

Logic & Defeasible Reasoning

Joint International Doctoral (Ph.D) degree in Law, Science and
Technology

Roberta Calegari

roberta.calegari@unibo.it

ALMA MATER STUDIORUM – Università di Bologna

02 Feb 2020



- 1 Defeasible Logic and Argumentation: Towards Conversation
- 2 Basic of Defeasible Logic
- 3 Defeasible Logic as Argumentation
- 4 Basics of Argumentation



Next in Line...

- 1 Defeasible Logic and Argumentation: Towards Conversation
- 2 Basic of Defeasible Logic
- 3 Defeasible Logic as Argumentation
- 4 Basics of Argumentation



Context

What you have seen

- agent communication (ACL) and coordination → towards agreement technologies
- conversational informatics and full human-agent conversation

What is missing

- agent communication (ACL) and coordination → towards agreement technologies
- ⇒ **defeasible logic & argumentation**
- conversational informatics and full human-agent conversation

Defeasible logic & c

Defeasible logic & argumentation

- enabler for conversational capabilities
- closer to human thinking
- defeasible logic for *defeasible inference* (instead of LP SLD-resolution)
- argumentation to support defeasible logic (and non-monotonic reasoning in general) for *converse* reaching an agreement

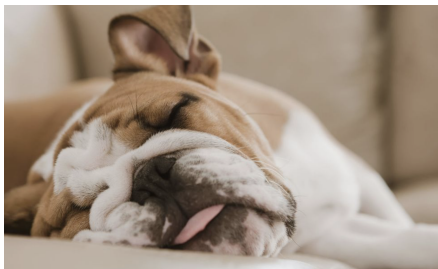


Next in Line...

- 1 Defeasible Logic and Argumentation: Towards Conversation
- 2 Basic of Defeasible Logic**
- 3 Defeasible Logic as Argumentation
- 4 Basics of Argumentation



Defeasibility



Reasonable results with minimum effort

philosophical logic kind of reasoning rationally compelling, though not deductively valid.

- a rule is given, but there may be specific exceptions to the rule, or subclasses that are subject to a different rule

defeasibility is found in literatures that are concerned with argument and the process of argument

Defeasible reasoning: fullest expression

- jurisprudence
 - ethics and moral philosophy, epistemology, pragmatics
 - conversational conventions, constructivist decision theories
 - knowledge representation and planning in AI
- presumptive reasoning (i.e., reasoning on the “face” of evidence)
- ceteris paribus (default) reasoning

Some schools of philosophy

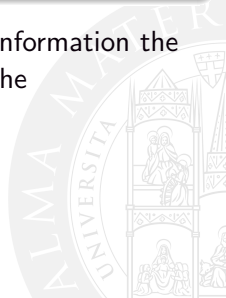
All reasoning is at most defeasible, and there is no such thing as absolutely certain deductive reasoning, since it is impossible to be absolutely certain of all the facts (and know with certainty that nothing is unknown). Thus all deductive reasoning is in reality contingent and defeasible.

Conclusive vs Defeasible Reasoning I

Conclusive Reasoning Schema: definition

A reasoning schema R is conclusive if one can always adopt R 's conclusions while endorsing R 's premises (and one should never reject R 's conclusions while endorsing R 's premises).

- cognitive transition operate regardless of any further information the agent possesses, as long as the reasoner instantiates the pre-conditions in the schema
- *monotonic reasoning* → conclusions always grow

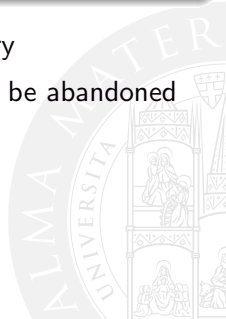


Conclusive vs Defeasible Reasoning II

Defeasible reasoning Schema: definition

A reasoning schema R is defeasible if one should, under certain conditions, refrain from adopting its conclusions though endorsing its premises.

- may be defeated by further information to the contrary
- *non-monotonic reasoning* → conclusions may need to be abandoned when new information is available



Conclusive vs Defeasible Reasoning III

Reasoning schema: Conclusive syllogism

- (1) all Y's are Z's; AND
- (2) x is Y
- IS A CONCLUSIVE REASON FOR
- (3) x is Z

Reasoning schema: Defeasible syllogism

- (1) all Y's are **normally** Z's; AND
- (2) x is Y
- IS A DEFEASIBLE REASON FOR
- (3) x is Z

Conclusive vs Defeasible Reasoning IV

Reasoning schema: Conclusive syllogism

- (1) all bachelors are unmarried; AND
- (2) John is a bachelor
- IS A CONCLUSIVE REASON FOR
- (3) John is unmarried

Reasoning schema: Defeasible syllogism

- (1) pet dogs are **normally** unaggressive; AND
- (2) Fido is a pet dog
- IS A DEFEASIBLE REASON FOR
- (3) Fido is unaggressive

Conclusive vs Defeasible Reasoning: adding knowledge I

Adding knowledge

The difference between conclusive and defeasible reasoning emerges most clearly when one acquires beliefs that contradict the conclusions of one's previous inferences.



Conclusive vs Defeasible Reasoning: adding knowledge II

Conclusive Syllogism: Let us assume, for example

- Mary knows that
 - bachelors are unmarried and
 - husbands are married
- after meeting John at a dinner party comes to believe
 - John is a bachelor
 - John is unmarried (leads Mary to believe)
- However, the day after a friend tells Mary that
 - John is Lisa's husband
 - John is married (leads Mary to believe)
- belief contradiction!!! → abandon the premises of one of these
 - withdraw John is Lisa's husband
 - or withdraw John is a bachelor

Conclusive vs Defeasible Reasoning: adding knowledge III

Defeasible Syllogism: Let us assume, for example

- one endorses all of the following propositions
 - Fido is a pet dog
 - pet dogs are normally unaggressive
 - Fido is a Doberman
 - Dobermans are normally aggressive
 - premises licences both of the defeasible inferences
 - Fido is unaggressive
 - Fido is aggressive
 - assume that the second inference is stronger than the first one
 - can maintain the premises of both inferences
- refrain from deriving the conclusion that
- Fido is unaggressive

Defeasible Reasoning I

Defeasible Reasoning

- not *truth-preserving*
- failure to satisfy truth preservation does not entail logical faultiness
- epistemology has come to identify various kinds of sound defeasible inference [Pollock, 1995]



Defeasible Reasoning II

Perceptual inference

Perceptual contents are a defeasible reason to believe in the existence of corresponding external objects. More generally, having a percept with content ϕ is a defeasible reason to believe ϕ .

For instance, having an image of a red book at the centre of my visual field is a defeasible reason to believe that there is a red book in front of me. This conclusion is defeated if I come to know that there are circumstances which do not ensure the reliability of my perceptions (e.g., I am watching a hologram).

Memory inference

Recalling ϕ is a defeasible reason to believe ϕ .

For instance, my memory that yesterday I had a faculty meeting is a defeasible reason for me to believe that indeed there was such meeting. This inference is defeated if I come to know that the supposed memory was an outcome of my imagination.

Defeasible Reasoning III

Enumerative induction

Observing samples of Φ , all of which have the feature ψ , is a defeasible reason to believe that all $\phi \in \Phi$ have the feature ψ .

For instance, believing that all crows I have ever seen are black is a defeasible reason to believe that all crows are black. This inference is defeated if I perceive one white crow.

Statistical syllogism

Believing that most $\phi \in \Phi$ are $\psi \in \Psi$ and $a \in \Phi$ is a defeasible reason to believe that $a \in \Psi$.

For instance my beliefs that most printed books have even-numbered pages on their left side and that the volume on the top of my table is a printed book are defeasible reason for me to believe that this volume has even-numbered pages on its left side. This inference is defeated if I discover that this volume was wrongly printed with even-numbered pages on its right side.

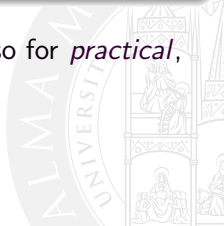
Defeasible Reasoning IV

Temporal persistence

Believing that ϕ is the case at time t_1 is a defeasible reason to believe that ϕ is still the case at a later time t_2 .

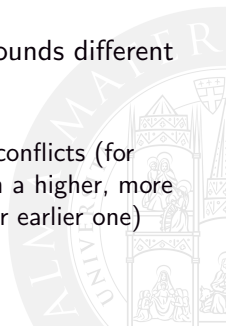
For instance, my belief that my computer was on the top of my table yesterday evening (when I last saw it) is a defeasible reason for me to believe that my computer is still there. This inference is defeated if I come to know that the computer was moved from the table after yesterday evening.

Similar defeasible reasoning schemata may be identified also for *practical*, and in particular *legal reasoning*.



Defeasible Reasoning: Legal Reasoning

- assume that propositions only concern the *majority of cases*, or the normal case
- the exception serves the rule, or at least, does not damage the rule
- deal appropriately with the anomalous case: not necessary the case to abandon the rule or to change its formulation
- assume that the operation of the rule is limited on grounds different from the grounds supporting the rule itself
 - exception, in a prevailing principles to the contrary
 - conflicting rules coupled with criteria for solving rule-conflicts (for instance, the traditional principles, according to which a higher, more special or later law norm over a lower, more general or earlier one)



Defeasible Reasoning: Collision and Defeat I

Assume that I believe that swans are normally white, and that I am told that there is a swan in the park

This enables the following defeasible inference (*statistical syllogism*)

- (1) most swans are white;
 - (2) the bird in the park is a swan
-
- (3) the bird in the park is white



Defeasible Reasoning: Collision and Defeat II

When I look out of the window, I see that the bird in the park, although being unmistakably a swan, looks kind of pinkish

This prompts the following *perceptual inference*

(1) I am having a pink image of the bird in the park

(2) the bird in the park is pink



Defeasible Reasoning: Collision and Defeat III

- conflicting conclusions, supported by competing defeasible inferences
 - according to the first inference, the bird is white, according to the second one it is pink
- being a moderate empiricist, I consider the perceptual inference to be stronger than the statistical one
 - I should abandon my *pro-tanto* belief that the swan is white and accept (though provisionally) that it is pink
- we say that the inference concluding that the swan is white is defeated by the perceptual inference according to which it is pink



Defeasible Reasoning: Collision and Defeat IV

Cognitive processes like this can be explained by introducing two notions

- collision
- defeat

Collision [Pollock and Cruz, 1999]

Let M be a reason for adopting Q and M^* be a reason for adopting Q^* . We say that there is a collision between M and M^* , when the combined cognitive state which consists in endorsing both of M and M^* does not support adopting both of Q and Q^* .



Defeasible Reasoning: Collision and Defeat V

When one finds oneself in a collision, one is prevented from performing both colliding inferences (just one or both)

- inferences which are prevented by the collision $\rightarrow$ to be defeated
- the reason that prevents deriving a conclusion $\rightarrow$ defeater

Defeat [Pollock and Cruz, 1999]

Let M be a reason for adopting Q . Premise M^* defeats (is a defeater for) M , iff the combined state consisting in endorsing both of M and M^* does not support adopting Q



Rebutting collision I

Rebutting collision

There is a rebutting collision between reasons M and M^* when

- M is a reason to adopt Q
- M^* is a reason to adopt Q^*
- Q is incompatible with Q^*

Rebutting collision: Inference $\mathcal{A}$ collides with inference $\mathcal{B}$

inference $\mathcal{A}$

(1) most swans are white;
(2) the bird in the park is
a swan

(3) the bird in the park is
white

inference $\mathcal{B}$

(1) I am having a pink
image of the bird in the park

(2) the bird in the park
is pink

Undercutting collision I

In many other cases, to assess the incompatibility of propositions one needs to consider further information, concerning meaning connections, causal links, or further facts.

Examples

- to assess that being pink and being white are incompatible states of one same object (our swan) one must know that an object cannot have two colours at the same time
- to know that there is a conflict between the fact that others detain and process one's personal data and one's free self-determination (as affirmed by privacy supporters), much psychological and sociological background-knowledge is to be assumed



Undercutting collision II

- incompatibility of two conclusions cannot be immediately detected by the reasoner
- but is rather the result of finding relevant information and of bringing it to bear through reasoning processes [Perelman and Olbrechts-Tyteca, 1997]



Undercutting collision III

Undercutting collision

There is an undercutting collision between reasons M and M^* when

- M is a reason to adopt Q
- M^* is a reason for believing that M does not support Q

Under these conditions we also say that M^* undercuts M



Undercutting collision IV

Undercutting collision: inference $\mathcal{A}$ collides with inference $\mathcal{B}$

inference $\mathcal{A}$

(1) I perceive a pink bird
in the park

(2) the bird in the park is
pink

inference $\mathcal{B}$

(1) There is red light outside

(2) Perceiving a pink object
under red light does not
warrant that it is pink

(3) My perceiving a pink bird
does not warrant that it is
pink

Preference-Based Reasoning I

When one endorses two colliding reasons:

- If one reason R_1 prevails over the other R_2 , we may reject R_2 and endorse R_1 (so that only R_2 is defeated)
- If, on the contrary, none of the two reasons prevails, both reasons are defeated

Preference-Based Reasoning: rebutting collision

A reason R_1 defeats a reason R_2 , whenever R_1 collides R_2 , and R_1 does not prevail over R_1 .

In addition, R_1 prevails over R_2 then R_1 strictly defeats R_2 (defeats R_2 , but is not defeated by it).

Preference-Based Reasoning II

Health-care legal issue

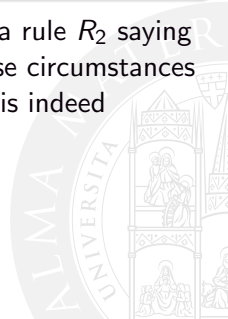
Consider a recent case that had to be addressed by the Italian privacy authority. It concerned the case of a woman who requested for health reasons to access data concerning the DNA of her father (the data was stored in the database of a hospital), who did not give his consent. Therefore, the authority needed to balance the privacy-based inference (the father's data could not be provided since sensitive data cannot be communicated without the consent of the data subject) and the inference based upon the right to health (one has a right to obtain what is needed for one's health, such as, for that woman, access to the father's DNA). In such a case the health-based inference was considered to be preferable to the privacy-based inference, so that the latter was viewed as being strictly defeated, and the former inference dictated the outcome of the case.

Preference-Based Reasoning III

Preference-Based Reasoning: undercutting collision

In case of undercutting collisions, on the contrary the undercutter prevails: it strictly defeats the attacked reason.

Assume that I find in a law text two rules: a rule R_1 , and a rule R_2 saying that R_1 is inapplicable under certain circumstances. If these circumstances are satisfied in the present case I should conclude that R_1 is indeed inapplicable, and refrain from deriving its conclusion.



Preference-Based Reasoning IV

Preference-Based Reasoning: undercutting collision

when facing a collision, we should reason as follows:

- in rebutting collisions, we should compare the strength of the conflicting reasons, and assume that any reason that is not stronger than its competitor is defeated (only stronger reasons prevail)
- in undercutting collisions, we should assume that the undercutter always prevails.



Preference-Based Reasoning V

Legal issue

Assume that I have heard two different accounts of the same event, from two friends, John and Mary:

- John tells me A ,
- Mary tells me $NOT A$ (A is not the case), and
- I consider both of them to be sufficiently reliable, under normal circumstances (so that I would have believed each one of them, if the other had kept silent).

I should view the statements of Mary and John as defeating one another, and refrain from forming any belief on the matter, unless I can assume that one of the two conclusions more reliable then the other

→ In this case, I should provisionally (*defeasibly* or *pro-tanto*) believe the content of the more reliable statement, and reject the other

Preference-Based Reasoning VI

Legal issue

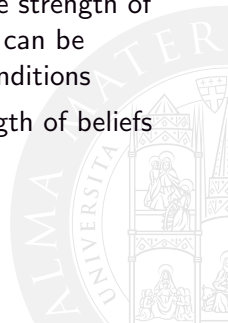
Assume that I come to know both of the following facts:

- John intentionally caused harm to Mary's property, driving into her fence, and,
 - he acted in a state of necessity, to avoid hitting a child who was crossing the street
- conclude that John has no duty to compensate Mary's damage, since the conclusion that he is not liable (having acted for the necessity of saving another's life) prevails over the conclusion that he is liable (having intentionally damaged another's property)



Preference-Based Reasoning VII

- this assumes that one has a way of determining what conclusion (if any) is more strongly supported. In some cases, one may do that by adopting mathematical methods
- one may use *probability* calculus, and assume that the strength of each conclusions corresponds to its probability, which can be computed by combining the probabilities of its pre-conditions
- other numerical calculations of the comparative strength of beliefs have also been proposed



Preference-Based Reasoning VIII

Legal scenario

Let us just observe, in general, that there are certain specific legal issues (in particular in the domain of evidence) where numerical calculi can provide appropriate answers.

However, these calculi do not provide a generally applicable solution for dealing with incompatible conclusions in moral and legal reasoning. In the law, it is rather the case that one needs to engage in priority reasoning, that is, one needs to bring to bear further information, and to decide accordingly which inference is to prevail. Though this information rarely is numerical, it enables in most cases a sufficiently precise assessment.



Reinstatement I

Reinstatement

When a defeater is strictly defeated by a further inference, then the inference originally attacked by the defeat may recover its capacity to establish its conclusion



Reinstatement II

Pink-swan example

- the bird of which I am having a pink vision is a swan, so that I would conclude for its whiteness, unless this conclusion was defeated by my perception of its pinkness
 - I realise that the sun is setting, and that its light makes all white things look pink
 - consequence of the perceptual inference being undercut, the inference for whiteness is reinstated
- I again *pro-tanto* believe that the bird is white



Reinstatement III

Criminal example: defeat by rebutting

- a detective is investigating the violent death of John, of which Mary, John's inconsolable girlfriend, is accused
- the detective believes that Mary loved John, but has evidence that her clothes were stained with John's blood
- him to build two inferences, which rebut one another

inference $\mathcal{A}$

(1) Mary loved John

(2) people **normally** do not kill their loved ones

(3) Mary has not killed John

inference $\mathcal{B}$

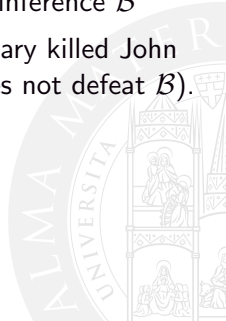
(1) Mary's clothes were stained with John's blood

(2) if one's clothes are stained with the victim's blood, then **normally** one has killed the victim

(3) Mary has killed John

Reinstatement IV

- assume that the detective also believes that inference $\mathcal{B}$ is preferable to inference $\mathcal{A}$ (he gives more credit to chemistry than to psychology)
- this allows the detective to endorse the conclusion of inference $\mathcal{B}$
- at this stage of the inquiry he forms the belief that Mary killed John (inference $\mathcal{B}$ defeats inference $\mathcal{A}$, but inference $\mathcal{A}$ does not defeat $\mathcal{B}$).



Reinstatement V

Criminal example: reinstatement through undercutting

- assume the detective discovers that Lisa (John's previous girlfriend) tried to frame Mary, by staining Mary's dress with John's blood
 - this alone would not be a reason to believe that Mary did not kill John, but rather a reason for considering that the inference $\mathcal{B}$ (from Mary's having blood-stained clothes to her being the murderer) is unreliable, and therefore to view this inference as being undercut
- inference $\mathcal{C}$ by undercutting inference $\mathcal{B}$ results in reinstating inference $\mathcal{A}$



Reinstatement VI

Criminal example: reinstatement through undercutting

inference $\mathcal{A}$

(1) Mary loved John

(2) people **normally** do not kill their loved ones

(3) Mary has not killed John

inference $\mathcal{B}$

(1) Mary's clothes were stained with John's blood

(2) if one's clothes are stained with the victim's blood, then **normally** one has killed the victim

(3) Mary has killed John

inference $\mathcal{C}$

(1) Lisa stained John's clothes with blood

(2) Mary's clothes being stained with John's blood does not warrant that Mary killed John

Reinstatement VII

Presumption: typical undercutting in legal reasoning

[Moore, 1987, Sartor, 1995]

- whenever a rule makes a certain legal effect dependent upon the fact that certain facts are not shown to hold
- reasoning with legal presumptions

inference $\mathcal{A}$

(1) If I do not believe that
one is guilty, then I
presume that one is innocent

(2) I do not believe that
Mary is guilty

(3) Mary is innocent

inference $\mathcal{B}$

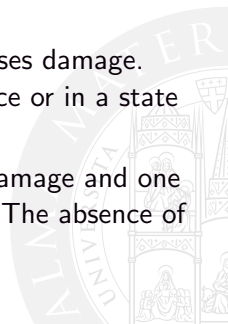
(1) I have evidence proving
that Mary is guilty

(2) Mary is guilty

Defeasibility in Legal Language I

The legislator often explicitly foresees the defeasibility of legal rules, by using different linguistic structures. For example, to establish that tort liability is excluded by self-defence or state of necessity, the legislator may use any of the following formulations:

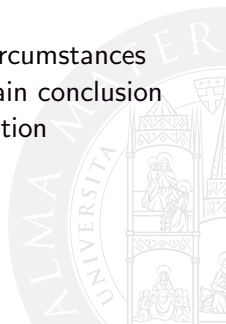
- *Unless clause*. One is liable if one voluntarily causes damage, unless one acts in self-defence or in a state of necessity
- *Explicit exception*. One is liable if one voluntarily causes damage. One is not liable for damages if one acts in self-defence or in a state of necessity
- *Presumption*. One is liable if one voluntarily causes damage and one does not act out of self-defence or state of necessity. The absence of self-defence and of a state of necessity is presumed



Defeasibility in Legal Language II

For concluding that one must make good a certain damage it is normally sufficient to ascertain that one voluntarily caused that damage, but this inference is defeated if the person turns out to have acted either in a state of necessity or in self-defence.

- *burden of proof between the parties*. distinguishing circumstances that have to be positively established to derive a certain conclusion from circumstances susceptible to blocking this derivation



Next in Line...

- 1 Defeasible Logic and Argumentation: Towards Conversation
- 2 Basic of Defeasible Logic
- 3 Defeasible Logic as Argumentation**
- 4 Basics of Argumentation



Next in Line...

- 1 Defeasible Logic and Argumentation: Towards Conversation
- 2 Basic of Defeasible Logic
- 3 Defeasible Logic as Argumentation
- 4 Basics of Argumentation**



References I



Moore, R. (1987).

Possible-world semantics for autoepistemic logic.

In *Readings in Nonmonotonic Reasoning*, pages 137–142. Morgan Kaufmann Publishers Inc., San Francisco, CA, USA.



Perelman, C. and Olbrechts-Tyteca, L. (1997).

Traité de l'argumentation. La nouvelle rhétorique.
Vrin.



Pollock, J. L. (1995).

Cognitive carpentry: A blueprint for how to build a person.
Mit Press.



Pollock, J. L. and Cruz, J. (1999).

Contemporary theories of knowledge, volume 35.
Rowman & Littlefield.



Sartor, G. (1995).

Defeasibility in legal reasoning.

In *Informatics and the foundations of legal reasoning*, pages 119–157. Springer.



Logic & Defeasible Reasoning

Joint International Doctoral (Ph.D) degree in Law, Science and
Technology

Roberta Calegari

roberta.calegari@unibo.it

ALMA MATER STUDIORUM – Università di Bologna

02 Feb 2020

