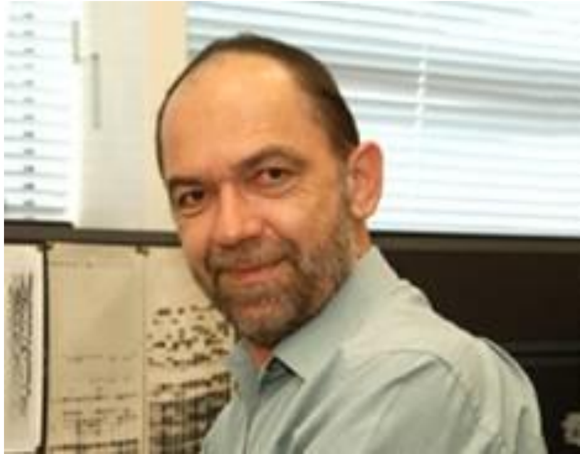
shared between experts and factfinders

DNA profiling

Successful

- High information value
- Scientific foundation
- Precise statistical information (Random Match Probability)





DNA profiling

DNA Profile		Allele frequency from database				Genotype frequency for locus	
Locus	Alleles	Times allele observed	Size of database	Frequency		Formula	Number
CSF1PO	10	109	432	$p=$	0.25	$2pq$	0.16
	11	134		$q=$	0.31		
TPOX	8	229	432	$p=$	0.53	p^2	0.28
	8						
THO1	6	102	428	$p=$	0.24	$2pq$	0.07
	7	64		$q=$	0.15		
vWA	16	91	428	$p=$	0.21	p^2	0.05
	16						
					profile frequency=		**0.00014**

Roughly
1 in 7000

Random Match Probability

Charles H. Brenner

“The DNA effect”

By the success and nature of DNA the following idea has gained momentum:

Evidence is only valuable when it comes with scientifically supported statistics.

(Cf. the CSI effect;
http://en.wikipedia.org/wiki/CSI_effect)

Proof
With and Without Probabilities

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Goal:

promote rational handling of evidence in courts

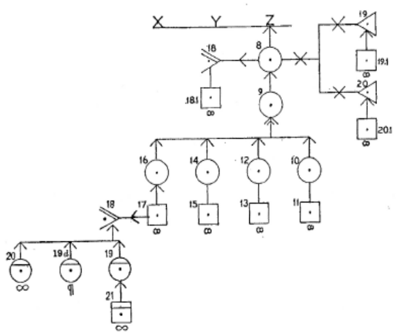
Tool needed:

a normative framework

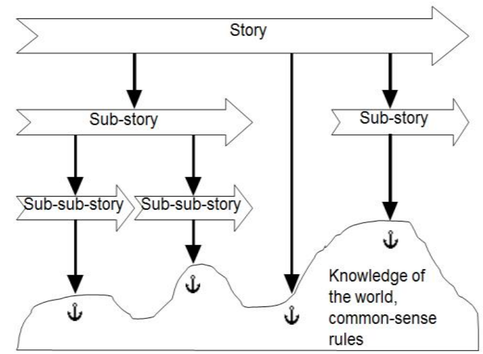
shared between experts and factfinders

Three normative frameworks

Arguments



Scenarios



Probabilities

$$\frac{p(H|E)}{p(not\text{-}H|E)} = \frac{p(E|H)}{p(E|not\text{-}H)} \cdot \frac{p(H)}{p(not\text{-}H)}$$

Posterior odds = Likelihood ratio · Prior odds

Three normative frameworks

$$\frac{p(H|E)}{p(not\!-\!H|E)} = \frac{p(E|H)}{p(E|not\!-\!H)} \cdot \frac{p(H)}{p(not\!-\!H)}$$

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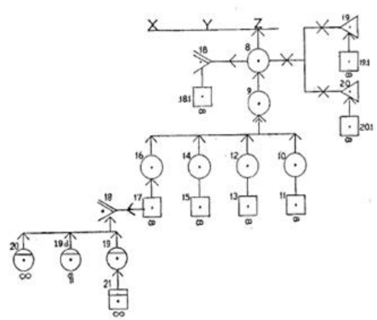
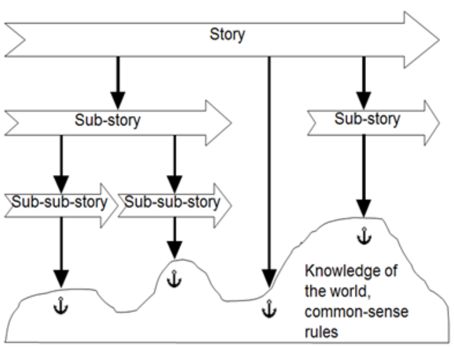
Probabilities

E.g., follow the calculus, don’t transpose conditional probabilities, don’t forget prior probabilities



Argumentation

E.g., take all arguments into account, both pro and con, assess strength and relative strength, avoid fallacies



Scenarios

E.g., consider alternative scenarios, assess plausibility and coherence, consider which evidence is explained or contradicted

Three normative frameworks

$$\frac{p(H|E)}{p(not{-}H|E)} = \frac{p(E|H)}{p(E|not{-}H)} \cdot \frac{p(H)}{p(not{-}H)}$$

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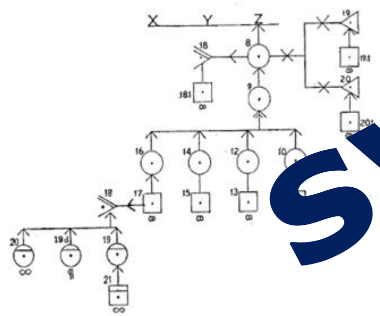

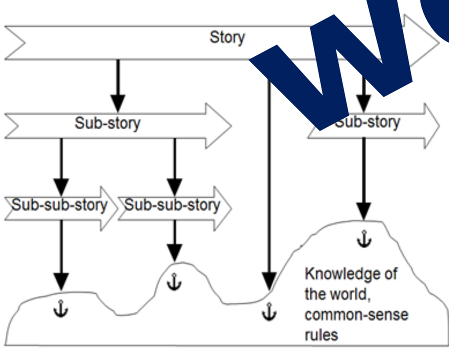

Probabilities

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Argumentation

E.g., take all arguments into account, both pro and con, assess strength and relative strength, avoid fallacies

Scenarios

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systematic, well-regulated

EVIDENTIAL REASONING
Chapter for the Handbook of Legal Reasoning

Marcello Di Bello & Bart Verheij – April 19, 2017

Contents

Conflicting evidence

Arguments Three kinds of attack can be distinguished: rebutting, undercutting and undermining. Three kinds of support can be distinguished: multiple, subordinated and coordinated. Arguments can involve complex structures of supporting and attacking reasons.

Scenarios There may be conflicting scenarios about what has happened. Evidence can be explained by one scenario, but not by another. Scenarios can be contradicted by evidence.

Probabilities Support can be characterized as "probability increase" or "positive likelihood ratio". Attack can be characterized as "probability decrease" or "negative likelihood ratio". The conflict between two pieces of evidence can be described probabilistically.

Evidential value

Probabilities The incremental evidential value is measured by probabilistic change. The overall evidential value is measured by the overall conditional probability. The use of evidence with high incremental evidential value has complications.

Arguments The reasons used can be conclusive or defeasible. Arguments can be evaluated by asking critical questions. It can be subject to debate whether a reason supports or attacks a conclusion.

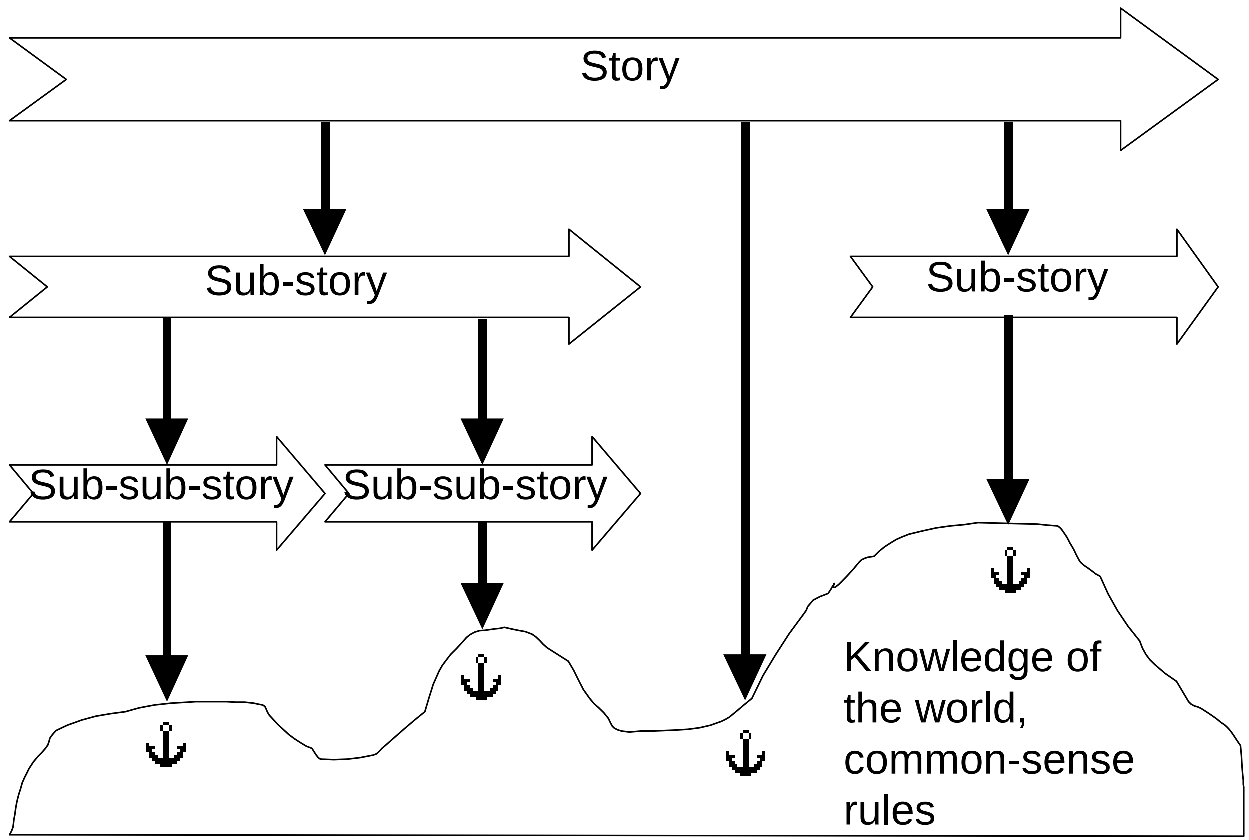
Scenarios Scenarios can be plausible and logically consistent. The more evidence a scenario can explain, the better. The more pieces of evidence a scenario is consistent with, the

Introduction

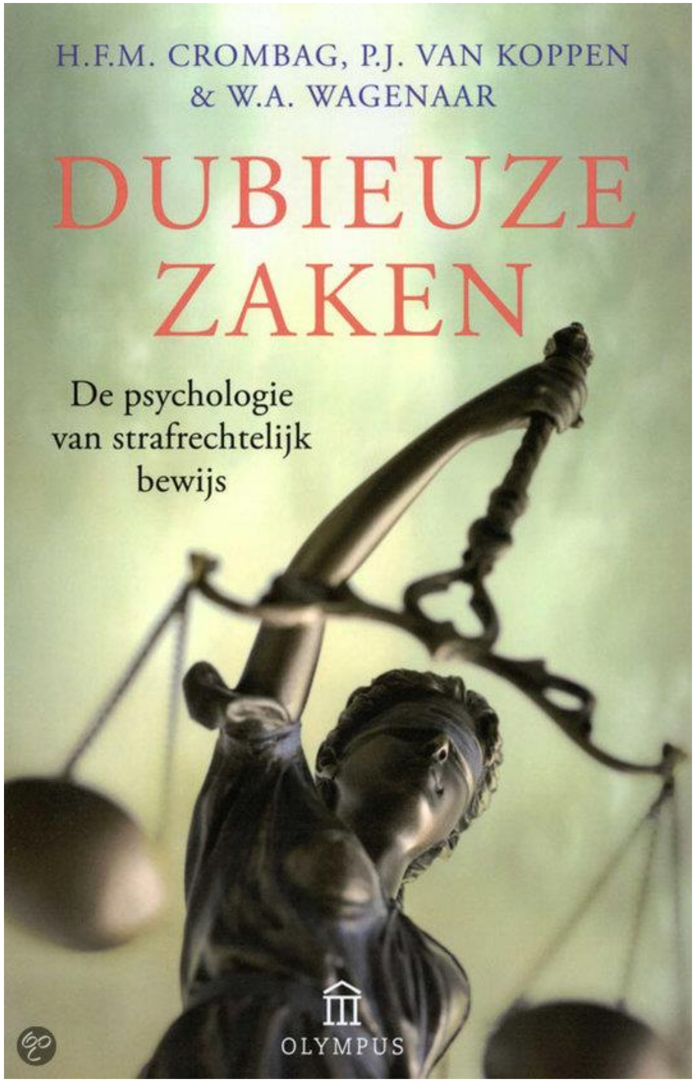
Hybrid models

AI & Law

Anchored narratives



Crombag, H.F.M., van Koppen, P.J., and Wagenaar, W.A. (1992, 1994), *Dubieuze Zaken: De Psychologie van Strafrechtelijk Bewijs. (Dubious Cases. The Psychology of Criminal Evidence.)* (Amsterdam: Contact).



geredetwijfel.nl

Ten universal rules of evidence

1. The prosecution must present at least **one well-shaped narrative**.
2. The prosecution must present **a limited set of well-shaped narratives**.
3. **Essential components** of the narrative must be **anchored**.
4. **Anchors** for different components of the charge **should be independent** of each other.
5. The trier of fact should give **reasons for the decision** by specifying the narrative and the accompanying anchoring.
6. A fact-finder's decision as to **the level of analysis** of the evidence **should be explained through an articulation of the general beliefs used as anchors**.
7. There should be **no competing story** with equally good or better anchoring.
8. There should be **no falsifications of the** indictment's **narrative** and nested sub-narratives.
9. There should be **no anchoring onto obviously false beliefs**.
10. **The indictment and the verdict should contain the same narrative**.

Wagenaar, W.A., van Koppen, P.J., and Crombag, H.F.M. (1993), *Anchored Narratives. The Psychology of Criminal Evidence* (London: Harvester Wheatsheaf).

Anchored narratives

ANT can be regarded as a mixed approach, with story-based and argument-based elements.

Verheij, B. (2000). Dialectical Argumentation as a Heuristic for Courtroom Decision Making. *Rationality, Information and Progress in Law and Psychology. Liber Amicorum Hans F. Crombag* (eds. van Koppen, P.J., & Roos, N.), 203-226. Maastricht: Metajuridica Publications.

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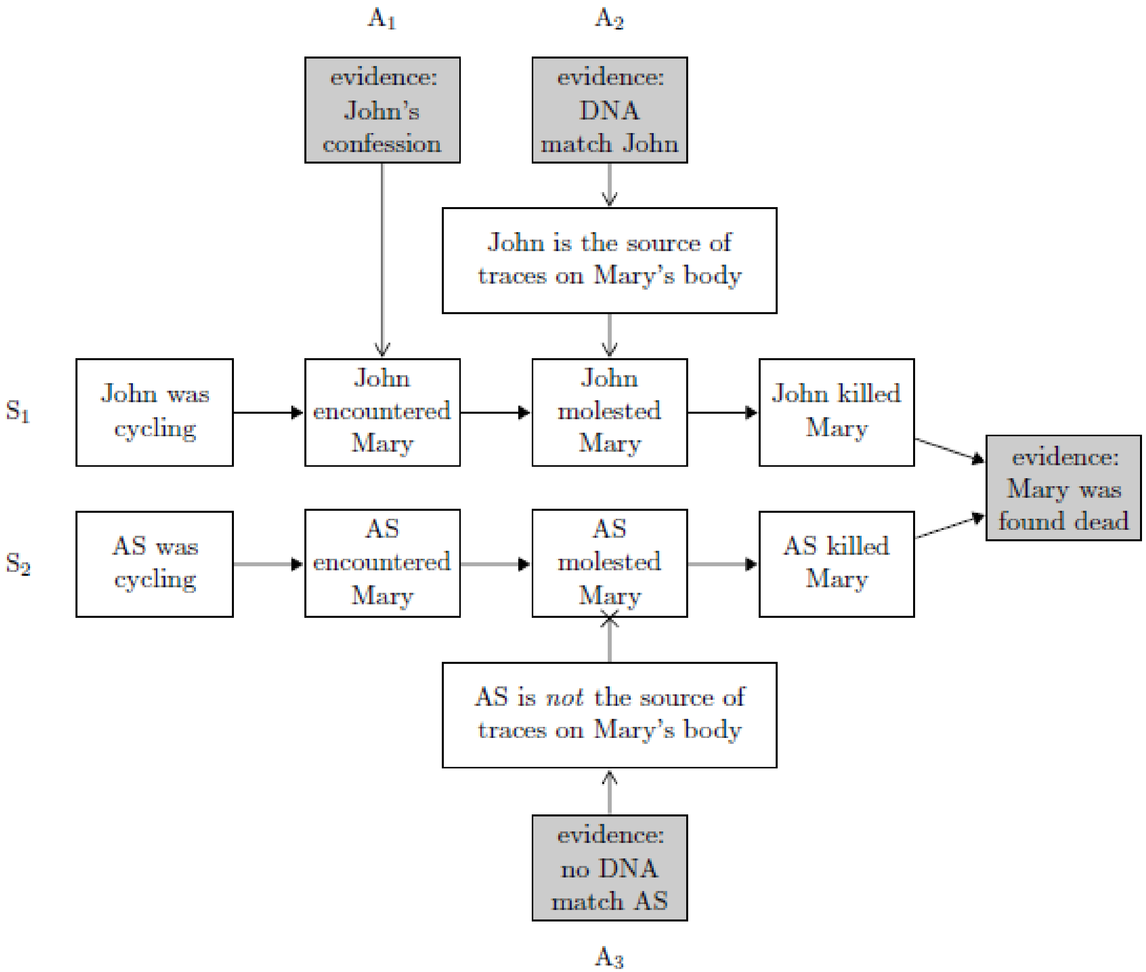
Arguments and scenarios



Bex 2009 dissertation

Connecting arguments and scenarios: a hybrid theory

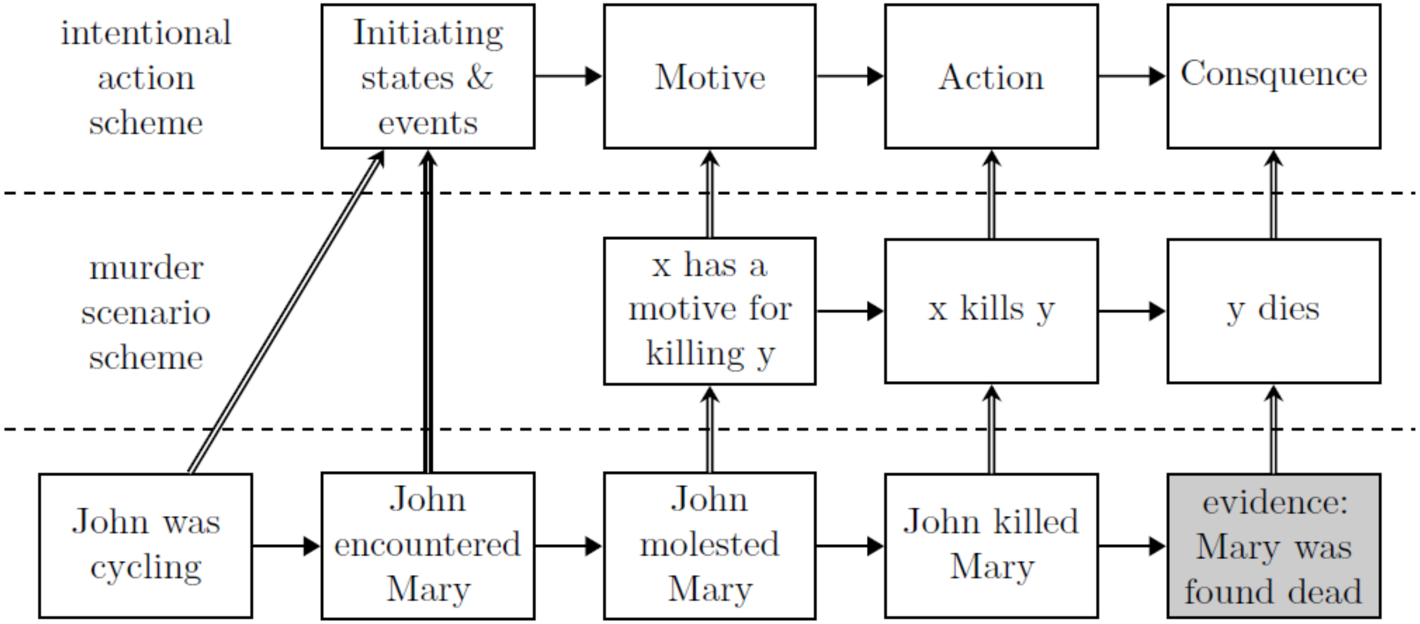


Figure 4: The scenario S_1 as an instance of different scenario schemes

Bex 2009 dissertation

Bayesian networks

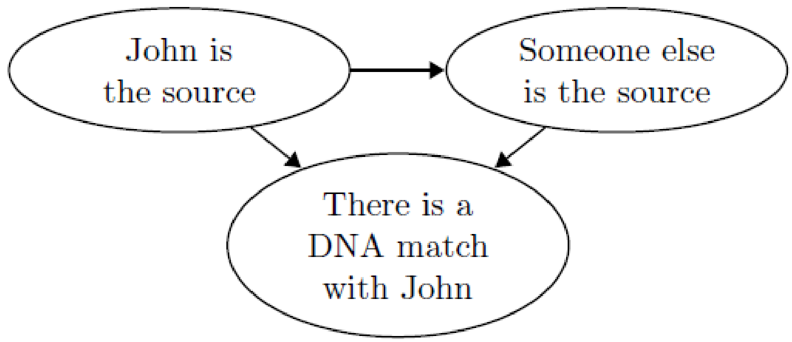


Figure 5: A Bayesian network structure with dependency relations

John is the source

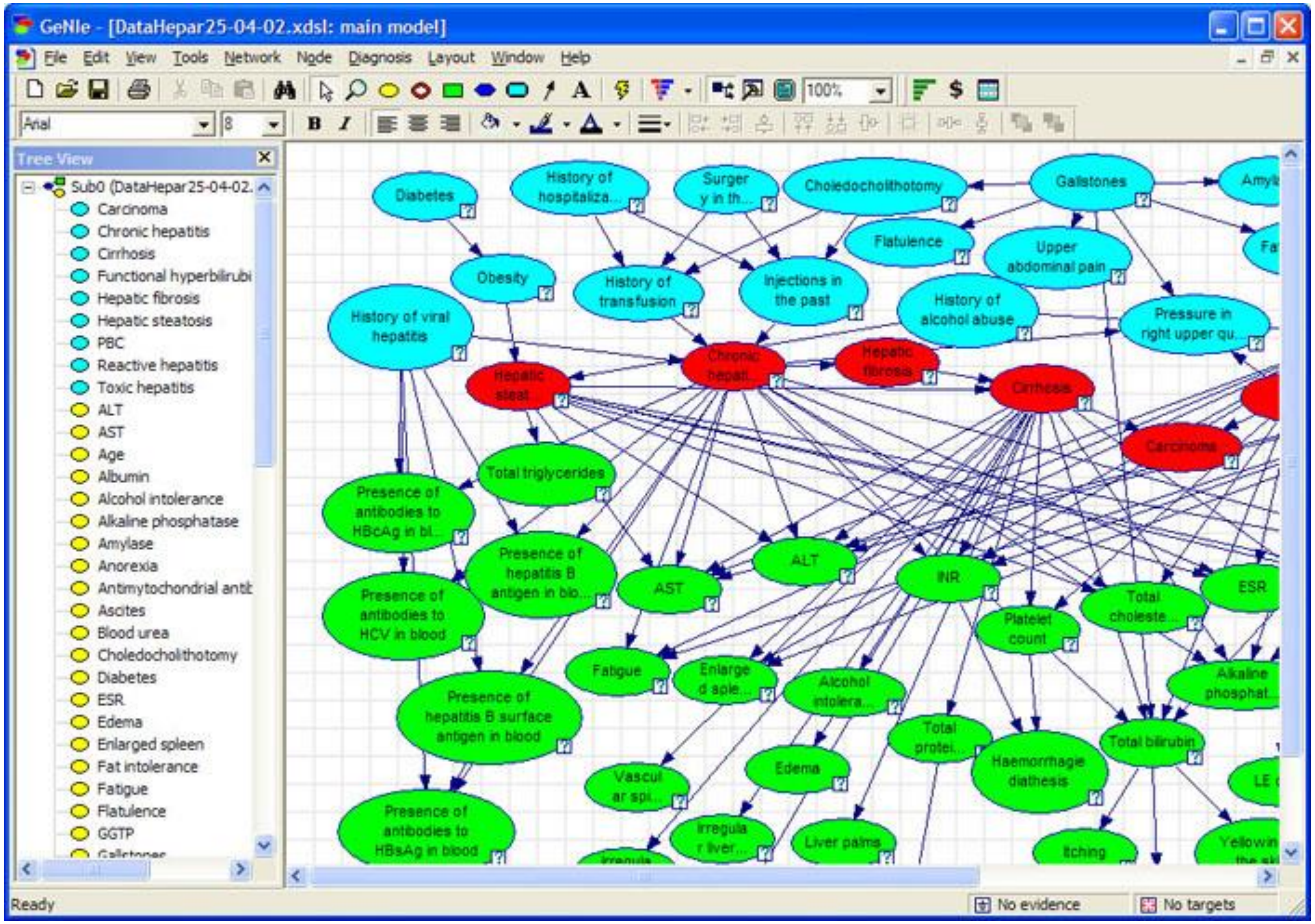
John is the source = false	8000/8001
John is the source = true	1/8001

Someone else is the source

John is the source	false	true
Someone else is the source = false	0	1
Someone else is the source = true	1	0

DNA match

John is the source	false		true	
Someone else	false	true	false	true
DNA match = false	0.5*	$1 - 0.66 \cdot 10^{-21}$	0	0.5*
DNA match = true	0.5*	$0.66 \cdot 10^{-21}$	1	0.5*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File Edit View Tools Network Node Diagnosis Layout Window Help
100%
Arial
8
Tree View
Sub0 (DataHepar25-04-02.
Carcinoma
Chronic hepatitis
Cirrhosis
Functional hyperbilirubi
Hepatic fibrosis
Hepatic steatosis
PBC
Reactive hepatitis
Toxic hepatitis
ALT
AST
Age
Albumin
Alcohol intolerance
Alkaline phosphatase
Amylase
Anorexia
Antimytochondrial antib
Ascites
Blood urea
Choledocholithotomy
Diabetes
ESR
Edema
Enlarged spleen
Fat intolerance
Fatigue
Flatulence
GGTP
Diabetes
History of hospitaliza...
Surger y in th...
Choledocholithotomy
Gallstones
Flatulence
Upper abdominal pain
Obesity
History of transfusion
Injections in the past
History of alcohol abuse
History of viral hepatitis
Pressure in right upper qu...
Hepatic steat...
Chronic hepati...
Hepatic fibrosis
Cirrhosis
Carcinoma
Total triglycerides
Presence of antibodies to HBcAg in bl...
Presence of hepatitis B antigen in blo...
AST
ALT
INR
ESR
Platelet count
Total choleste...
Presence of antibodies to HCV in blood
Fatigue
Enlarge d sple...
Alcohol intolera...
Alkaline phosphat...
Presence of hepatitis B surface antigen in blood
Total protei...
Haemorrhagic diathesis
Total bilirubin
Vascul ar spi...
Edema
Irregula r liver...
Liver palms
Itching
Presence of antibodies to HBsAg in blood
Ready
No evidence
No targets

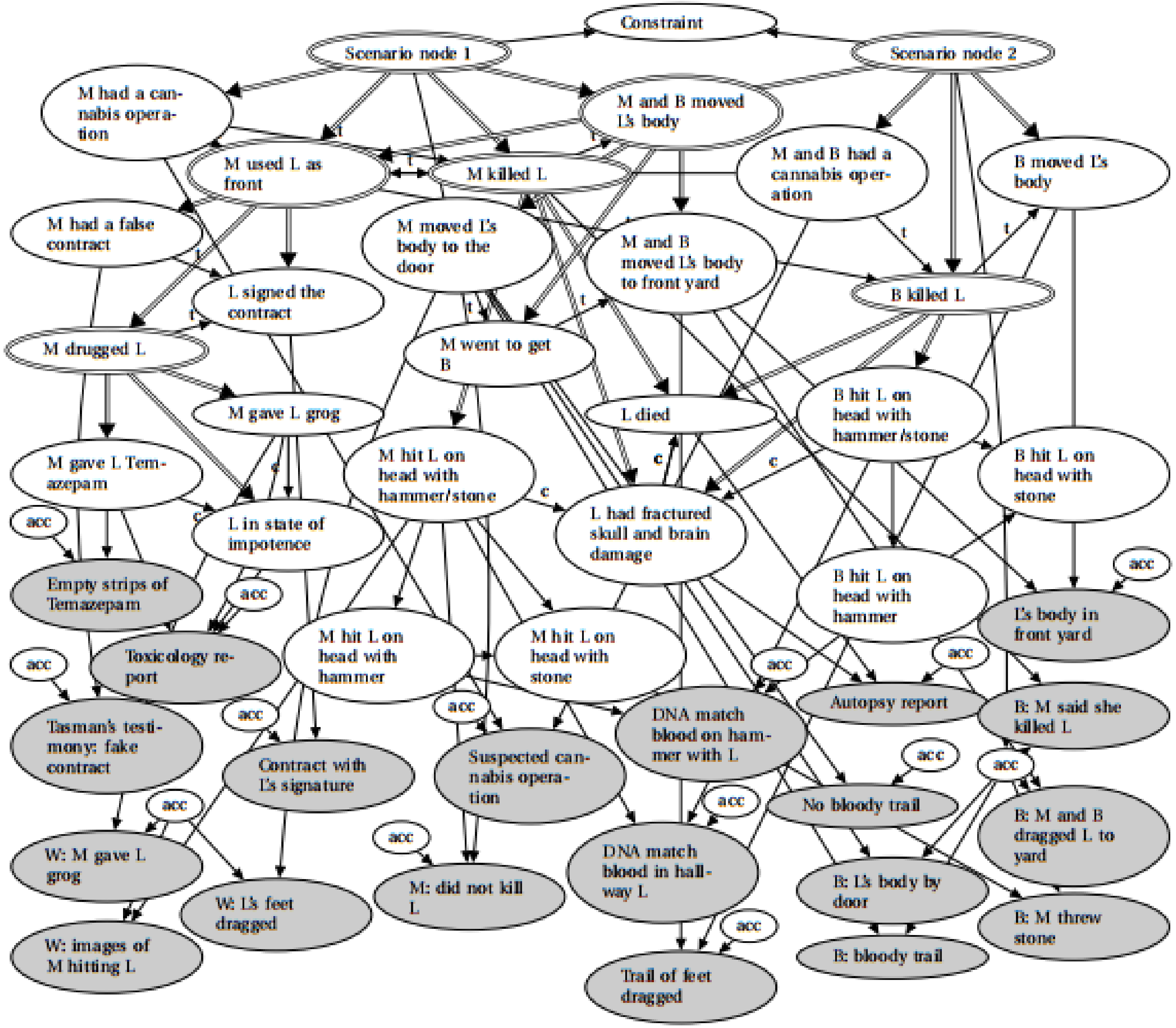


Figure 4.11: Scenario 1 and scenario 2 with evidence. Evidential nodes are indicated as grey nodes.

Vlek 2016 dissertation

114 *Chapter 6. Case study: the Nijmegen case*

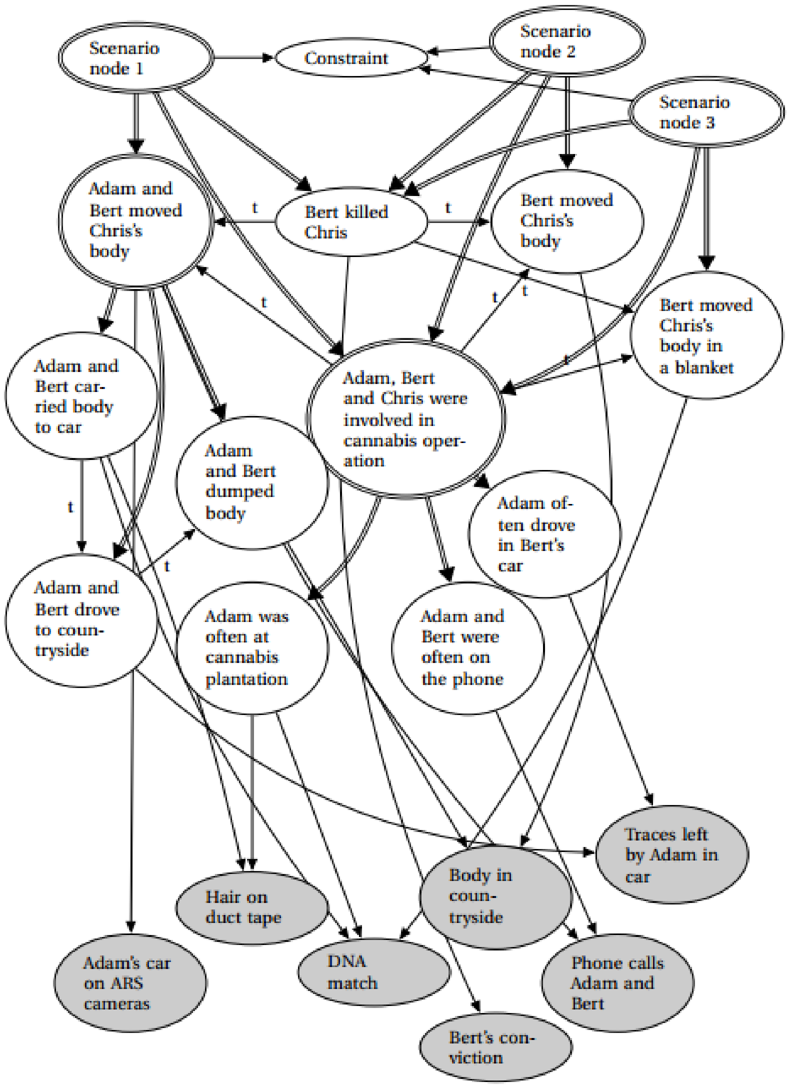


Figure 6.5: A network for the case study: The three scenarios with evidence. Evidential nodes are indicated as grey nodes.

Vlek 2016 dissertation

- **Scenarios in the network**:
  - Scenario 1 (prior probability: 0.001, posterior probability: 0.5296):

    Scenario: Bert killed Chris, and Adam, Bert and Chris were involved in cannabis operation. Then Adam and Bert moved Chris's body.

    Adam, Bert and Chris were involved in cannabis operation: Adam was often at cannabis location and Adam and Bert were often on the phone and Adam often drove in Bert's car.

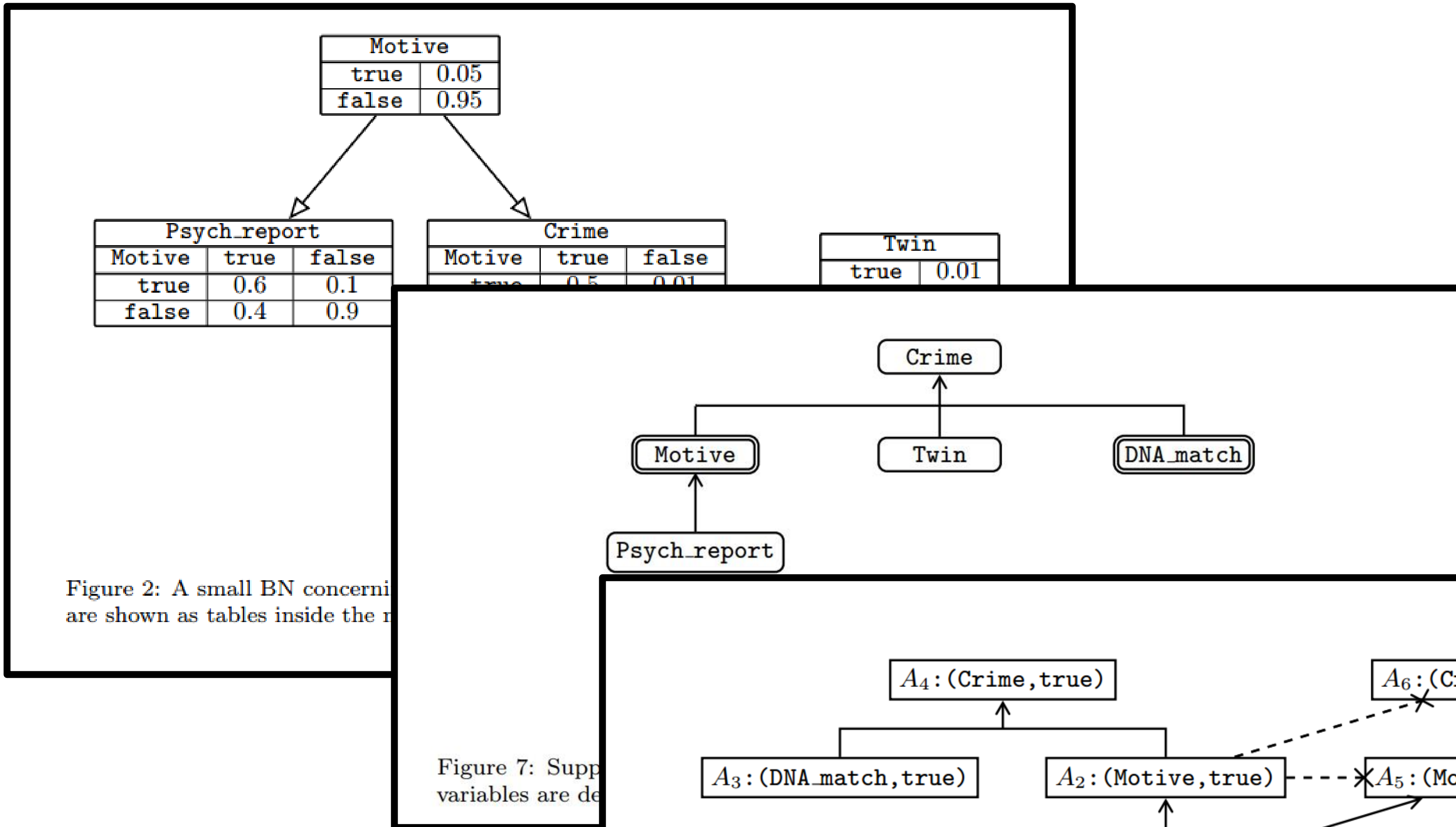
    Adam and Bert moved Chris's body: Adam and Bert carried body to car. Then Adam and Bert drove to countryside. Then Adam and Bert dumped body.
  - Scenario 2 (prior probability: 0.001, posterior probability: 0.1180):

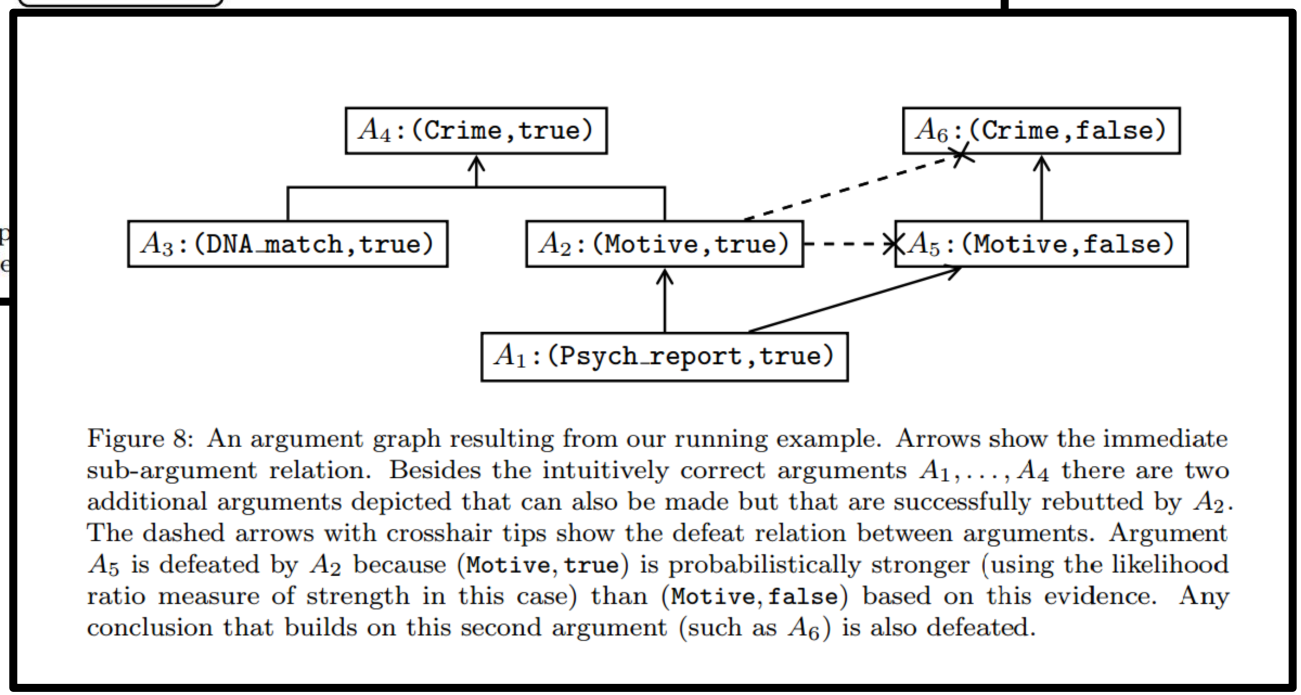
    Scenario: Bert killed Chris, and Adam, Bert and Chris were involved in cannabis operation. Then Bert moved Chris's body.

    Adam, Bert and Chris were involved in cannabis operation: Adam was often at cannabis location and Adam and Bert were often on the phone and Adam often drove in Bert's car.
  - Scenario 3 (prior probability: 0.001, posterior probability: 0.2913):

    Scenario: Bert killed Chris, and Adam, Bert and Chris were involved in cannabis operation. Then Bert moved Chris's body in a blanket.

    Adam, Bert and Chris were involved in cannabis operation: Adam was often at cannabis location and Adam and Bert were often on the phone and Adam often drove in Bert's car.
- **Scenario quality**
  - Scenario 1 is complete and consistent. It contains the supported implausible element `Bert killed Chris`.
  - Scenario 2 is complete and consistent. It contains the supported implausible element `Bert killed Chris`.
  - Scenario 3 is complete and consistent. It contains the supported implausible element `Bert killed Chris`.
- **Evidence related to each scenario**
  - Evidence for and against scenario 1:
    * Adam's car not on ARS cameras: weak evidence to attack scenario 1.
    * DNA match: moderate evidence to support scenario 1.
    * Hair on duct tape: moderate evidence to support scenario 1.
    * Bert's conviction: moderate evidence to support scenario 1.
    * Body in countryside: strong evidence to support scenario 1.
    * Phone calls Adam and Bert: weak evidence to support scenario 1.
    * Traces of Adam in car: weak evidence to support scenario 1.
    * All evidence combined: strong evidence to support scenario 1.
  - Evidence for and against scenario 2:
    * Adam's car not on ARS cameras: weak evidence to attack scenario 2.
    * DNA match: moderate evidence to support scenario 2.





Timmer 2017 dissertation

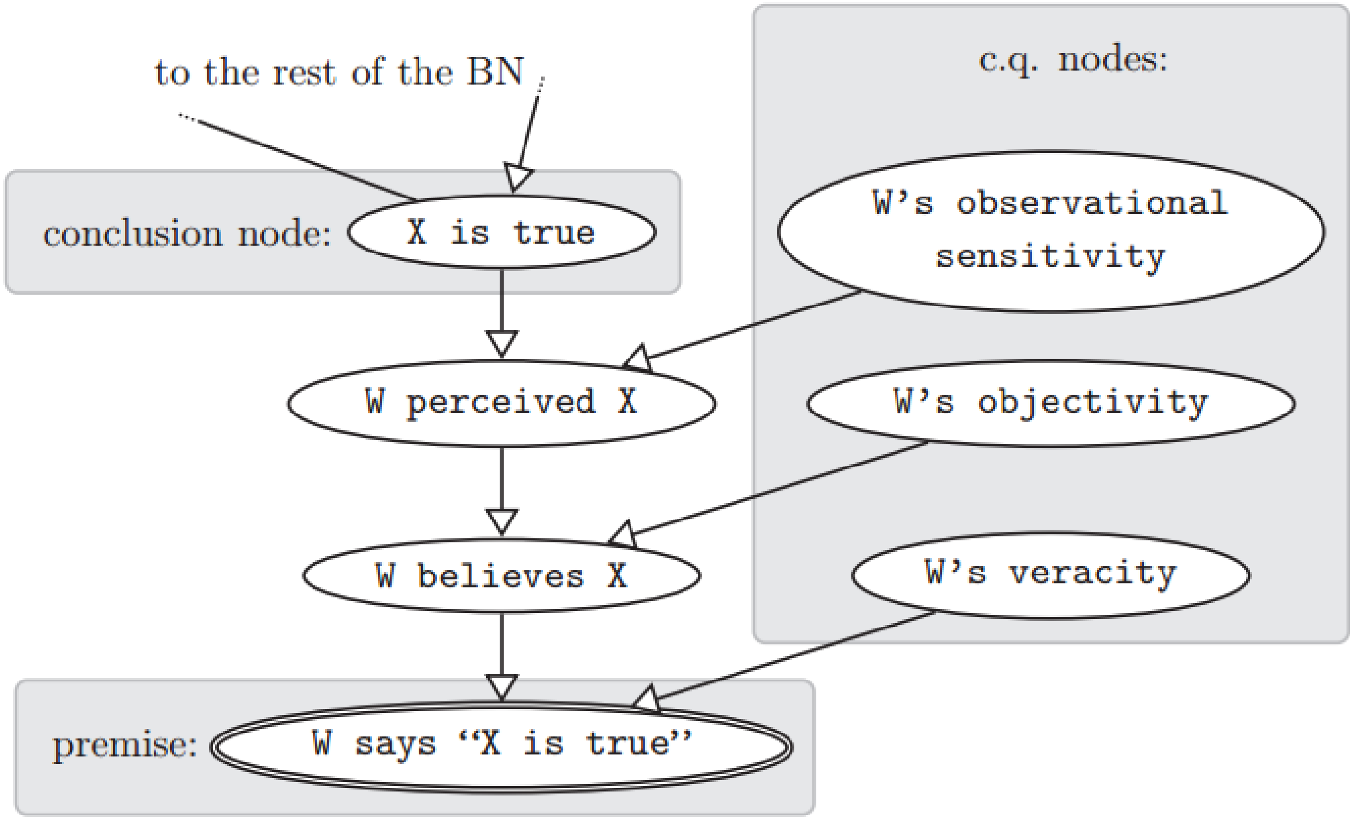


Figure 5.7: Modelling critical questions as a chain of exceptions.

Timmer 2017 dissertation

NWO Forensic Science project

- A method to incorporate argument schemes in a Bayesian Network (Timmer, 2017; Timmer et al., 2015a);
- An algorithm to extract argumentative information from a Bayesian Network modeling hypotheses and evidence (Timmer, 2017; Timmer et al., 2016);
- A method to manually design a Bayesian Network incorporating hypothetical scenarios and the available evidence (Vlek, 2016; Vlek et al., 2014);
- A method to generate a structured explanatory text of a Bayesian Network modeled according to this method (Vlek, 2016; Vlek et al., 2016);
- A case study testing the design method (Vlek, 2016; Vlek et al., 2014);
- A case study testing the explanation method (Vlek, 2016).

http://www.ai.rug.nl/~verheij/nwofs/

Bayesian Network modeling with idioms

Strengths

- Explicit complex model (allows for discussion)
- Correct calculations (supported by software)
- Systematic, reusable (idioms)

Issues

- Design (numbers, dependencies, compositionality of idioms)
- Interpretation (formal versus material meaning)

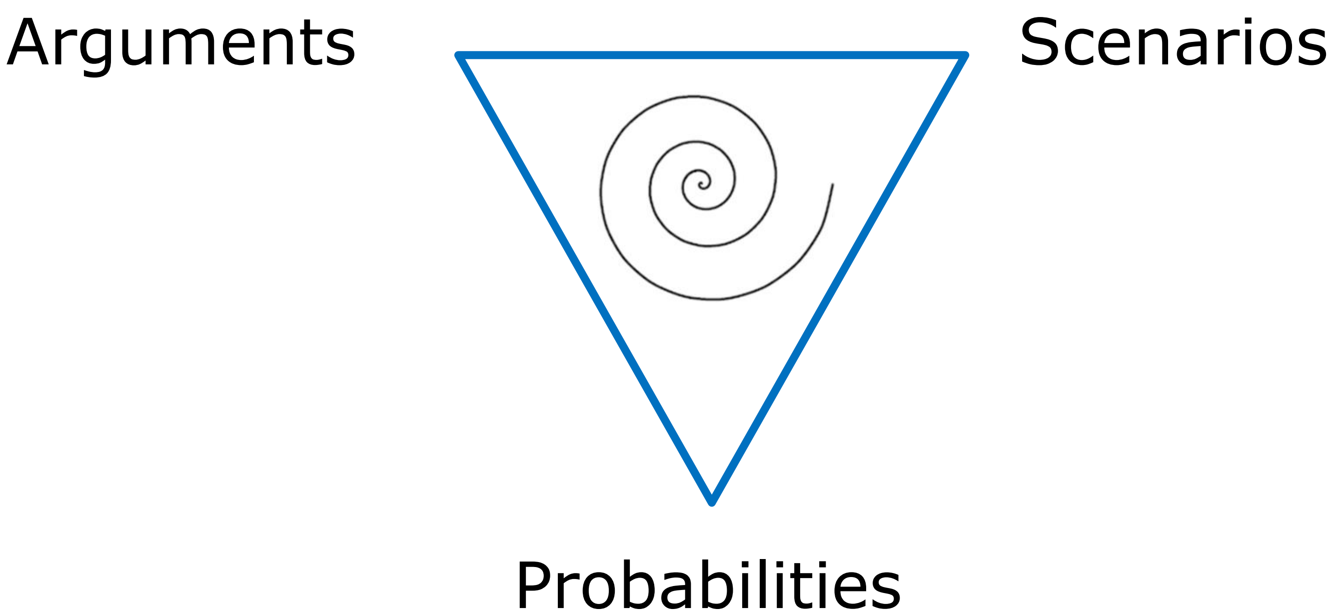
Goal:

promote rational handling of evidence in courts

Tool needed:

a normative framework

shared between experts and factfinders



Verheij, B. (2017). Proof With and Without Probabilities. Correct Evidential Reasoning with Presumptive Arguments, Coherent Hypotheses and Degrees of Uncertainty. *Artificial Intelligence and Law* 25 (1), 127-154. http://dx.doi.org/10.1007/s10506-017-9199-4

Integrating the three perspectives

- They are just three different ways of speaking about the same things, each emphasising some specific aspects

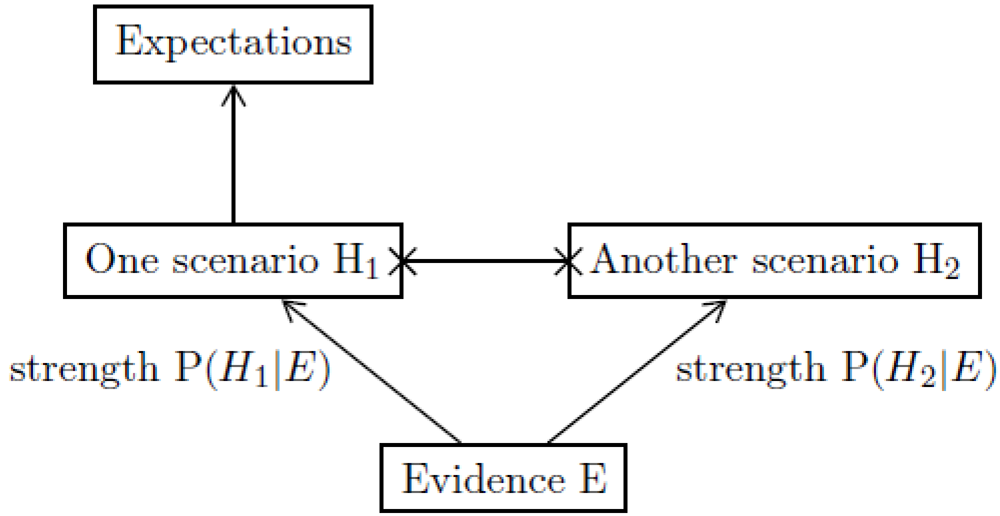
- There is no need to idolize any

- There is no need to demonize any

Hypothesis

There exists an
integrated perspective
on
arguments, scenarios and probabilities
as
normative tools for evidential reasoning
in which each has
its **natural and transparent** place.

Arguments, scenarios and probabilities



Verheij, B. (2014). To Catch a Thief With and Without Numbers: Arguments, Scenarios and Probabilities in Evidential Reasoning. *Law, Probability and Risk*, 13, 307-325.

Definition 1. *(Case models) A* case model *is a pair* $(C, \geq)$ *with finite* $C \subseteq L$*, such that the following hold, for all* φ*,* ψ *and* $\chi \in C$*:*

1. $\not\models \neg\varphi$;
2. *If* $\not\models \varphi \leftrightarrow \psi$*, then* $\models \neg(\varphi \wedge \psi)$;
3. *If* $\models \varphi \leftrightarrow \psi$*, then* $\varphi = \psi$;
4. $\varphi \geq \psi$ *or* $\psi \geq \varphi$;
5. *If* $\varphi \geq \psi$ *and* $\psi \geq \chi$*, then* $\varphi \geq \chi$.

Case models are `with and without numbers' in a precise sense:

- the ordering can be derived from a numeric representation;
- it is without numbers since an ordering is a qualitative relation.

Proof With and Without Probabilities

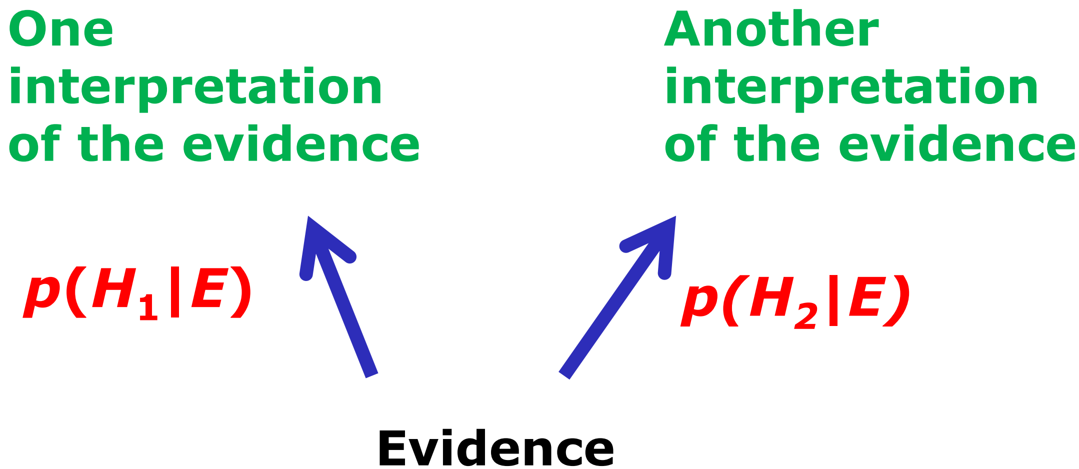
Correct Evidential Reasoning with Presumptive Arguments, Coherent Hypotheses and Degrees of Uncertainty

Bart Verheij

Received: date / Accepted: date

Abstract Evidential reasoning is hard, and errors can lead to miscarriages of justice with serious consequences. Analytic methods for the correct handling of evidence come in different styles, typically focusing on one of three tools: arguments, scenarios or probabilities. Recent research used Bayesian Networks for connecting arguments, scenarios, and probabilities. Well-known issues with Bayesian Networks were encountered: More numbers are needed than are available, and there is a risk of misinterpretation of the graph underlying the Bayesian Network, for instance as a causal model. The formalism presented here models presumptive arguments about coherent hypotheses that are compared in terms of their strength. No choice is needed between qualitative or quantitative analytic styles, since the formalism can be interpreted with and without numbers. The formalism is applied to key concepts in argumentative, scenario and probabilistic analyses of evidential reasoning, and is illustrated with a fictional crime investigation example based on Alfred Hitchcock's film 'To Catch A Thief'.

Verheij, B. (2017). Proof With and Without Probabilities.
Correct Evidential Reasoning with Presumptive Arguments,
Coherent Hypotheses and Degrees of Uncertainty.
Artificial Intelligence and Law 25 (1), 127-154.
http://dx.doi.org/10.1007/s10506-017-9199-4.


One interpretation of the evidence
Another interpretation of the evidence
$p(H_1|E)$
$p(H_2|E)$
Evidence

Proof With and Without Probabilities

An argumentation theory that connects

- presumptive arguments,
- coherent hypotheses, and
- degrees of uncertainty

using classical logic and standard probability theory.

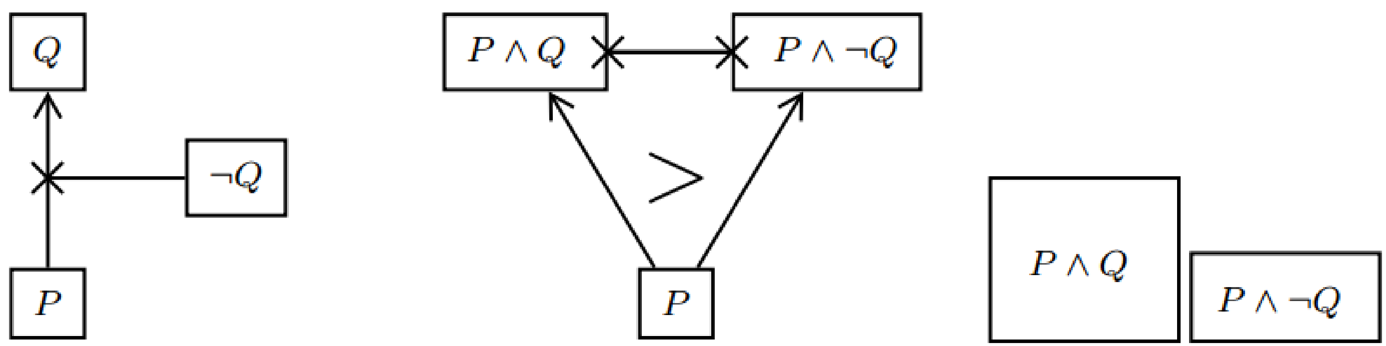


Fig. 1 General idea: an argument with a counterargument (left); arguments for conflicting cases and their comparison (middle); cases and their comparitive value (right)

- Patients have reported a sexual assault by their doctor (`patients`).
- The DNA of a trace of semen found on one patient is compared with the DNA in a blood sample taken from the doctor. There is no match ($\neg$`dna-match`).
- The doctor had implanted a drain into his arm, filled with someone else's blood (`implant`).

See https://en.wikipedia.org/wiki/DNA_profiling#Fake_DNA_evidence

By `patients`, we presume `dna-match` and `guilt`

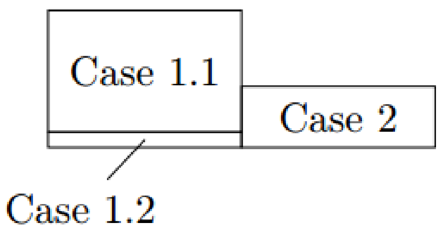
```
patients ~> dna-match ∧ guilt
```

We find `¬dna-match`, so now we presume `¬guilt`

```
patients ∧ ¬dna-match ~> ¬guilt
```

We find `implant`, so we presume, in fact conclude, `guilt`

```
patients ∧ ¬dna-match ∧ implant ~> guilt
patients ∧ ¬dna-match ∧ implant => guilt
```



Case 1.1: $\texttt{guilt} \wedge \texttt{patients} \wedge \texttt{dna-match}$

Case 1.2: $\texttt{guilt} \wedge \texttt{patients} \wedge \neg\texttt{dna-match} \wedge \texttt{implant}$

Case 2: $\neg\texttt{guilt} \wedge \texttt{patients} \wedge \neg\texttt{dna-match}$

Case 1.1 $>$ Case 2 $>$ Case 1.2

Figure 2: Case model for the example

$$\text{Case 1.1} > \text{Case 2} > \text{Case 1.2}$$

$$3 > 2 > 1$$

Pr(Case1.1)	=	3/(3+2+1)	=	50%
Pr(Case2)	=	2/(3+2+1)	~	33%
Pr(Case1.2)	=	1/(3+2+1)	~	17%

$$\text{Case } 1.1 > \text{Case } 2 > \text{Case } 1.2$$

$$\pi > e > 1$$

$$\begin{array}{llll}
\Pr(\text{Case1.1}) & = & \pi/(\pi+e+1) & \sim\ 46\% \\
\Pr(\text{Case2}) & = & e/(\pi+e+1) & \sim\ 40\% \\
\Pr(\text{Case1.2}) & = & 1/(\pi+e+1) & \sim\ 14\%
\end{array}$$

$$\text{Case 1.1} > \text{Case 2} > \text{Case 1.2}$$

very high > low > extremely small

Pr(Case1.1)	~	99%
Pr(Case2)	~	1%
Pr(Case1.2)	~	0.0..01%

$$\text{Case } 1.1 > \text{Case } 2 > \text{Case } 1.2$$

very high > low > extremely small

Pr(Case1.1) ~ 99%
Pr(Case2) ~ 1%
Pr(Case1.2) ~ 0.0..01%

(It seems that we don’t need the numbers)

Kinds of argument validity

Coherent arguments

$(C, \geq) \models (\varphi, \psi)$ if and only if $\exists \omega \in C$: $\omega \models \varphi \wedge \psi$.

Conclusive arguments

$(C, \geq) \models \varphi \Rightarrow \psi$ if and only if $\exists \omega \in C$: $\omega \models \varphi \wedge \psi$ and $\forall \omega \in C$: if $\omega \models \varphi$, then $\omega \models \varphi \wedge \psi$.

Presumptively valid arguments

$(C, \geq) \models \varphi \rightsquigarrow \psi$ if and only if $\exists \omega \in C$:

1. $\omega \models \varphi \wedge \psi$; and
2. $\forall \omega' \in C$: if $\omega' \models \varphi$, then $\omega \geq \omega'$.

Arguments	*Scenarios*	*Probabilities*
Coherence	Coherence	$p>0$
Presumptive validity	Plausible	p maximal, $p> t$
Conclusive	Beyond a reasonable doubt	$p=1$

Three kinds of validity

Coherent arguments

$p(\psi \mid \varphi) > 0$

$(C, \geq) \models (\varphi, \psi)$ if and only if $\exists \omega \in C$: $\omega \models \varphi \wedge \psi$.

Presumptive arguments

$p(\psi \mid \varphi) > t$

$(C, \geq) \models \varphi \rightsquigarrow \psi$ if and only if $\exists \omega \in C$:

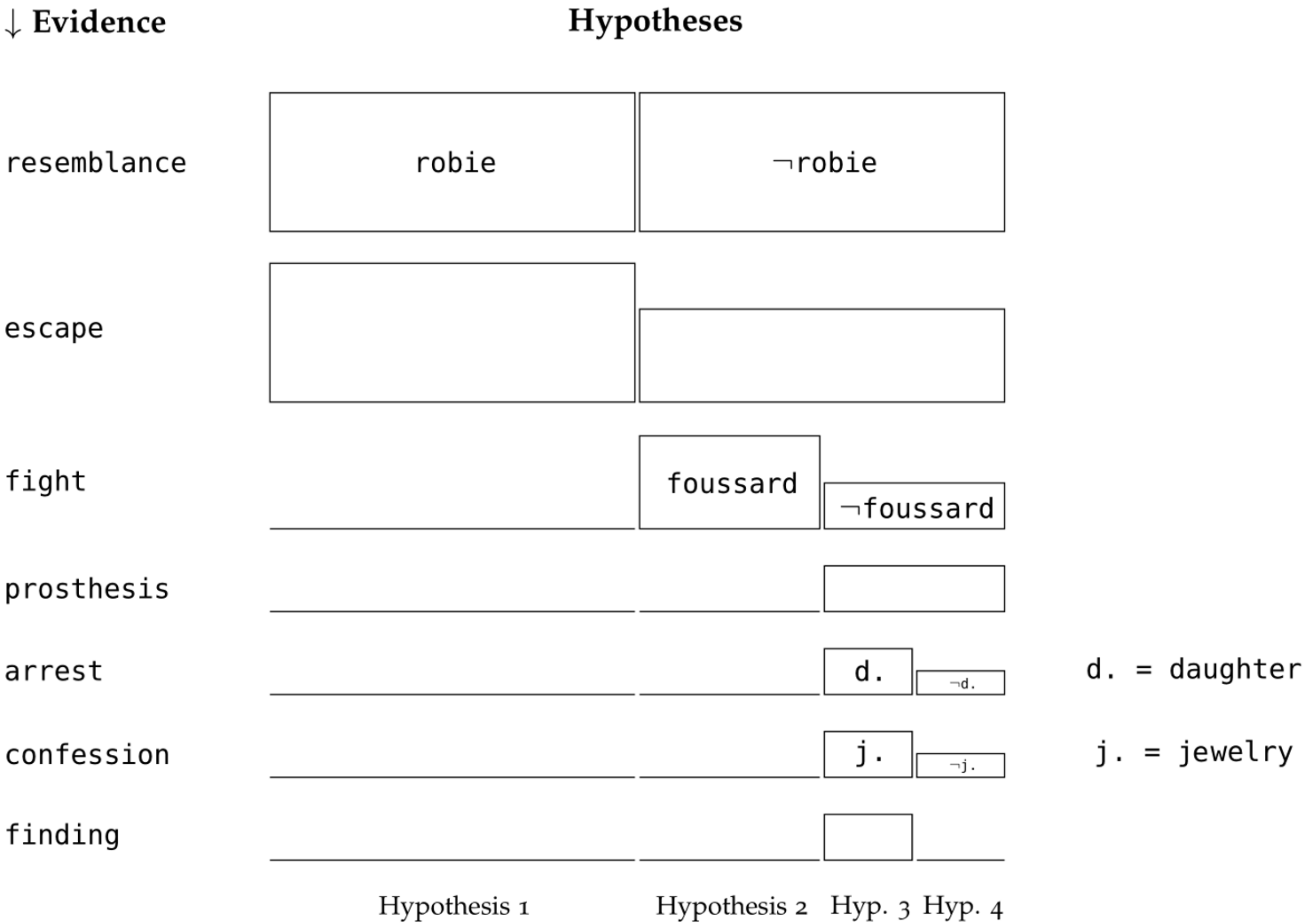
1. $\omega \models \varphi \wedge \psi$; and
2. $\forall \omega' \in C$: if $\omega' \models \varphi$, then $\omega \geq \omega'$.

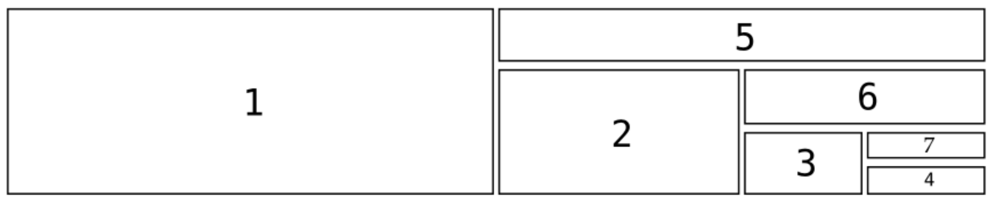
Conclusive arguments

$p(\psi \mid \varphi) = 1$

$(C, \geq) \models \varphi \Rightarrow \psi$ if and only if $\exists \omega \in C$: $\omega \models \varphi \wedge \psi$ and $\forall \omega \in C$: if $\omega \models \varphi$, then $\omega \models \varphi \wedge \psi$.

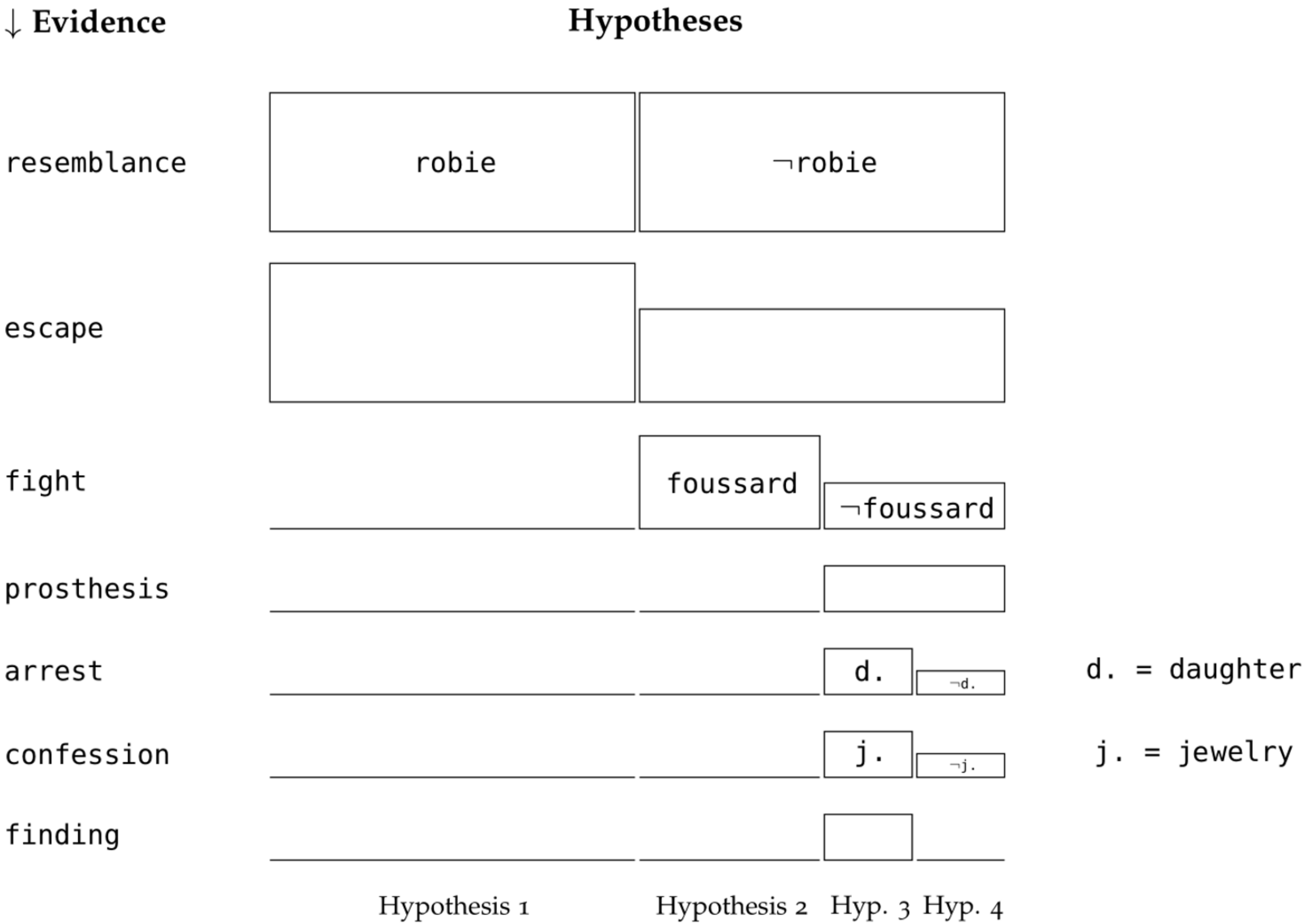

PARAMOUNT PRESENTS
CARY GRANT
GRACE KELLY
in
ALFRED HITCHCOCK'S
TO CATCH A THIEF
Color by TECHNICOLOR
VISTAVISION
with
JESSIE ROYCE LANDIS
JOHN WILLIAMS
Directed by
ALFRED HITCHCOCK
Screenplay by
JOHN MICHAEL HAYES
Based on the novel by David Dodge


↓ Evidence
Hypotheses
resemblance
robie
¬robie
escape
fight
foussard
¬foussard
prosthesis
arrest
d.
¬d.
d. = daughter
confession
j.
¬j.
j. = jewelry
finding
Hypothesis 1
Hypothesis 2
Hyp. 3
Hyp. 4



Block 1: Robie indeed was the thief

Block 3: Resistance friend Foussard’s daughter was the thief


↓ Evidence
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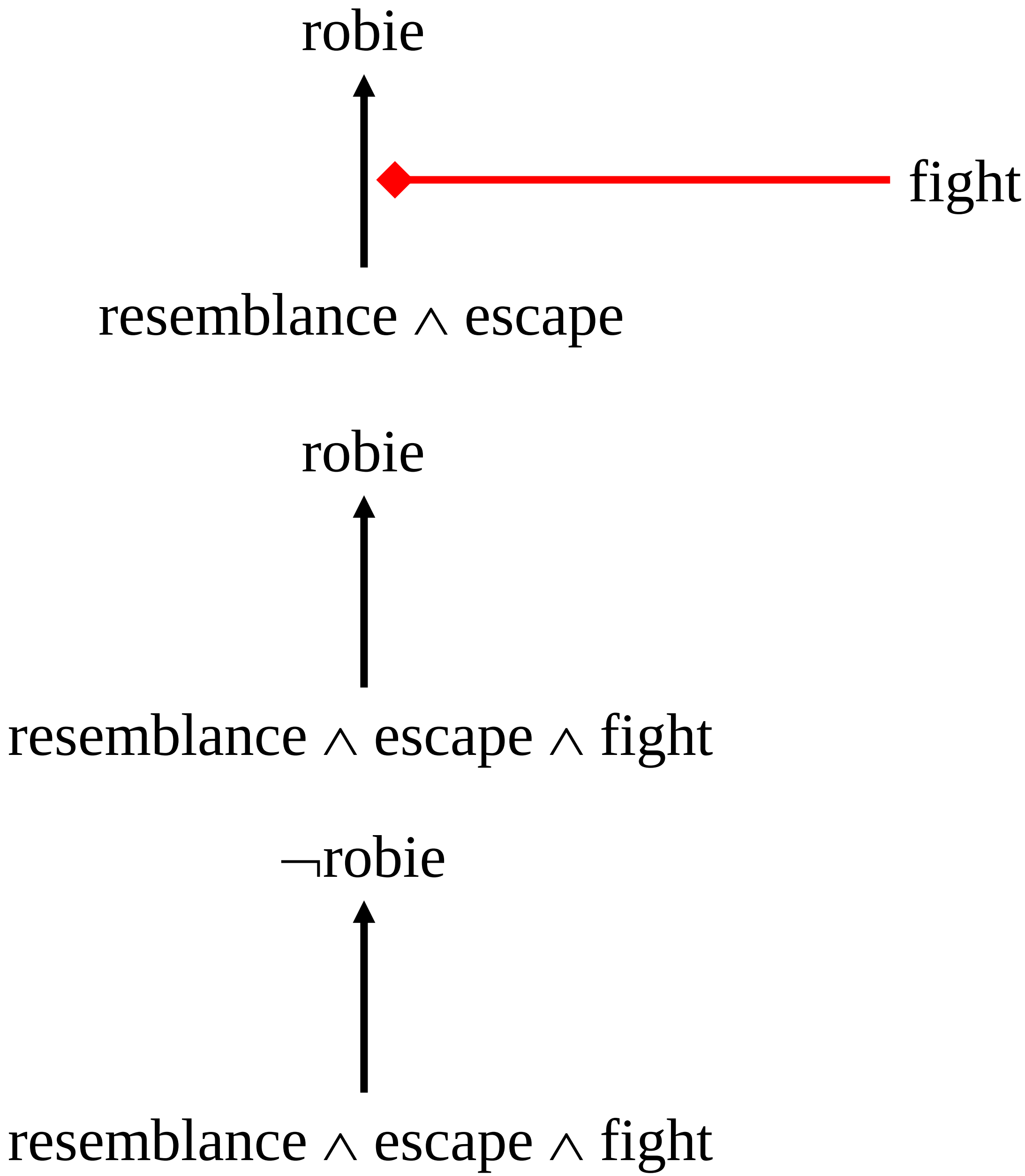
foussard
¬foussard
d.
¬d.
j.
¬j.
d. = daughter
j. = jewelry
Hypothesis 1
Hypothesis 2
Hyp. 3
Hyp. 4

$$\begin{array}{c} \text{robie} \\ \uparrow \\ \text{resemblance} \wedge \text{escape} \end{array}$$

coherent, presumptive, not conclusive

$$\begin{array}{c} \neg\text{robie} \\ \uparrow \\ \text{resemblance} \wedge \text{escape} \end{array}$$

coherent, not presumptive, not conclusive



defeating,
rebutting

not coherent,
not presumptive,
not conclusive

coherent,
presumptive,
conclusive

$$\neg \text{robie} \wedge \neg \text{fousard} \wedge \text{daughter} \wedge \text{jewelry}$$

$$\uparrow$$

$$\text{resemblance} \wedge \text{escape} \wedge \text{fight} \wedge \text{prosthesis} \wedge \text{arrest} \wedge \text{confession} \wedge \text{finding}$$

coherent, presumptive, conclusive

finding

↑ coherent, presumptive, not conclusive

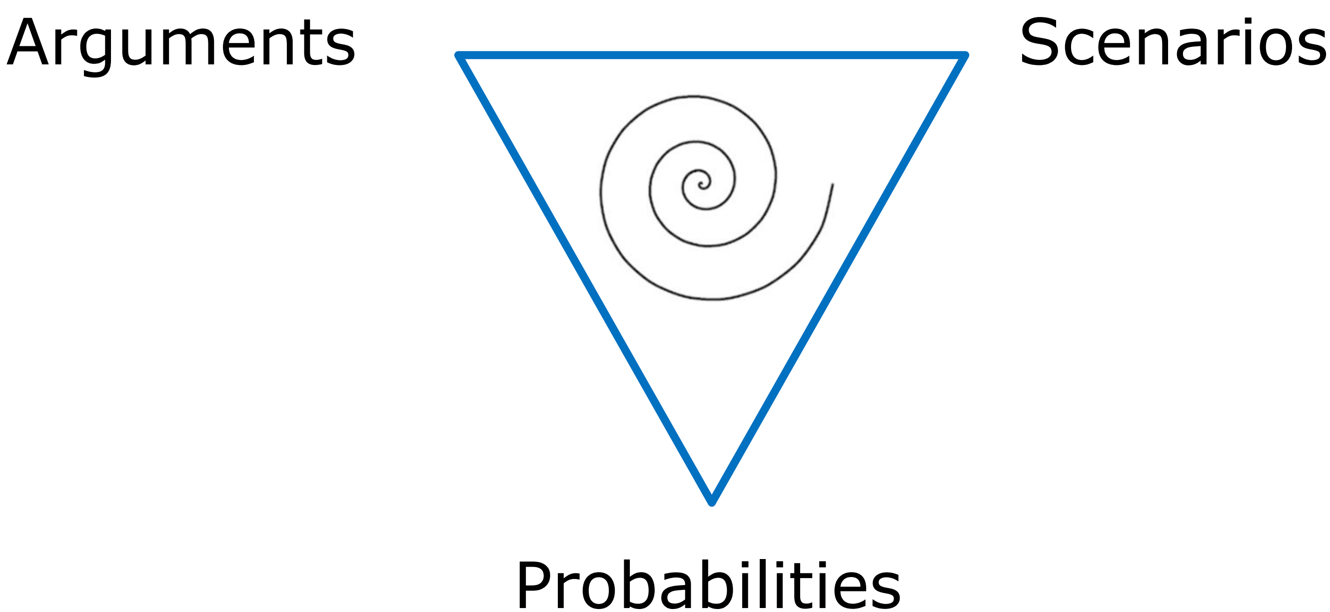
jewelry

↑ coherent, presumptive, not conclusive

confession

Hypothesis

There exists an
integrated perspective
on
arguments, scenarios and probabilities
as
normative tools for evidential reasoning
in which each has
its **natural and transparent** place.



Verheij, B. (2017). Proof With and Without Probabilities. Correct Evidential Reasoning with Presumptive Arguments, Coherent Hypotheses and Degrees of Uncertainty. *Artificial Intelligence and Law* 25 (1), 127-154. http://dx.doi.org/10.1007/s10506-017-9199-4

Introduction

Hybrid models

AI & Law

Artificial intelligence and Law

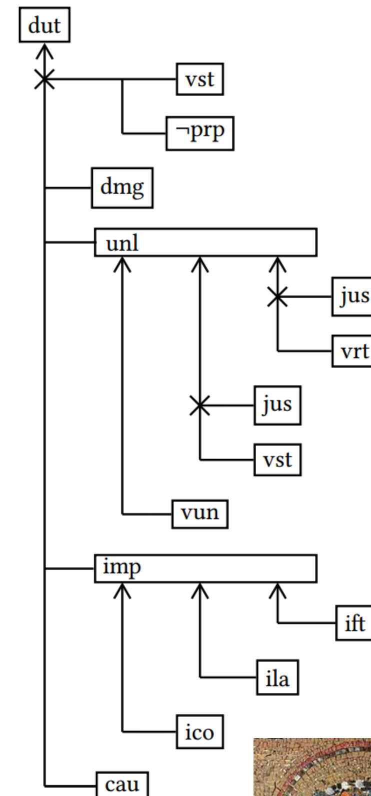
Legal artificial intelligence

Artificial Intelligence and Law

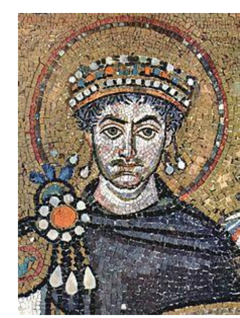
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	¬dut	¬dut	¬dut	dut	dut	dut	dut	dut	dut	dut	dut	dut	¬dut	¬dut	¬dut
¬dmg	dmg	dmg	dmg	dmg	dmg	dmg	dmg	dmg	dmg	dmg	dmg	dmg	dmg	dmg	dmg
	¬unl	unl	unl	unl	unl	unl	unl	unl	unl	unl	unl	unl	¬unl	¬unl	unl
		¬imp	imp	imp	imp	imp	imp	imp	imp	imp	imp	imp			imp
			¬cau	cau	cau	cau	cau	cau	cau	cau	cau	cau			cau
	¬vrt			vrt	vrt	vrt	¬vrt	¬vrt	¬vrt	¬vrt	¬vrt	¬vrt	vrt	¬vrt	
	¬vst			¬vst	¬vst	¬vst	vst	vst	vst	¬vst	¬vst	¬vst	¬vst	vst	vst
	¬vun			¬vun	¬vun	¬vun	¬vun	¬vun	¬vun	vun	vun	vun			
		¬ift		ift	¬ift	¬ift	ift	¬ift	¬ift	ift	¬ift	¬ift			
		¬ila		¬ila	ila	¬ila	¬ila	ila	¬ila	¬ila	ila	¬ila			
		¬ico		¬ico	¬ico	ico	¬ico	¬ico	ico	¬ico	¬ico	ico			
				¬jus	¬jus	¬jus	¬jus	¬jus	¬jus	¬jus	¬jus	¬jus	jus	jus	
				prp	prp	prp									¬prp

$1 > 2 > 3 > 4 > 5 \sim 6 \sim 7 \sim 8 \sim 9 \sim 10 \sim 11 \sim 12 \sim 13 > 14 \sim 15 \sim 16$

Data



Knowledge



The two faces of
Artificial Intelligence

Expert systems
Business rules
Open data
IBM's Deep Blue
Complex structure

Knowled
Fou

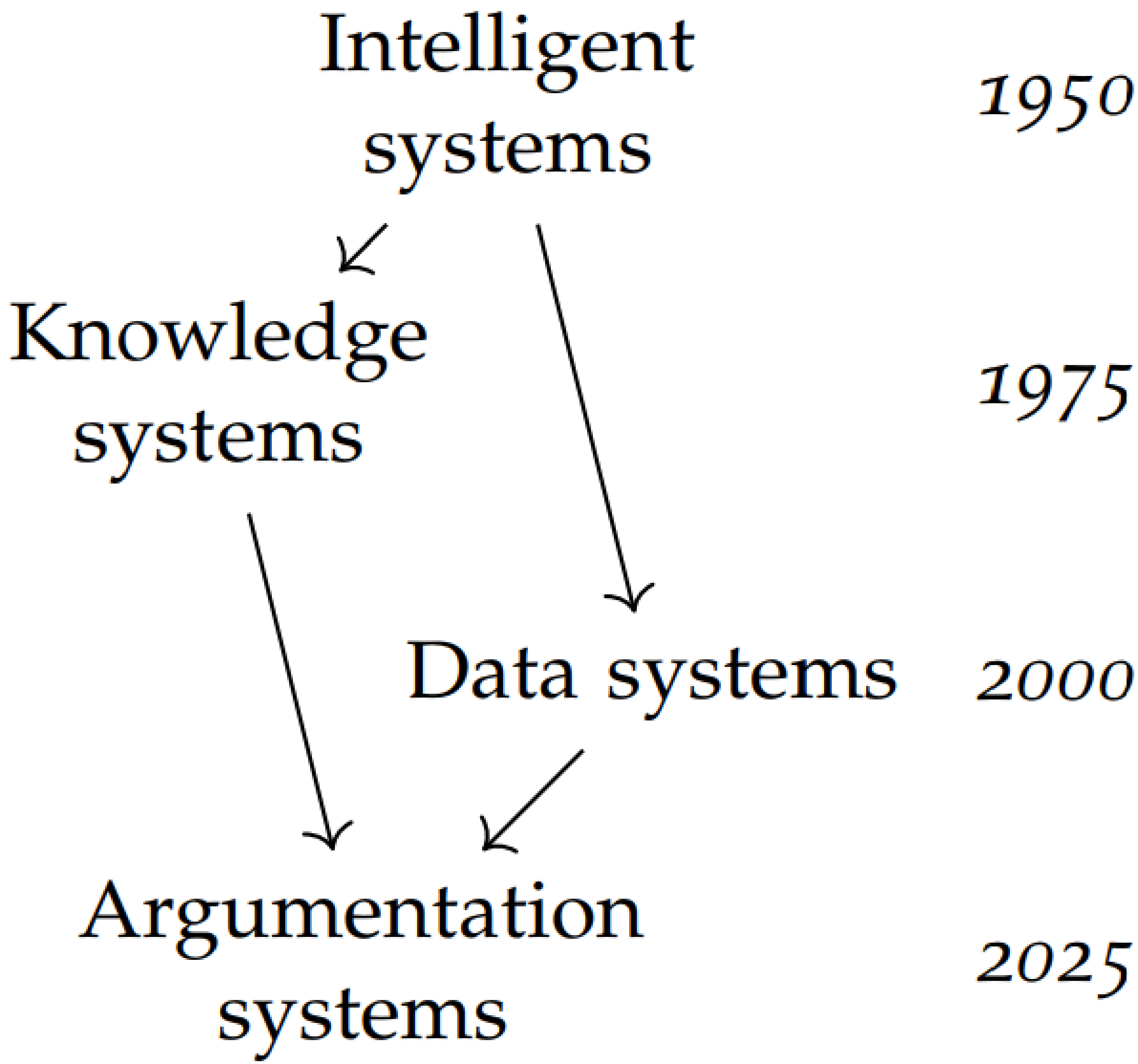
Explainability

Adaptive system
Machine le
Big d
tson
ptive structure

Data tech
Foundation:
probability theory

Scalability

Argumentation technology


Intelligent systems
1950
Knowledge systems
1975
Data systems
2000
Argumentation systems
2025

Spring School on Argumentation in Artificial Intelligence and Law

Day 1 Tuesday April 10

Abstract and structured formal frameworks for argumentation

8:30	Introduction and abstract argumentation frameworks (Bart Verheij)
10:00	*Break*
10:30	Structured argumentation frameworks, in particular ASPIC+ (Henry Prakken)
12:00	*Break*
14:30	Legal defeasibility as modelled in abstract and structured argumentation frameworks (Giovanni Sartor)
16:00	*Break*
16:30	Discussion
17:30	

Spring School on Argumentation in Artificial Intelligence and Law

Day 2 Wednesday April 11

Legal argumentation

8:30	Cases & Rules: HYPO, CATO and beyond (Henry Prakken)
10:00	*Break*
10:30	Case models (Bart Verheij)
12:00	*Break*
14:30	Balancing & interpretation (Giovanni Sartor)
16:00	*Break*
16:30	Discussion
17:30	

Spring School on Argumentation in Artificial Intelligence and Law

Day 3 Thursday April 12

Evidence

8:30	Burdens of proof in the law (Giovanni Sartor)
10:00	*Break*
10:30	Three approaches to rational proof in criminal cases (Henry Prakken)
12:00	*Break*
14:30	Hybrid models of rational legal proof (Bart Verheij)
16:00	*Break*
16:30	Discussion
17:30	

Spring School on Argumentation in Artificial Intelligence and Law

Invited graduate course
at the Institute of Logic and Cognition, Sun Yat-Sen University, Guangzhou

Henry Prakken, Giovanni Sartor, Bart Verheij, April 2018

http://www.ai.rug.nl/~verheij/sysu2018/

Three frameworks

Di Bello & Verheij 2018

Hybrid models

Verheij et al 2016

Vlek et al 2017

Timmer 2017

Verheij 2017a

Bayesian Networks project

http://www.ai.rug.nl/~verheij/nwofs/