

## Logical Reasoning as Argumentation,

**Or: How Lessons from the Law  
Are Changing Artificial Intelligence**

Bart Verheij  
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university of  
 groningen

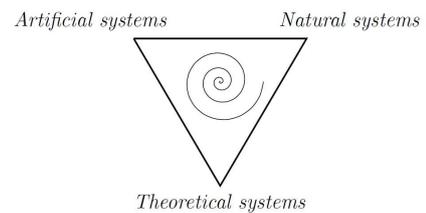
faculty of mathematics  
and natural sciences



Why study  
**argumentation?**

Why from a  
**computational**  
and/or  
**linguistic**  
perspective?

Maria Becker, *Argumentative Reasoning, Clause Types and Implicit Knowledge*  
Kristijonas Cyras, *ABA+: Assumption-Based Argumentation with Preferences*  
Tanja N. Daub, *An Automated Planning Approach for Generating Argument Dialogue Strategies*  
Jerome Delobelle, *Argumentation Reasoning Tools for Online Debate Platforms*  
Mariela Morveli-Espinoza, *Calculating rhetorical arguments strength and its application in dialogues of persuasive negotiation*  
Umer Mushtaq, *Combining Belief Revision and Abstract Dialectical Framework (ADF)*  
Daniel Neugebauer, *Formal Models for the Semantic Analysis of D-BAS*  
Andreas Niskanen, *Synthesizing Argumentation Frameworks from Examples*  
Andrea Paziienza, *Abstract Argumentation for Argument-based Machine Learning*  
Prakash Poudyal, *Automatic Extraction and Structure of Arguments in Legal Documents*  
Lucas Rizzo, *Enhancing Decision-Making and Knowledge Representation with Argumentation Theory*  
Hilmar Schadrack, *Properties and Computational Complexity of Different Models for Abstract Argumentation*  
Christof Spanning, *Relations between Syntax and Semantics in Abstract Argumentation*

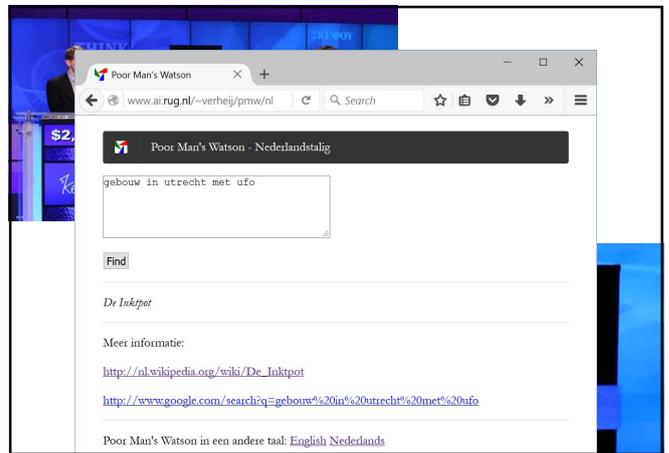
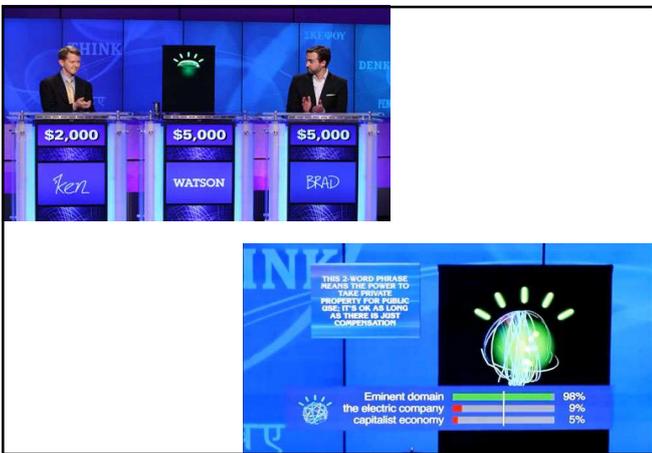
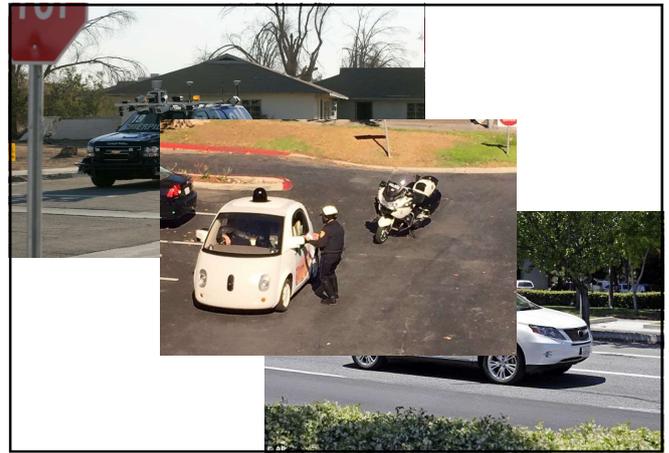
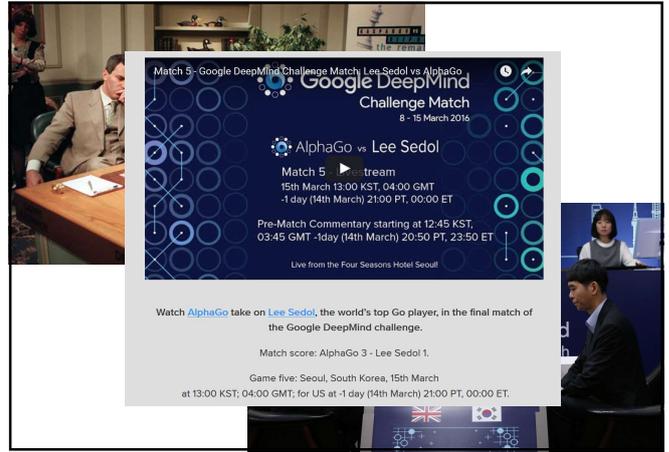


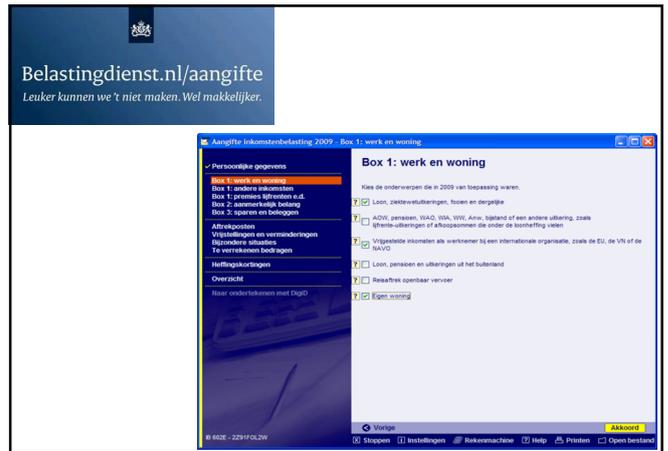
## Bart Verheij

MSc Math (University of Amsterdam)  
PhD AI and Law (Maastricht University)  
Researcher/lecturer AI and Law (Maastricht University)  
Researcher/lecturer Knowledge and Agent Technology (University of Groningen)  
Resident fellow CodeX center for legal informatics, now affiliated faculty (Stanford University)  
Chair of Artificial Intelligence and Argumentation (University of Groningen)

Realizing the **dreams** and  
countering the **concerns**  
connected to AI require the same innovation:

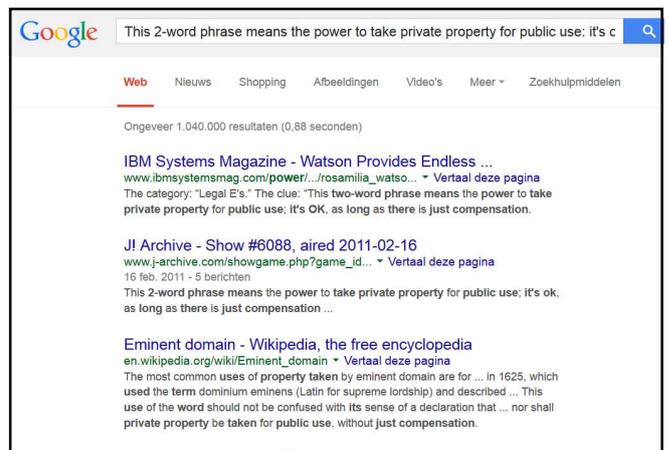
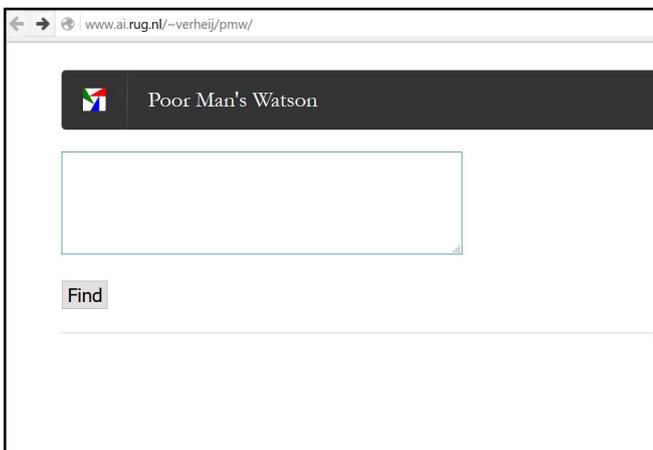
the development of **argumentation technology**





## IBM's debating technologies

1:38  
<https://www.youtube.com/watch?v=7g59PJxbGhY>





**The challenge**

Develop grounded models of our complex world

**The two faces of Artificial Intelligence**

Expert systems	Adaptive systems
Business rules	Machine learning
Open data	Big data
IBM's Deep Blue	IBM's Watson
Complex structure	Adaptive structure
<b>Knowledge tech</b>	<b>Data tech</b>
Foundation: logic	Foundation: probability theory
Explainability	Scalability

**The two faces of Artificial Intelligence**

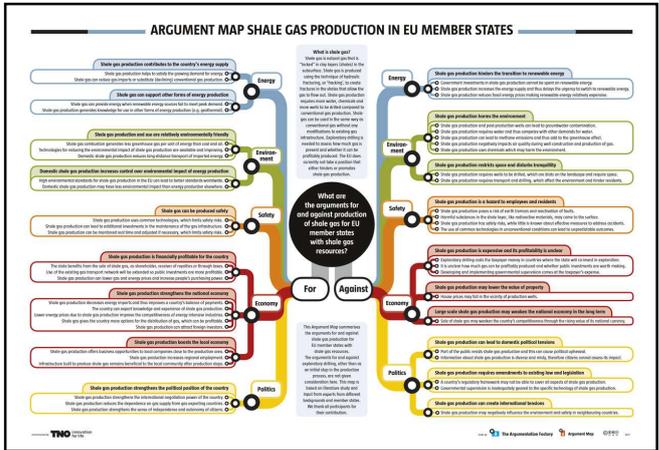
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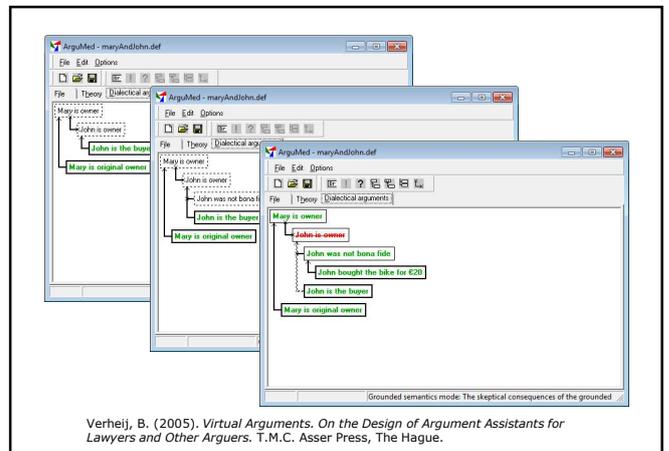
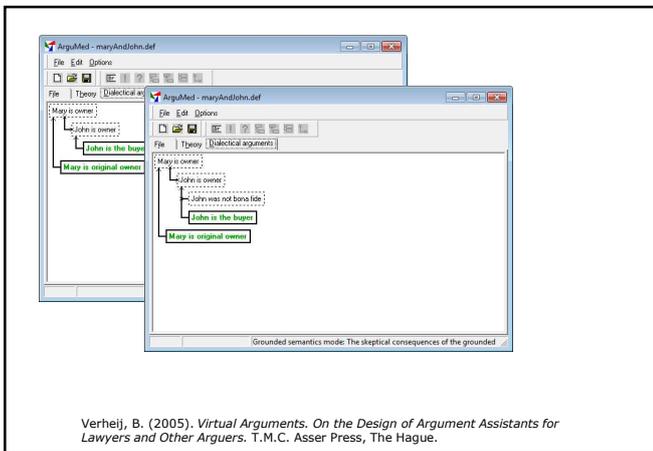
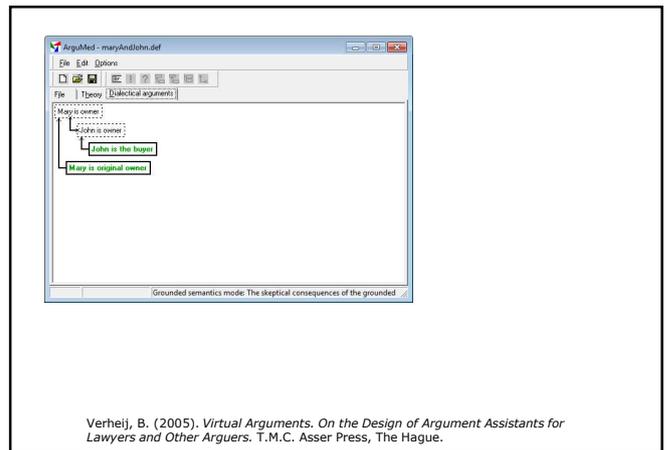
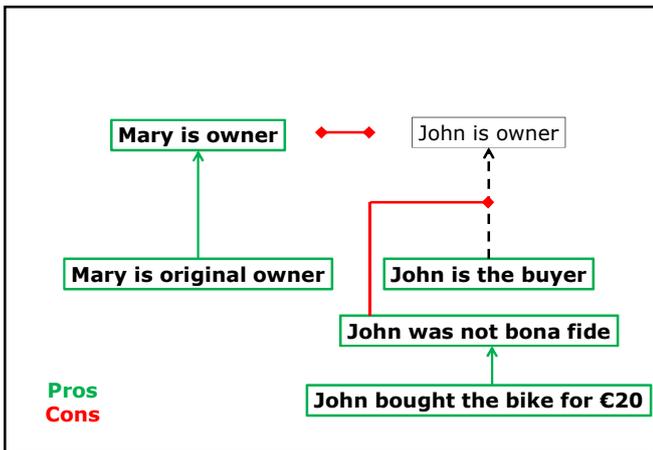
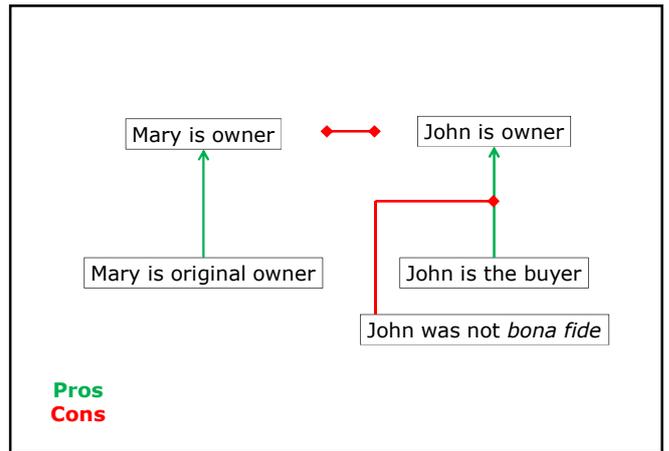
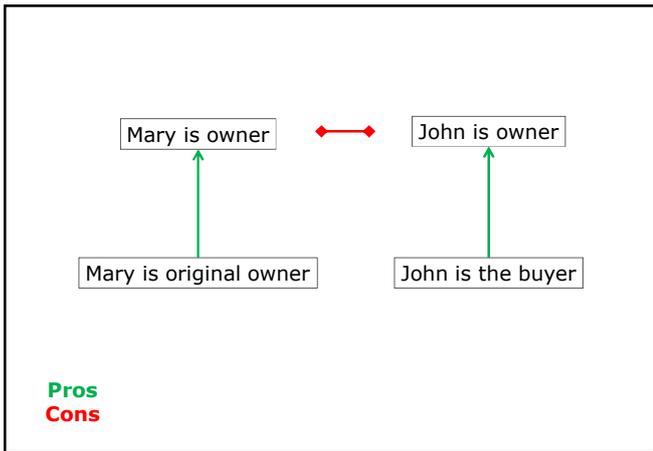
*Argumentation technology*

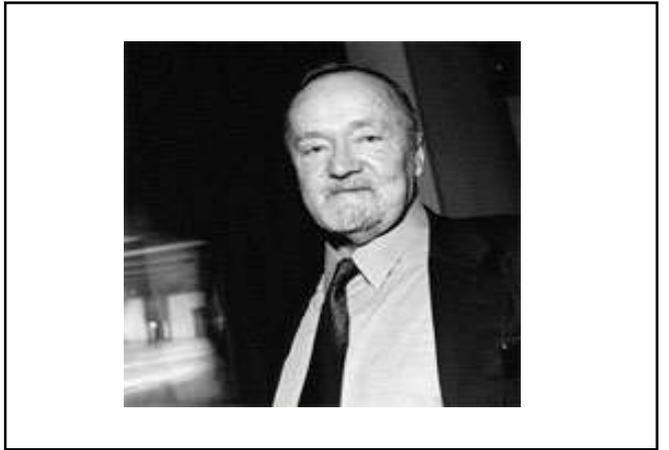
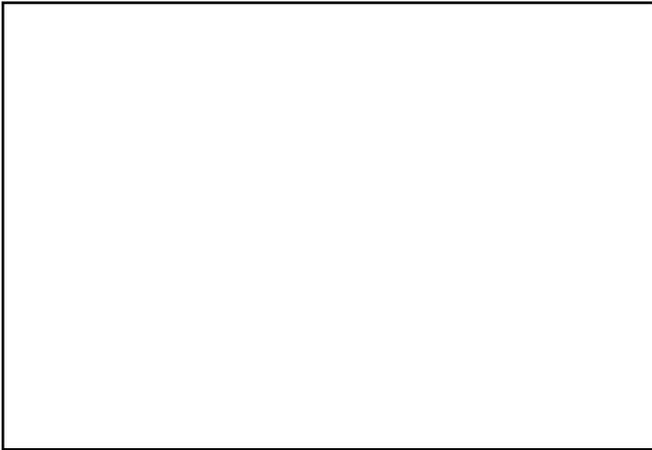
**Argumentation**

Argumentation is an interactive social process aimed at the balancing of different positions and interests.

Chapter 11: Argumentation and Artificial Intelligence

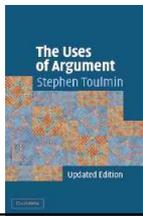




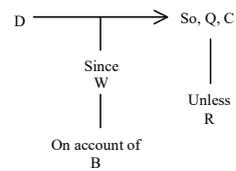


### Main themes of Toulmin (1958)

- 1. Argument analysis involves half a dozen distinct elements, not just two.
- 2. Many, if not most, arguments are substantial, hence defeasible.
- 3. Standards of good reasoning and argument assessment are non-universal.
- 4. Logic is to be regarded as generalised jurisprudence.



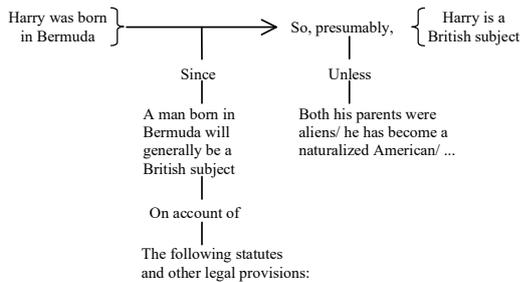
### Toulmin's model



Hitchcock, D., & B. Verheij (eds.) (2006). *Arguing on the Toulmin Model. New Essays in Argument Analysis and Evaluation*. *Argumentation Library*, Vol. 10. Springer, Dordrecht.

Hitchcock, D. & B. Verheij (2005). The Toulmin model today: Introduction to special issue of *Argumentation* on contemporary work using Stephen Edelston Toulmin's layout of arguments. *Argumentation*, Vol. 19, No. 3, pp. 255-258.

### Toulmin's model



### Toulmin on logic

- Logic as psychology
- Logic as sociology
- Logic as technology
- Logic as mathematics
- Logic as jurisprudence

## Defeasible reasoning

In 1987, John Pollock published the paper 'Defeasible reasoning' in the *Cognitive Science* journal.

What in AI is called "non-monotonic reasoning" coincides with the philosophical notion of "defeasible reasoning".

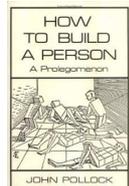
He defines **conclusive and prima facie reasons**, and **rebutting and undercutting defeaters**.



## Pollock on argument defeat

(2.2) P is a *prima facie reason* for S to believe Q if and only if P is a reason for S to believe Q and there is an R such that R is logically consistent with P but (P & R) is not a reason for S to believe Q.

(2.3) R is a *defeater* for P as a *prima facie reason* for S to believe Q if and only if P is a reason for S to believe Q and R is logically consistent with P but (P & R) is not a reason for S to believe Q.

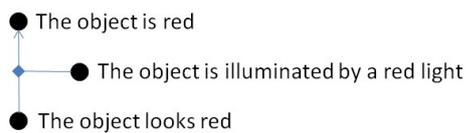


## Pollock on argument defeat

(2.4) R is a *rebutting defeater* for P as a *prima facie reason* for S to believe Q if and only if R is a defeater and R is a reason for believing  $\sim Q$ .

(2.5) R is an *undercutting defeater* for P as a *prima facie reason* for S to believe Q if and only if R is a defeater and R is a reason for denying that P wouldn't be true unless Q were true.

## Pollock's red light example



Undercutting defeat



## Classes of specific reasons

- (1) Deductive reasons
- (2) Perception
- (3) Memory
- (4) Statistical syllogism
- (5) Induction

Pollock 1995, *Cognitive Carpentry*

## Dung's basic principle of argument acceptability



The one who has the last word laughs best.



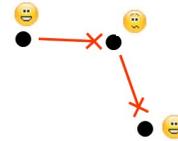
## Dung's basic principle of argument acceptability



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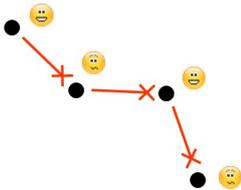
## Dung's basic principle of argument acceptability



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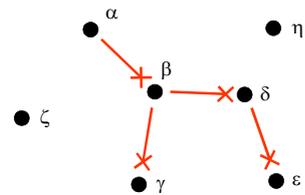
## Dung's basic principle of argument acceptability



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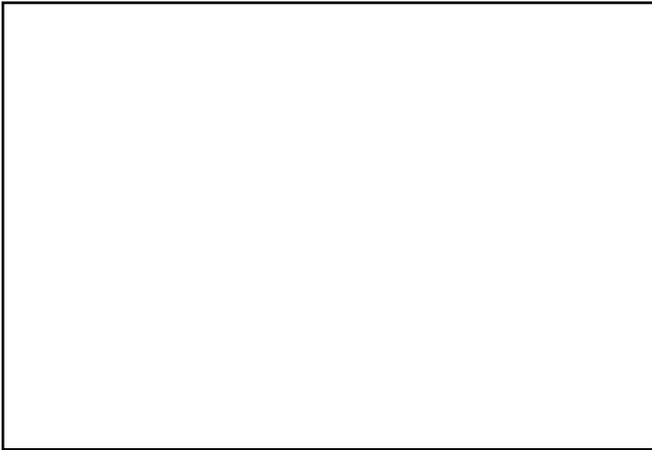


## Dung's admissible sets



Admissible, e.g.:  $\{\alpha, \gamma\}$ ,  $\{\alpha, \gamma, \delta, \zeta, \eta\}$   
Not admissible, e.g.:  $\{\alpha, \beta\}$ ,  $\{\gamma\}$





### Combining support and attack

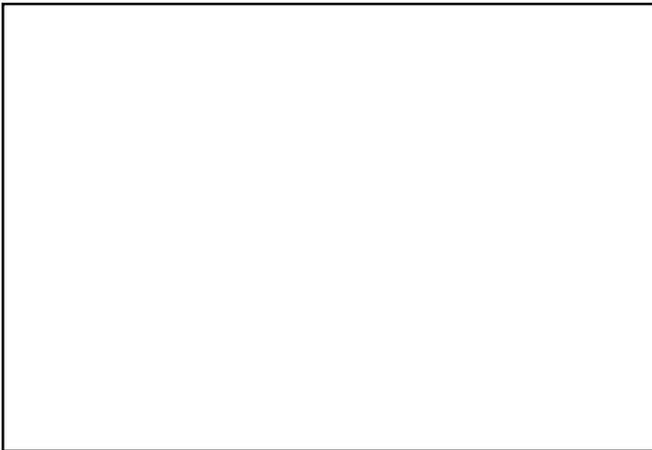
Approach 1:  
Dung's abstract arguments have internal structure

Abstract version: ● —●—● —●

### Combining support and attack

Approach 2:  
Arguments can attack or support

### Arguing about support and attack



### Toulmin's model

### Datum and claim

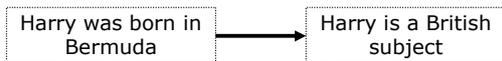


### Datum and claim

$$\frac{D \quad D \sim > C}{C}$$

- D: Harry was born in Bermuda.
- C: Harry is a British subject.
- $D \sim > C$ : If Harry was born in Bermuda, he is a British subject.

### Datum and claim



$$\frac{\cancel{D} \quad \cancel{D \sim > C}}{\quad}$$

### Datum and claim



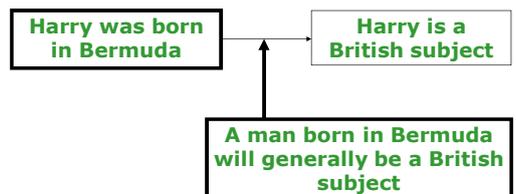
$$\frac{D \quad \cancel{D \sim > C}}{\quad}$$

### On arguments and Modus ponens

1. Harry was born in Bermuda. Therefore, he is a British subject.
2. Harry was born in Bermuda. If Harry was born in Bermuda, he is a British subject. Therefore, he is a British subject.

In the present setting, Modus ponens is *not* a representation of an argument, but specifies how evaluation values are transferred.

### Warrant



## Warrant

$$\frac{D \quad \frac{W \quad W \sim > (D \sim > C)}{D \sim > C}}{C}$$

- D: Harry was born in Bermuda.  
 C: Harry is a British subject.  
 W: A man born in Bermuda will generally be a British subject.

## Warrant

A man born in Bermuda will generally be a British subject.

If *Person* was born in Bermuda, then *Person* is a British subject.

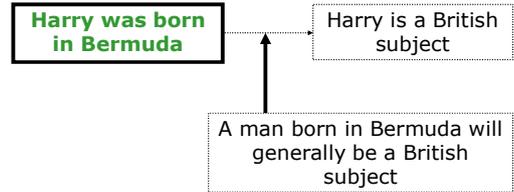
If Harry was born in Bermuda, then he is a British subject.

## Warrant

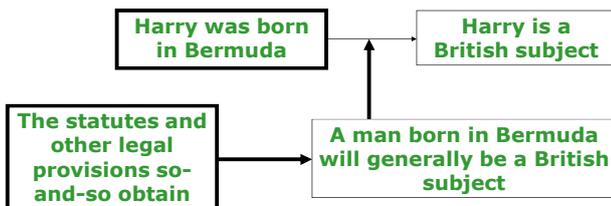
$$\frac{D \quad \frac{W \quad W \sim > (D \sim > C)}{D \sim > C}}{C}$$

- D: Harry was born in Bermuda.  
 C: Harry is a British subject.  
 W: A man born in Bermuda will generally be a British subject.

## Warrant



## Backing



## Backing

$$\frac{B \quad \frac{B \sim > W \quad W \sim > (D \sim > C)}{D \sim > C}}{C}$$

- B: The statutes and other legal provisions so-and-so obtain.  
 W: A man born in Bermuda will generally be a British subject.  
 B ~> W: If the statutes and other legal provisions so-and-so obtain, a man born in Bermuda will generally be a British subject.

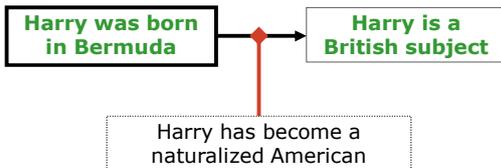
### Remarks on nesting

1. In the diagrams, the nesting of the conditionals passes almost unnoticed.
2. Logically, nesting can be as deep as deemed appropriate.
3. "Epistemologically", there is presumably not much need for deep nesting.

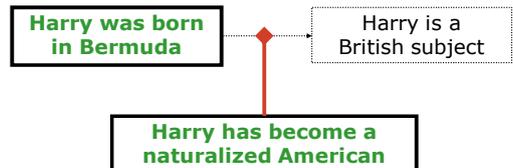
### Attack I (no warrants)



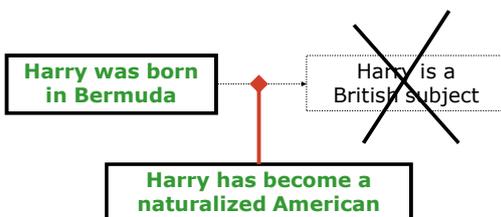
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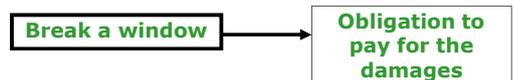
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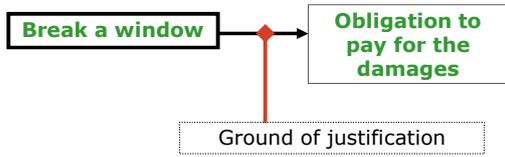
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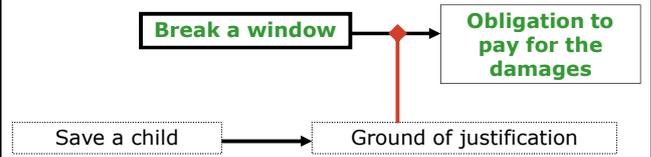
### Reinstatement



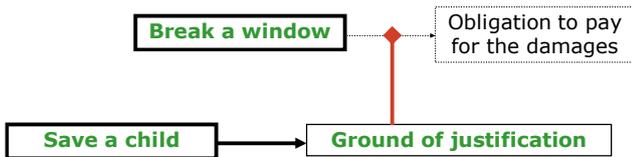
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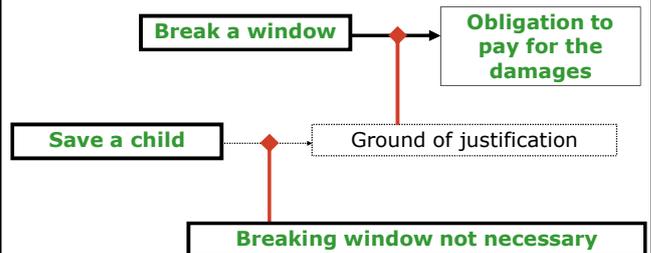
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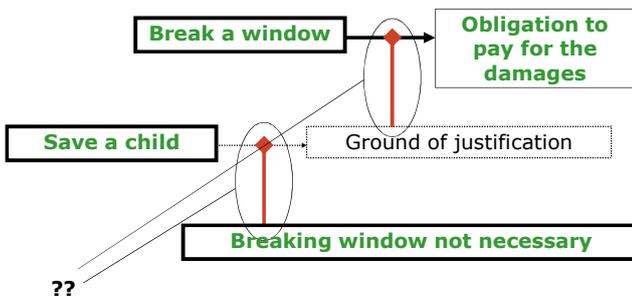
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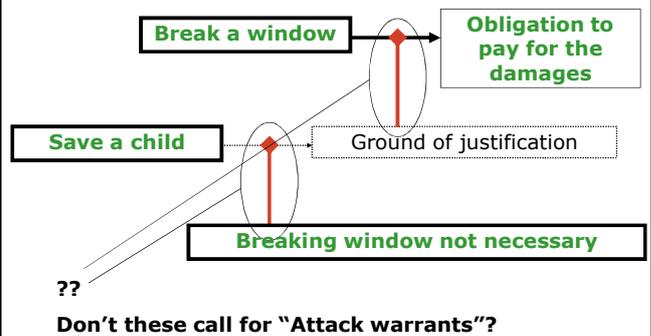
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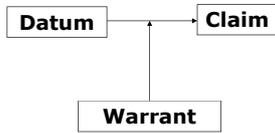
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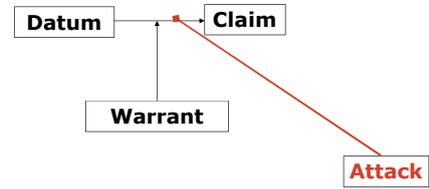
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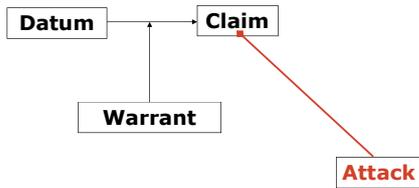
### Attack II (with warrants)



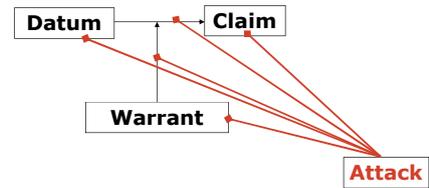
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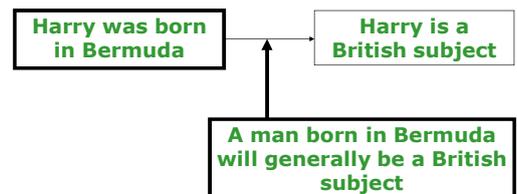


### Attack II (with warrants)

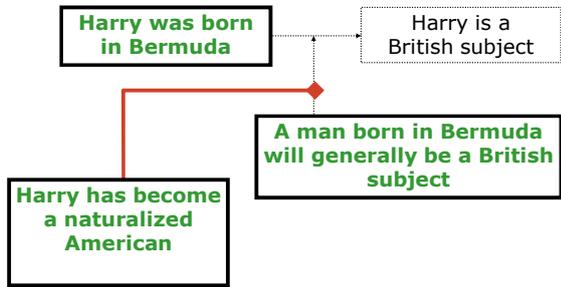
If we look at the warrant-datum-claim part of Toulmin's scheme, there are five statements that can be argued against:

- The datum *D*
- The claim *C*
- The warrant *W*
- The implicit conditional 'If *D*, then *C*' that expresses the bridge from datum to claim.
- The implicit conditional 'If *W*, then if *D*, then *C*' that expresses the bridge between warrant and the previous implicit conditional.

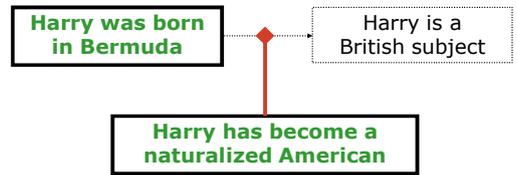
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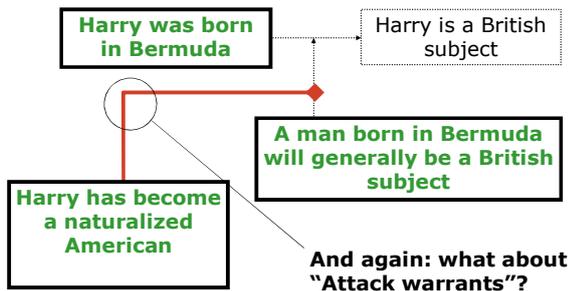
### Attack II (with warrants)



### Attack I (no warrants)



### Attack II (with warrants)



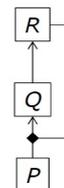
### Pollock on reasons

Some reasons are **conclusive**. These are not defeasible and entail their conclusions.

Other reasons are **prima facie**. They create a presumption for their conclusion and may be defeated.

**Defeaters** are a special kind of reasons, namely reasons that defeat prima facie reasons.

### One of Pollock's puzzles



## Pollock on argument strength and probabilities

1. Reasons can have **different strengths**, and conclusions can differ in their degree of justification.
2. Degrees of justification **do not work like probabilities**.

## Pollock on argument strength and probabilities

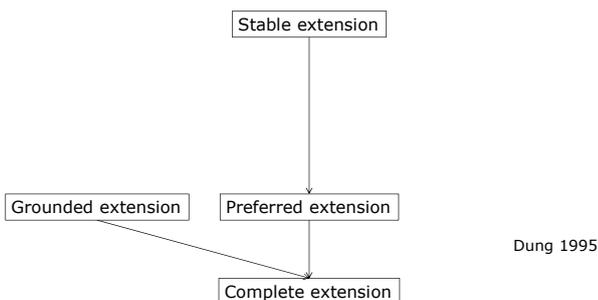
1. Reasons can have **different strengths**, and conclusions can differ in their degree of justification. ✓
2. Degrees of justification **do not work like probabilities**. ?

## State of the art in formal and computational argumentation

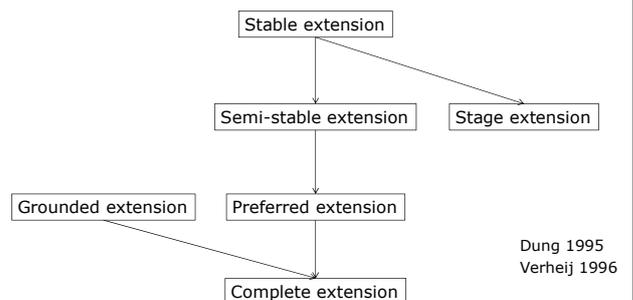
Today's models of argumentation have **non-standard** formal foundations.

Cf. the history of the field  
Toulmin, Reiter, Pollock, Dung

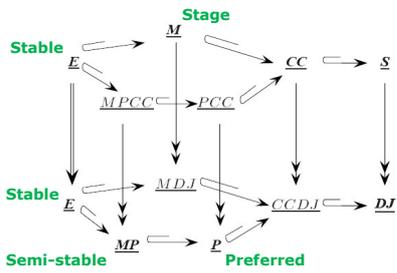
## Abstract argumentation semantics (1995)



## Abstract argumentation semantics (1996)

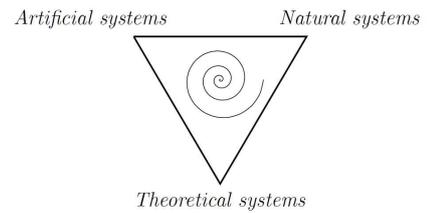


## Argumentation semantics (2003)



DefLog Verheij 2003

Where do we stand?



What next?

How to make progress?

## Open questions about argumentation

### The semantics question:

*How is argumentation connected to the world of facts and data?*

Today's argumentation models do not have a transparent connection to the world of facts and data

### The normative question:

*When are the process of argumentation and its outcomes acceptable?*

Today's argumentation models do not provide clear acceptability criteria

## Further reading

van Eemeren, F.H., Garsen, B., Krabbe, E.C.W.,  
Snoeck Henkemans, A.F., Verheij, B., &  
Wagemans, J.H.M. (2014). Chapter 11:  
Argumentation and Artificial Intelligence.  
*Handbook of Argumentation Theory*. Dordrecht:  
Springer.  
<http://www.ai.rug.nl/~verheij/publications/handbook2014.htm>