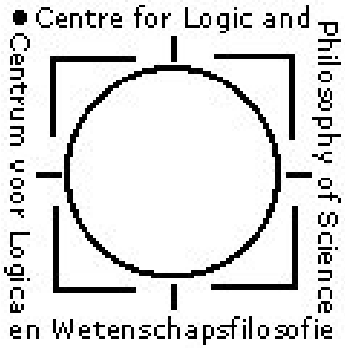
LMPS 2007



Content-Guidance in Formal Problem Solving Processes

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Outline

Some Background

Elements of a psp backbone
procedure
rules
instructions
marking

An Example of the Backbone

Adaptive logics

Extra-Logical Extensions

Comments

Some Background (1)

- Vienna Circle: (degenerated to) a priori methodology
- Historicism (Kuhn, . . .): relativism
- today: scientific problem-solving is content-guided
  “what we have learned, including what we have learned about how to learn” (Shapere)

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all possibilities / historicism

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Aim of this paper:

- formal approach to problem solving
- in which there is large room for content-guidance

($\Rightarrow$ example)

Some Background (2)

direct sources of inspiration:

- philosophy of science/epistemology:
  - problem solving: Kuhn, Laudan, *Nickles*, . . .
  - 'contextual': specific certainties, relevant data, methodological instructions, . . . for each problem
- logic:
  - procedures
  - prospective dynamics
  - adaptive logics
  - erotetic logic (varying on Wiśniewski)

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problem determined by (changing) *constraints*

- conditions on solution
- methodological instructions / heuristics / examples
- certainties (conceptual system, ...)

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some elements of the plot:

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  corrective: handling inconsistency (and similar), ambiguity, vagueness, ...
  ampliative: inductive generalization, abduction, ...

  control defeasible inferences by conditions and marking

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- model-based reasoning (mainly future research)

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from the general plot (consolations?)

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  $$\Rightarrow \begin{cases} \text{conceptual change} \\ \text{generation of new concepts} \end{cases}$$
- many ampliative mechanisms (abduction overestimated)
- independent of ontological debates

Elements of a psp backbone

lines of psp

- problem lines: example $\{?\{p \vee q, \sim p \vee q\}, ?\{r, \sim r\}\}$

  problem = non-empty set of questions

- declarative lines
  - conditional: $[B_1, \ldots, B_n]\, A$
  - unconditional: $[\emptyset]\, A$, viz. A

Outline

psp

- stage of a psp: sequence of lines
- psp: chain of stages
- next stage: add new line + apply marking definitions
- governed by *procedure*

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procedure (set of instructions)

- *rule of inference*: to derive A from $B_1, \ldots, B_n$
- *instruction*:
  rule of inference + permissions/obligations

  permissions/obligations depend on the present stage (lines + marks)
- below: instructions (including the rules)

varying on Smullyan

$\mathfrak{a}$	$\mathfrak{a}_1$	$\mathfrak{a}_2$		$\mathfrak{b}$	$\mathfrak{b}_1$	$\mathfrak{b}_2$
$A \wedge B$	A	B		$\sim(A \wedge B)$	$*A$	$*B$
$A \equiv B$	$A \supset B$	$B \supset A$		$\sim(A \equiv B)$	$\sim(A \supset B)$	$\sim(B \supset A)$
$\sim(A \vee B)$	$*A$	$*B$		$A \vee B$	A	B
$\sim(A \supset B)$	A	$*B$		$A \supset B$	$*A$	B
$\sim\sim A$	A	A				

complement of A: $*A = B$ if $A = \sim B$; otherwise $*A = \sim A$

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$A \wedge B$	A	B		$\sim(A \wedge B)$	$*A$	$*B$
$A \equiv B$	$A \supset B$	$B \supset A$		$\sim(A \equiv B)$	$\sim(A \supset B)$	$\sim(B \supset A)$
$\sim(A \vee B)$	$*A$	$*B$		$A \vee B$	A	B
$\sim(A \supset B)$	A	$*B$		$A \supset B$	$*A$	B
$\sim\sim A$	A	A				

formula analysing rules:

$$\frac{[\Delta]\,\mathfrak{a}}{[\Delta]\,\mathfrak{a}_1 \quad [\Delta]\,\mathfrak{a}_2} \qquad \frac{[\Delta]\,\mathfrak{b}}{[\Delta \cup \{*\mathfrak{b}_2\}]\,\mathfrak{b}_1 \quad [\Delta \cup \{*\mathfrak{b}_1\}]\,\mathfrak{b}_2}$$

$\mathfrak{a}$	$\mathfrak{a}_1$	$\mathfrak{a}_2$		$\mathfrak{b}$	$\mathfrak{b}_1$	$\mathfrak{b}_2$
$A \wedge B$	A	B		$\sim(A \wedge B)$	$*A$	$*B$
$A \equiv B$	$A \supset B$	$B \supset A$		$\sim(A \equiv B)$	$\sim(A \supset B)$	$\sim(B \supset A)$
$\sim(A \vee B)$	$*A$	$*B$		$A \vee B$	A	B
$\sim(A \supset B)$	A	$*B$		$A \supset B$	$*A$	B
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condition analysing rules:

$$\frac{[\Delta \cup \{\mathfrak{a}\}]\,A}{[\Delta \cup \{\mathfrak{a}_1, \mathfrak{a}_2\}]\,A} \qquad \frac{[\Delta \cup \{\mathfrak{b}\}]\,A}{[\Delta \cup \{\mathfrak{b}_1\}]\,A \quad [\Delta \cup \{\mathfrak{b}_2\}]\,A}$$

$\mathfrak{a}$	$\mathfrak{a}_1$	$\mathfrak{a}_2$		$\mathfrak{b}$	$\mathfrak{b}_1$	$\mathfrak{b}_2$
$A \wedge B$	A	B		$\sim(A \wedge B)$	$*A$	$*B$
$A \equiv B$	$A \supset B$	$B \supset A$		$\sim(A \equiv B)$	$\sim(A \supset B)$	$\sim(B \supset A)$
$\sim(A \vee B)$	$*A$	$*B$		$A \vee B$	A	B
$\sim(A \supset B)$	A	$*B$		$A \supset B$	$*A$	B
$\sim\sim A$	A	A				

positive part relation

1. $\mathrm{pp}(A, A)$.
2. $\mathrm{pp}(A, \mathfrak{a})$ if $\mathrm{pp}(A, \mathfrak{a}_1)$ or $\mathrm{pp}(A, \mathfrak{a}_2)$.
3. $\mathrm{pp}(A, \mathfrak{b})$ if $\mathrm{pp}(A, \mathfrak{b}_1)$ or $\mathrm{pp}(A, \mathfrak{b}_2)$.
4. If $\mathrm{pp}(A, B)$ and $\mathrm{pp}(B, C)$, then $\mathrm{pp}(A, C)$.

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The instructions

Main Start a psp with the line:

1 $\{?\{M, \sim M\}\}$ Main

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Target If P is the problem of an unmarked problem line, and A is a direct answer of a member of P, then one may add:

k $[A]\, A$ Target

The instructions

Main Start a psp with the line:

1 $\{?\{M, \sim M\}\}$ Main

Target If P is the problem of an unmarked problem line, and A is a direct answer of a member of P, then one may add:

k $[A]\, A$ Target

Prem If A is an unmarked target, $B \in \Gamma$, and $\mathrm{pp}(A, B)$, then one may add:

k B Prem

Formula analysing rules:

$$\frac{[\Delta]\,\alpha}{[\Delta]\,\alpha_1 \quad [\Delta]\,\alpha_2} \qquad \frac{[\Delta]\,\beta}{[\Delta \cup \{*\beta_2\}]\,\beta_1 \quad [\Delta \cup \{*\beta_1\}]\,\beta_2}$$

FAR If C is an unmarked target, $[\Delta]\,A$ is the formula of an unmarked line i, $[\Delta]\,A \,/\, [\Delta \cup \Delta']\,B$ is a formula analysing rule, and $\mathrm{pp}(C, B)$, then one may add:

k $\qquad [\Delta \cup \Delta']\,B \qquad\qquad i$; R

in which R is the name of the formula analysing rule.

Condition analysing rules:

$$\frac{[\Delta \cup \{\alpha\}]\, A}{[\Delta \cup \{\alpha_1, \alpha_2\}]\, A} \qquad \frac{[\Delta \cup \{\beta\}]\, A}{[\Delta \cup \{\beta_1\}]\, A \quad [\Delta \cup \{\beta_2\}]\, A}$$

CAR If A is an unmarked target, $[\Delta \cup \{B\}]\, A$ is the formula of an unmarked line i, and $[\Delta \cup \{B\}]\, A$ / $[\Delta \cup \Delta']\, A$ is a condition analysing rule, then one may add:

k $[\Delta \cup \Delta']\, A$ i; R

in which R is the name of the condition analysing rule.

Eliminate some problems without answering them:

EM0 If $[\Delta \cup \{*A\}]\, A$ is the formula of a line i that is neither R-marked nor I-marked, then one may add:

k	$[\Delta]\, A$	i; EM0

EM If A is an unmarked target, $[\Delta \cup \{B\}]\, A$ and $[\Delta' \cup \{\sim B\}]\, A$ are the respective formulas of the unmarked or only D-marked lines i and j, and $\Delta \subseteq \Delta'$ or $\Delta' \subseteq \Delta$, then one may add:

k	$[\Delta \cup \Delta']\, A$	i, j; EM

eliminate solved questions from a problem and summarize remaining problems (and paths):

Trans If A is an unmarked target, and $[\Delta \cup \{B\}]\, A$ and $[\Delta']\, B$ are the respective formulas of the at most S-marked lines i and j, then one may add:

k	$[\Delta \cup \Delta']\, A$	i, j; Trans

handle derived problems:

DP If A is an unmarked target from problem line i and $[B_1, \ldots, B_n]\, A$ is the formula of an unmarked line j, then one may add:

k $\quad \{?\{B_1, \sim B_1\}, \ldots, ?\{B_n, \sim B_n\}\}$ $\quad i, j$; DP

Remark:

no instruction for applying EFQ

in view of the intended applications
(deriving predictions, explanations, etc.)

Outline

Marking definitions

redundant lines are R-marked:

Definition

An at most S-marked declarative line i that has $[\Delta]\, A$ as its formula is R-marked at a stage iff, at that stage, $[\Theta]\, A$ is the formula of a line for some $\Theta \subset \Delta$.

Definition

An unmarked problem line i is R-marked at a stage iff, at that stage, a direct answer A of a question of line i is the formula of a line.

- target from a problem line
- resolution line
- direct target from
- target sequence
- grounded target sequence

inoperative lines are I-marked (not useful for extant problem):

Definition

An at most S-marked target line that has $[A]\,A$ as its formula is I-marked at a stage iff every problem line from which A is a target is marked at that stage.

Definition

An at most S-marked resolution line of which $[\Delta^1]\,A^1$ is the formula and $\Delta^1 \neq \emptyset$ is *I-marked* at a stage iff, at that stage, for every grounded target sequence $\langle [\Delta^n]\,A^n, \ldots, [\Delta^1]\,A^1 \rangle$,

(i) some target $[A^i]\,A^i$ $(1 \leq i \leq n)$ is marked, or
(ii) $\{A^n, \ldots, A^1\} \cap \Delta^1 \neq \emptyset$, or
(iii) $\Delta^1 \cup \ldots \cup \Delta^n \cup \Gamma^\circ_s$ is flatly inconsistent.

Definition

An unmarked problem line is I-marked iff no unmarked resolution line generates it.

Dead end lines are D-marked (no further action from such line)

- A is a *dead end* (A is literal and not positive part of premise)
- CAR-descendant of $[\Delta]\, B$

Definition

An at most S-marked resolution line with formula $[\Delta]\, A$ is D-marked at a stage iff some $B \in \Delta$ is a dead end or, at that stage, all CAR-descendants of $[\Delta]\, A$ occur in the psp and are D-marked.

Definition

An at most S-marked target line with formula $[A]\, A$ is D-marked at a stage iff A is a dead end or no further action can be taken in view of target A.

for all consistent Γ:

if $\Gamma \vdash A$, then the procedure applied to Γ and $\{?\{A, \sim A\}\}$ results in the answer A,

and

if $\Gamma \nvdash A$, then the procedure applied to Γ and $\{?\{A, \sim A\}\}$ stops without the main problem being answered or results in the answer $\sim A$.

Speed up the procedure by S-marks

- Γ°_{s} union of the Γ and of the set of the conditionless formulas that occur at stage s of the psp

Definition

A R-unmarked resolution line in which $[\Delta^1]\, A^1$ is derived is S-marked iff

(i) $\Delta^1 \cap \Gamma^{\circ}_{s} \neq \emptyset$, or

(ii) for some target sequence $\langle [\Delta^n]\, A^n, \ldots, [\Delta^1]\, A^1 \rangle$, $\{A^n\} \cup \Delta^1$ is flatly inconsistent whereas Δ^1 is not flatly inconsistent, or

(iii) $\Delta_1 \subset \Delta^n \cup \ldots \cup \Delta^2$ for some target sequence $\langle [\Delta^n]\, A^n, \ldots, [\Delta^1]\, A^1 \rangle$.

instruction: operate on S-marked lines before doing anything else

An Example of the Backbone

main problem: $?\{p \vee q, \sim(p \vee q)\}$

premise set:
$\{\sim s, \sim u \vee r, (r \wedge t) \vee s, (q \vee u) \supset (\sim t \vee q), t \supset u\}$

logic: $\mathbf{CL}^{-}$ + an erotetic logic (fixed by the procedure)

procedure: prospective dynamics + problems

$\{\sim s, \sim u \vee r, (r \wedge t) \vee s, (q \vee u) \supset (\sim t \vee q), t \supset u\}$

1 $\{?\{p \vee q, \sim(p \vee q)\}\}$ Main

$\{\sim s, \sim u \vee r, (r \wedge t) \vee s, (q \vee u) \supset (\sim t \vee q), t \supset u\}$

1	$\{?\{p \vee q, \sim(p \vee q)\}\}$	Main
2	$[\sim(p \vee q)]\,\sim(p \vee q)$	Target

$\{\sim s, \sim u \vee r, (r \wedge t) \vee s, (q \vee u) \supset (\sim t \vee q), t \supset u\}$

1	$\{?\{p \vee q, \sim(p \vee q)\}\}$	Main	
2	$[\sim(p \vee q)]\ \sim(p \vee q)$	Target	D^3
3	$[\sim p, \sim q]\ \sim(p \vee q)$	2; C$\sim\vee$E	D^3

$\{\sim s, \sim u \vee r, (r \wedge t) \vee s, (q \vee u) \supset (\sim t \vee q), t \supset u\}$

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3	$[\sim p, \sim q]\, \sim(p \vee q)$	2; C$\sim\vee$E	D^3
4	$[p \vee q]\, p \vee q$	Target	

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3	$[\sim p, \sim q]\, \sim(p \vee q)$	2; C$\sim\vee$E	D^3
4	$[p \vee q]\, p \vee q$	Target	
5	$[p]\, p \vee q$	4; C$\vee$E	D^5

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1	$\{?\{p \vee q, \sim(p \vee q)\}\}$	Main	
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3	$[\sim p, \sim q]\, \sim(p \vee q)$	2; C$\sim\vee$E	D^3
4	$[p \vee q]\, p \vee q$	Target	
5	$[p]\, p \vee q$	4; C$\vee$E	D^5
6	$[q]\, p \vee q$	4; C$\vee$E	

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4	$[p \vee q]\, p \vee q$	Target	
5	$[p]\, p \vee q$	4; C$\vee$E	D^5
6	$[q]\, p \vee q$	4; C$\vee$E	
7	$\{?\{q, \sim q\}\}$	4, 6; DP	

$\{\sim s, \sim u \vee r, (r \wedge t) \vee s, (q \vee u) \supset (\sim t \vee q), t \supset u\}$

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4	$[p \vee q]\, p \vee q$	Target	
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6	$[q]\, p \vee q$	4; C$\vee$E	
7	$\{?\{q, \sim q\}\}$	4, 6; DP	
8	$[q]\, q$	Target	

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4	$[p \vee q]\, p \vee q$	Target	
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8	$[q]\, q$	Target	
9	$(q \vee u) \supset (\sim t \vee q)$	Prem	

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4	$[p \vee q]\, p \vee q$	Target	
5	$[p]\, p \vee q$	4; C$\vee$E	D^5
6	$[q]\, p \vee q$	4; C$\vee$E	
7	$\{?\{q, \sim q\}\}$	4, 6; DP	
8	$[q]\, q$	Target	
9	$(q \vee u) \supset (\sim t \vee q)$	Prem	
10	$[q \vee u] \sim t \vee q$	9; $\supset$E	

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7	$\{?\{q, \sim q\}\}$	4, 6; DP	
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9	$(q \vee u) \supset (\sim t \vee q)$	Prem	
10	$[q \vee u] \sim t \vee q$	9; $\supset$E	
11	$[q] \sim t \vee q$	10; C$\vee$E	

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6	$[q]\, p \vee q$	4; C$\vee$E	
7	$\{?\{q, \sim q\}\}$	4, 6; DP	
8	$[q]\, q$	Target	
9	$(q \vee u) \supset (\sim t \vee q)$	Prem	
10	$[q \vee u]\, \sim t \vee q$	9; $\supset$E	
11	$[q]\, \sim t \vee q$	10; C$\vee$E	
12	$[q, t]\, q$	11; $\vee$E	

$\{\sim s, \sim u \vee r, (r \wedge t) \vee s, (q \vee u) \supset (\sim t \vee q), t \supset u\}$

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2	$[\sim(p \vee q)]\, \sim(p \vee q)$	Target	D^3
3	$[\sim p, \sim q]\, \sim(p \vee q)$	2; C$\sim\vee$E	D^3
4	$[p \vee q]\, p \vee q$	Target	
5	$[p]\, p \vee q$	4; C$\vee$E	D^5
6	$[q]\, p \vee q$	4; C$\vee$E	
7	$\{?\{q, \sim q\}\}$	4, 6; DP	
8	$[q]\, q$	Target	
9	$(q \vee u) \supset (\sim t \vee q)$	Prem	
10	$[q \vee u]\, \sim t \vee q$	9; $\supset$E	
11	$[q]\, \sim t \vee q$	10; C$\vee$E	
12	$[q, t]\, q$	11; $\vee$E	I^{12}
13	$[u]\, \sim t \vee q$	10; C$\vee$E	

$\{\sim s, \sim u \vee r, (r \wedge t) \vee s, (q \vee u) \supset (\sim t \vee q), t \supset u\}$

1	$\{?\{p \vee q, \sim(p \vee q)\}\}$	Main	
2	$[\sim(p \vee q)]\, \sim(p \vee q)$	Target	D^3
3	$[\sim p, \sim q]\, \sim(p \vee q)$	2; C$\sim\vee$E	D^3
4	$[p \vee q]\, p \vee q$	Target	
5	$[p]\, p \vee q$	4; C$\vee$E	D^5
6	$[q]\, p \vee q$	4; C$\vee$E	
7	$\{?\{q, \sim q\}\}$	4, 6; DP	
8	$[q]\, q$	Target	
9	$(q \vee u) \supset (\sim t \vee q)$	Prem	
10	$[q \vee u]\, \sim t \vee q$	9; $\supset$E	
11	$[q]\, \sim t \vee q$	10; C$\vee$E	
12	$[q, t]\, q$	11; $\vee$E	I^{12}
13	$[u]\, \sim t \vee q$	10; C$\vee$E	
14	$[u, t]\, q$	13; $\vee$E	

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1	$\{?\{p \vee q, \sim(p \vee q)\}\}$	Main	
2	$[\sim(p \vee q)]\, \sim(p \vee q)$	Target	D^3
3	$[\sim p, \sim q]\, \sim(p \vee q)$	2; C$\sim\vee$E	D^3
4	$[p \vee q]\, p \vee q$	Target	
5	$[p]\, p \vee q$	4; C$\vee$E	D^5
6	$[q]\, p \vee q$	4; C$\vee$E	
7	$\{?\{q, \sim q\}\}$	4, 6; DP	
8	$[q]\, q$	Target	
9	$(q \vee u) \supset (\sim t \vee q)$	Prem	
10	$[q \vee u]\, \sim t \vee q$	9; $\supset$E	
11	$[q]\, \sim t \vee q$	10; C$\vee$E	
12	$[q, t]\, q$	11; $\vee$E	I^{12}
13	$[u]\, \sim t \vee q$	10; C$\vee$E	
14	$[u, t]\, q$	13; $\vee$E	
15	$\{?\{u, \sim u\}, ?\{t, \sim t\}\}$	8, 14; DP	

$\{\sim s, \sim u \vee r, (r \wedge t) \vee s, (q \vee u) \supset (\sim t \vee q), t \supset u\}$

1	$\{?\{p \vee q, \sim(p \vee q)\}\}$	Main	
2	$[\sim(p \vee q)]\, \sim(p \vee q)$	Target	D^3
3	$[\sim p, \sim q]\, \sim(p \vee q)$	2; C$\sim\vee$E	D^3
4	$[p \vee q]\, p \vee q$	Target	
5	$[p]\, p \vee q$	4; C$\vee$E	D^5
6	$[q]\, p \vee q$	4; C$\vee$E	
7	$\{?\{q, \sim q\}\}$	4, 6; DP	
8	$[q]\, q$	Target	
9	$(q \vee u) \supset (\sim t \vee q)$	Prem	
10	$[q \vee u] \sim t \vee q$	9; $\supset$E	
11	$[q] \sim t \vee q$	10; C$\vee$E	
12	$[q, t]\, q$	11; $\vee$E	I^{12}
13	$[u] \sim t \vee q$	10; C$\vee$E	
14	$[u, t]\, q$	13; $\vee$E	
15	$\{?\{u, \sim u\}, ?\{t, \sim t\}\}$	8, 14; DP	
16	$[t]\, t$	Target	

$\{\sim s, \sim u \vee r, (r \wedge t) \vee s, (q \vee u) \supset (\sim t \vee q), t \supset u\}$

1	$\{?\{p \vee q, \sim(p \vee q)\}\}$	Main	
2	$[\sim(p \vee q)]\, \sim(p \vee q)$	Target	D^3
3	$[\sim p, \sim q]\, \sim(p \vee q)$	2; C$\sim\vee$E	D^3
4	$[p \vee q]\, p \vee q$	Target	
5	$[p]\, p \vee q$	4; C$\vee$E	D^5
6	$[q]\, p \vee q$	4; C$\vee$E	
7	$\{?\{q, \sim q\}\}$	4, 6; DP	
8	$[q]\, q$	Target	
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10	$[q \vee u]\, \sim t \vee q$	9; $\supset$E	
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12	$[q, t]\, q$	11; $\vee$E	I^{12}
13	$[u]\, \sim t \vee q$	10; C$\vee$E	
14	$[u, t]\, q$	13; $\vee$E	
15	$\{?\{u, \sim u\}, ?\{t, \sim t\}\}$	8, 14; DP	
16	$[t]\, t$	Target	

1, 6, 14–16

$\{\sim s, \sim u \vee r, (r \wedge t) \vee s, (q \vee u) \supset (\sim t \vee q), t \supset u\}$

1	$\{?\{p \vee q, \sim(p \vee q)\}\}$	Main
...		
6	$[q]\, p \vee q$	4; C$\vee$E
...		
14	$[u, t]\, q$	13; $\vee$E
15	$\{?\{u, \sim u\}, ?\{t, \sim t\}\}$	8, 14; DP
16	$[t]\, t$	Target

$\{\sim s, \sim u \vee r, (r \wedge t) \vee s, (q \vee u) \supset (\sim t \vee q), t \supset u\}$

1	$\{?\{p \vee q, \sim(p \vee q)\}\}$	Main
...		
6	$[q]\, p \vee q$	4; C$\vee$E
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15	$\{?\{u, \sim u\}, ?\{t, \sim t\}\}$	8, 14; DP
16	$[t]\, t$	Target
17	$(r \wedge t) \vee s$	Prem

$\{\sim s, \sim u \vee r, (r \wedge t) \vee s, (q \vee u) \supset (\sim t \vee q), t \supset u\}$

1	$\{?\{p \vee q, \sim(p \vee q)\}\}$	Main
...		
6	$[q]\, p \vee q$	4; C$\vee$E
...		
14	$[u, t]\, q$	13; $\vee$E
15	$\{?\{u, \sim u\}, ?\{t, \sim t\}\}$	8, 14; DP
16	$[t]\, t$	Target
17	$(r \wedge t) \vee s$	Prem
18	$[\sim s]\, r \wedge t$	17; $\vee$E

$\{\sim s, \sim u \vee r, (r \wedge t) \vee s, (q \vee u) \supset (\sim t \vee q), t \supset u\}$

1	$\{?\{p \vee q, \sim(p \vee q)\}\}$	Main
...		
6	$[q]\, p \vee q$	4; C$\vee$E
...		
14	$[u, t]\, q$	13; $\vee$E
15	$\{?\{u, \sim u\}, ?\{t, \sim t\}\}$	8, 14; DP
16	$[t]\, t$	Target
17	$(r \wedge t) \vee s$	Prem
18	$[\sim s]\, r \wedge t$	17; $\vee$E
19	$[\sim s]\, t$	18; $\wedge$E

$\{\sim s, \sim u \vee r, (r \wedge t) \vee s, (q \vee u) \supset (\sim t \vee q), t \supset u\}$

1	$\{?\{p \vee q, \sim(p \vee q)\}\}$	Main
...		
6	$[q]\, p \vee q$	4; C$\vee$E
...		
14	$[u, t]\, q$	13; $\vee$E
15	$\{?\{u, \sim u\}, ?\{t, \sim t\}\}$	8, 14; DP
16	$[t]\, t$	Target
17	$(r \wedge t) \vee s$	Prem
18	$[\sim s]\, r \wedge t$	17; $\vee$E
19	$[\sim s]\, t$	18; $\wedge$E
20	$\{?\{s, \sim s\}\}$	16, 19; DP

$\{\sim s, \sim u \vee r, (r \wedge t) \vee s, (q \vee u) \supset (\sim t \vee q), t \supset u\}$

1	$\{?\{p \vee q, \sim(p \vee q)\}\}$	Main
...		
6	$[q]\, p \vee q$	4; C$\vee$E
...		
14	$[u, t]\, q$	13; $\vee$E
15	$\{?\{u, \sim u\}, ?\{t, \sim t\}\}$	8, 14; DP
16	$[t]\, t$	Target
17	$(r \wedge t) \vee s$	Prem
18	$[\sim s]\, r \wedge t$	17; $\vee$E
19	$[\sim s]\, t$	18; $\wedge$E
20	$\{?\{s, \sim s\}\}$	16, 19; DP
21	$[\sim s] \sim s$	Target

$\{\sim s, \sim u \vee r, (r \wedge t) \vee s, (q \vee u) \supset (\sim t \vee q), t \supset u\}$

1	$\{?\{p \vee q, \sim(p \vee q)\}\}$	Main	
...			
6	$[q]\, p \vee q$	4; C$\vee$E	
...			
14	$[u, t]\, q$	13; $\vee$E	
15	$\{?\{u, \sim u\}, ?\{t, \sim t\}\}$	8, 14; DP	
16	$[t]\, t$	Target	
17	$(r \wedge t) \vee s$	Prem	
18	$[\sim s]\, r \wedge t$	17; $\vee$E	
19	$[\sim s]\, t$	18; $\wedge$E	S^{22}
20	$\{?\{s, \sim s\}\}$	16, 19; DP	R^{22}
21	$[\sim s] \sim s$	Target	R^{22}
22	$\sim s$	Prem	

$\{\sim s, \sim u \vee r, (r \wedge t) \vee s, (q \vee u) \supset (\sim t \vee q), t \supset u\}$

1	$\{?\{p \vee q, \sim(p \vee q)\}\}$	Main	
...			
6	$[q]\, p \vee q$	4; C$\vee$E	
...			
14	$[u, t]\, q$	13; $\vee$E	S^{23}
15	$\{?\{u, \sim u\}, ?\{t, \sim t\}\}$	8, 14; DP	R^{23}
16	$[t]\, t$	Target	R^{23}
17	$(r \wedge t) \vee s$	Prem	
18	$[\sim s]\, r \wedge t$	17; $\vee$E	
19	$[\sim s]\, t$	18; $\wedge$E	S^{22} R^{23}
20	$\{?\{s, \sim s\}\}$	16, 19; DP	R^{22}
21	$[\sim s] \sim s$	Target	R^{22}
22	$\sim s$	Prem	
23	t	19, 22; Trans	

$\{\sim s, \sim u \vee r, (r \wedge t) \vee s, (q \vee u) \supset (\sim t \vee q), t \supset u\}$

1	$\{?\{p \vee q, \sim(p \vee q)\}\}$	Main	
...			
6	$[q]\, p \vee q$	4; C$\vee$E	
...			
14	$[u, t]\, q$	13; $\vee$E	S^{23} R^{24}
15	$\{?\{u, \sim u\}, ?\{t, \sim t\}\}$	8, 14; DP	R^{23}
16	$[t]\, t$	Target	R^{23}
17	$(r \wedge t) \vee s$	Prem	
18	$[\sim s]\, r \wedge t$	17; $\vee$E	
19	$[\sim s]\, t$	18; $\wedge$E	S^{22} R^{23}
20	$\{?\{s, \sim s\}\}$	16, 19; DP	R^{22}
21	$[\sim s] \sim s$	Target	R^{22}
22	$\sim s$	Prem	
23	t	19, 22; Trans	
24	$[u]\, q$	14, 23; Trans	

$\{\sim s, \sim u \vee r, (r \wedge t) \vee s, (q \vee u) \supset (\sim t \vee q), t \supset u\}$

1	$\{?\{p \vee q, \sim(p \vee q)\}\}$	Main	
...			
6	$[q]\, p \vee q$	4; C$\vee$E	
...			
14	$[u, t]\, q$	13; $\vee$E	S^{23} R^{24}
15	$\{?\{u, \sim u\}, ?\{t, \sim t\}\}$	8, 14; DP	R^{23}
16	$[t]\, t$	Target	R^{23}
17	$(r \wedge t) \vee s$	Prem	
18	$[\sim s]\, r \wedge t$	17; $\vee$E	
19	$[\sim s]\, t$	18; $\wedge$E	S^{22} R^{23}
20	$\{?\{s, \sim s\}\}$	16, 19; DP	R^{22}
21	$[\sim s] \sim s$	Target	R^{22}
22	$\sim s$	Prem	
23	t	19, 22; Trans	
24	$[u]\, q$	14, 23; Trans	
25	$\{?\{u, \sim u\}\}$	8, 24; DP	

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1	$\{?\{p \vee q, \sim(p \vee q)\}\}$	Main	
...			
6	$[q]\, p \vee q$	4; C$\vee$E	
...			
14	$[u, t]\, q$	13; $\vee$E	S^{23} R^{24}
15	$\{?\{u, \sim u\}, ?\{t, \sim t\}\}$	8, 14; DP	R^{23}
16	$[t]\, t$	Target	R^{23}
17	$(r \wedge t) \vee s$	Prem	
18	$[\sim s]\, r \wedge t$	17; $\vee$E	
19	$[\sim s]\, t$	18; $\wedge$E	S^{22} R^{23}
20	$\{?\{s, \sim s\}\}$	16, 19; DP	R^{22}
21	$[\sim s] \sim s$	Target	R^{22}
22	$\sim s$	Prem	
23	t	19, 22; Trans	
24	$[u]\, q$	14, 23; Trans	
25	$\{?\{u, \sim u\}\}$	8, 24; DP	

1, 6, 23–25

$\{\sim s, \sim u \vee r, (r \wedge t) \vee s, (q \vee u) \supset (\sim t \vee q), t \supset u\}$

1	$\{?\{p \vee q, \sim(p \vee q)\}\}$	Main
...		
6	$[q]\, p \vee q$	4; C$\vee$E
...		
23	t	19, 22; Trans
24	$[u]\, q$	14, 23; Trans
25	$\{?\{u, \sim u\}\}$	8, 24; DP

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1	$\{?\{p \vee q, \sim(p \vee q)\}\}$	Main
...		
6	$[q]\, p \vee q$	4; C$\vee$E
...		
23	t	19, 22; Trans
24	$[u]\, q$	14, 23; Trans
25	$\{?\{u, \sim u\}\}$	8, 24; DP
26	$[u]\, u$	Target

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1	$\{?\{p \vee q, \sim(p \vee q)\}\}$	Main
...		
6	$[q]\, p \vee q$	4; C$\vee$E
...		
23	t	19, 22; Trans
24	$[u]\, q$	14, 23; Trans
25	$\{?\{u, \sim u\}\}$	8, 24; DP
26	$[u]\, u$	Target
27	$t \supset u$	Prem

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1	$\{?\{p \vee q, \sim(p \vee q)\}\}$	Main	
...			
6	$[q]\, p \vee q$	4; C$\vee$E	
...			
23	t	19, 22; Trans	
24	$[u]\, q$	14, 23; Trans	
25	$\{?\{u, \sim u\}\}$	8, 24; DP	
26	$[u]\, u$	Target	
27	$t \supset u$	Prem	
28	$[t]\, u$	27; $\supset$E	S^{28}

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1	$\{?\{p \vee q, \sim(p \vee q)\}\}$	Main	
...			
6	$[q]\, p \vee q$	4; C$\vee$E	
...			
23	t	19, 22; Trans	
24	$[u]\, q$	14, 23; Trans	S^{29}
25	$\{?\{u, \sim u\}\}$	8, 24; DP	R^{29}
26	$[u]\, u$	Target	R^{29}
27	$t \supset u$	Prem	
28	$[t]\, u$	27; $\supset$E	S^{28} R^{29}
29	u	23, 28; Trans	

$\{\sim s, \sim u \vee r, (r \wedge t) \vee s, (q \vee u) \supset (\sim t \vee q), t \supset u\}$

1	$\{?\{p \vee q, \sim(p \vee q)\}\}$	Main	
...			
6	$[q]\, p \vee q$	4; C$\vee$E	S^{30}
...			
23	t	19, 22; Trans	
24	$[u]\, q$	14, 23; Trans	S^{29} R^{30}
25	$\{?\{u, \sim u\}\}$	8, 24; DP	R^{29}
26	$[u]\, u$	Target	R^{29}
27	$t \supset u$	Prem	
28	$[t]\, u$	27; $\supset$E	S^{28} R^{29}
29	u	23, 28; Trans	
30	q	24, 29; Trans	

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1	$\{?\{p \vee q, \sim(p \vee q)\}\}$	Main	R^{31}
...			
6	$[q]\, p \vee q$	4; C$\vee$E	S^{30} R^{31}
...			
23	t	19, 22; Trans	
24	$[u]\, q$	14, 23; Trans	S^{29} R^{30}
25	$\{?\{u, \sim u\}\}$	8, 24; DP	R^{29}
26	$[u]\, u$	Target	R^{29}
27	$t \supset u$	Prem	
28	$[t]\, u$	27; $\supset$E	S^{28} R^{29}
29	u	23, 28; Trans	
30	q	24, 29; Trans	
31	$p \vee q$	6, 30; Trans	

$\{\sim s, \sim u \vee r, (r \wedge t) \vee s, (q \vee u) \supset (\sim t \vee q), t \supset u\}$

1	$\{?\{p \vee q, \sim(p \vee q)\}\}$	Main	R^{31}
...			
6	$[q]\, p \vee q$	4; C$\vee$E	S^{30} R^{31}
...			
23	t	19, 22; Trans	
24	$[u]\, q$	14, 23; Trans	S^{29} R^{30}
25	$\{?\{u, \sim u\}\}$	8, 24; DP	R^{29}
26	$[u]\, u$	Target	R^{29}
27	$t \supset u$	Prem	
28	$[t]\, u$	27; $\supset$E	S^{28} R^{29}
29	u	23, 28; Trans	
30	q	24, 29; Trans	
31	$p \vee q$	6, 30; Trans	

problem solved

Adaptive logics (only Standard Format)

characterization

- *lower limit logic* **LLL**
- *set of abnormalities* Ω
- *strategy*

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upper limit logic:
syntax: **ULL** = **LLL** + axiom/rule
semantics: the **LLL**-models that verify no abnormality

general idea behind adaptive logics:
$Cn_{\mathbf{AL}}(\Gamma)$: $Cn_{\mathbf{LLL}}(\Gamma)$ + what follows if as many members of Ω are false as the premises permit

Example: the inconsistency-adaptive **CLuN**^{r}

- *lower limit logic*: **CLuN**
- *set of abnormalities*: $\Omega = \{\exists(A \wedge \sim A) \mid A \in \mathcal{F}\}$
- *strategy*: Reliability

upper limit logic:

CL = **CLuN** + $(A \wedge \sim A) \supset B$

semantically: the **CLuN**-models that verify no inconsistency

corrective adaptive logic (if **CL** is the standard)

Example: logic of inductive generalization: $\mathbf{IL}^m$

- *lower limit logic*: **CL**
- *set of abnormalities*: $\Omega = \{\exists A \wedge \exists \sim A \mid A \in \mathcal{F}^\circ\}$
- *strategy*: Minimal Abnormality

upper limit logic:

UCL = **CL** + $\exists\alpha A(\alpha) \supset \forall\alpha A(\alpha)$

semantically: the uniform **CL**-models ($v(\pi^r) \in \{\emptyset, D^{(r)}\}$)

ampliative adaptive logic (if **CL** is the standard)

standard format provides

- proofs
- semantics
- most of metatheory (including soundness and completeness)
- prospective dynamics (published for Reliability)

further examples (relevant for philosophy of science)

- many other inconsistency-handling (+ other logical symbols)
- ambiguity-adaptive
- vagueness-adaptive
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- plausibility-adaptive
- compatibility
- diagnosis
- abduction
- analogies, metaphors
- erotetic evocation/implication (problem solving)
- ...

Some Extra-Logical Extensions (1)

answerable questions

$\mathbb{A}$ is a set of couples $(\Delta : Q)$ in which Δ is a set of statements and Q is a question

idea: if the members of Δ are true, Q can be answered by observational/experimental means
(not Hintikka's oracle)

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psp guides (which observations/experiments should be carried out)

Some Extra-Logical Extensions (2)

bringing in available information (formerly judged irrelevant)

one tries to solve problem from theory T and set of data
later a theory T' turns out to be relevant
(because a target is a positive part of an axiom of T')

Some Extra-Logical Extensions (2)

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psp guides (which further theories are relevant?)

Some Extra-Logical Extensions (3)

plausible conjectures

where A is an abnormality, introduce $\Diamond^i A$ or $\Diamond^i \neg A$

- basis: worldview, personal constraint, study of situation, blind guess
- thus reducing a disjunction of abnormalities
- = defeasibly obtaining more consequences (plausibility-adaptive logic)

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...

Comments (1)

framework that contains **open slots**

these make content guidance possible

but the framework is **formal**

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but the framework is **formal**

prospective dynamics pushes the ‘logical’ part of the heuristics into the proof

part of remaining heuristics is fixed by procedure

still remaining heuristics

Comments (2)

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- multiplicity of adaptive logics for every purpose (to be justified)

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content-guided

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  to be decided in view of what was learned about world/learning in specific domain/context

Comments (4)

conclusion

framework that contains **open slots**

these make content guidance possible

but the framework is **formal**

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conclusion

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status of the approach itself: provisional hypothesis