Computational Models for Human Reasoning and Beyond

Emmanuelle Dietz

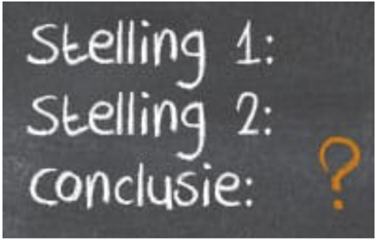
CLASP - Centre for Linguistic Theory and Studies in Probability, University of Gothenburg, Sweden

AIRBUS

What I will talk about today

1. Two Human Reasoning Tasks $\rightsquigarrow$ **Syllogistic Reasoning** and **Conditional Reasoning**
    - In both tasks, reasoning needs to be done based on language
    - (Natural) languages are quite ambigious
    - The human reasoning tasks show that
        - Humans reasoning diverges from Classical Logic
        - The context influences how humans reason
2. We call these extra-logical properties $\rightsquigarrow$ **Cognitive Principles**
3. Cognitive principles can be modelled formally in Argumentation $\rightsquigarrow$ **Cognitive Argumentation**
4. Simulation within a cognitive architecture $\rightsquigarrow$ **Bridging to lower levels of cognition**
5. Cognitive Principles as one aspect to help $\rightsquigarrow$ **Benchmarking Cognitive Models**
6. How human reasoning might solve combinatorial problems in application $\rightsquigarrow$ **Excursion to Industry**

Syllogistic Reasoning



Syllogistic Reasoning Task

Khemlani and Johnson-Laird (2012)

Some artists are not bakers   All bakers are chemists

What follows about the relation between artists and chemists?

- All artists are chemists
- No artists are chemists
- Some artists are chemists
- Some artists are not chemists
- All chemists are artists
- No chemists are artists
- Some chemists are artists $\rightsquigarrow$ **19%** !
- Some chemists are not artists $\rightsquigarrow$ **46%** !
- No valid conclusion (NVC) $\rightsquigarrow$ **20%** !

Syllogisms: Moods

mood	natural language	first-order logic	abbreviation
affirmative universal	all a are b	$\forall X(a(X) \rightarrow b(X))$	Aab
affirmative existential	some a are b	$\exists X(a(X) \wedge b(X))$	Iab
negative universal	no a are b	$\forall X(a(X) \rightarrow \neg b(X))$	Eab
negative existential	some a are not b	$\exists X(a(X) \wedge \neg b(X))$	Oab

Some artists are not bakers $\Rightarrow$ Oab

All bakers are chemists $\Rightarrow$ Abc

Syllogisms: Figures

- 4 figures

	premise 1	premise 2
figure 1	a-b	b-c
figure 2	b-a	c-b
figure 3	a-b	c-b
figure 4	b-a	b-c

- 64 pairs of premises
- abbreviated by the first and the second mood of the figure

Some artists are not bakers

All bakers are chemists $\Rightarrow$ OA1

- 512 (not necessarily valid) syllogisms
- possible conclusions are the 4 moods instantiated by a-c and c-a

All artists are bakers

All bakers are chemists $\Rightarrow$ AA1

All artists are chemists $\Rightarrow$ Aac

Human Syllogistic Reasoning

Khemlani and Johnson-Laird (2012) made a meta-study on syllogistic reasoning

- 64 different pairs of premises and 512 different syllogisms
- Data from 6 psychological experiments
- Comparison of this data with 12 cognitive theories
- None of the current theories models human syllogistic reasoning adequately!
- *If psychologists could agree on an adequate theory of syllogistic reasoning, then progress toward a more general theory of reasoning would seem to be feasible*

The human syllogistic reasoning approach under the Weak Completion Semantics, a three-valued logic programming approach, outperforms any of the twelve cognitive theories!

Costa, Dietz Saldanha, Hölldobler (2017) Dietz Saldanha, Hölldobler, Mörbitz (2018)

Formalization of observations made in psychology and philosophy of language (Grice [1975])

Existential Import $\rightsquigarrow$ All bakers are chemists implies that bakers exist

Maxim of Quantity $\rightsquigarrow$ Some artists are not bakers implies Not all artists are not bakers

$\rightsquigarrow$ **Cognitive Principles !**

Some artists are not bakers All bakers are chemists

Majority concluded Some artists are chemists (19%), Some artists are not chemists (46%) and No valid conclusion (20%)

Different sets of principles characterize different reasoners ! (Dietz Saldanha, Schambach 2019)

	Cluster 1	Cluster 2	...
Principle 1	✓	✓	
Principle 2	-	✓	
...			
	$\Downarrow$ No valid conclusion	$\Downarrow$ Some chemists are not artists	

$\rightsquigarrow$ Modeling of cognitive principles in Cognitive Argumentation ! (Dietz Saldanha, Kakas (2019))

COGNITIVE ARGUMENTATION

Why Argumentation?

- provides flexibility for reasoning, handling conflicts and changes
- Some arguments might be stronger than other arguments

  $\leadsto$ can explain individual reasoning patterns
- Strong evidence from psychology (Mercier and Sperber, 2011)

  $\leadsto$ **arguments are the means for human reasoning**

Associations represented through Argument Schemes (Pollock, 1995, Walton, 1996)

- Generic form of assications, common, stereotypical reasoning patterns
- Labeled with names, which allow meta-information about them such as relative strength relations

  $\leadsto$ affects the ability of arguments to defend against other arguments
- powerful in understanding the structure of arguments & plays a key role in teaching critical thinking skills

  $\leadsto$ `https://www.rationaleonline.com/`

Cognitive Argumentation successfully accounts for all typical reasoning tasks Dietz, Kakas (2019; 2020, 2021)

$\leadsto$ **Cognitive principles as argument schemes**

Cognitive Argumentation

Cognitive Principles

1. Humans make assumptions while reasoning
2. Many of these assumptions are not necessarily valid in classical logic
3. These typical assumptions are extra-logical
4. Yet, humans are pretty good in explaining plausibly why they make these assumptions

⇝ Characterization as argument schemes

⇝ These schemes guide argument construction

TIME SCALE OF HUMAN ACTION

Scale (sec)	Time Units	System	World (theory)
10^{7}	months		SOCIAL BAND
10^{6}	weeks		
10^{5}	days		
10^{4}	hours	Task	RATIONAL BAND
10^{3}	10 min	Task	
10^{2}	minutes	Task	
10^{1}	10 sec	Unit task	COGNITIVE BAND
10^{0}	1 sec	Operations	
10^{-1}	100 ms	Deliberate act	
10^{-2}	10 ms	Neural circuit	BIOLOGICAL BAND
10^{-3}	1 ms	Neuron	
10^{-4}	100 µs	Organelle	

Cognitive Argumentation

- $\mathcal{P}$ set of propositional variables, $\neg\mathcal{P} = \{\neg x \mid x \in \mathcal{P}\}$ $\rightsquigarrow \{e, \ell, o, t\}$
- $\mathcal{S} = (\mathcal{F}, \mathcal{A})$ cognitive state, with set of facts $\mathcal{F}$ and relevance set $\mathcal{A}$ $\rightsquigarrow (\{e\}, \{e, \ell\})$

Argument scheme AS is a pair of precondition and position of the form

$$\text{AS} \quad = \quad (\text{Pre}, \text{Pos})$$

where $\text{Pre}, \text{Pos} \subseteq (\mathcal{P} \cup \neg\mathcal{P})$

- Argument Δ is a set of argument schemes

$\rightsquigarrow$ A short introduction to the library task

The Library Task

THE LIBRARY TASK (Byrne, 1989)

- If she has an essay to finish, then she will study late in the library
- She has an essay to finish

What follows?

1. She will study late in the library 96%
2. She will not study late in the library
3. She may or may not study late in the library

THE LIBRARY TASK (Byrne, 1989)

- If she has an essay to finish, then she will study late in the library
- If she has a textbook to read, then she will study late in the library
- She has an essay to finish

What follows?

1. She will study late in the library 96%
2. She will not study late in the library
3. She may or may not study late in the library

$\leadsto$ Humans seem to suppress previously drawn information. They reason non-monotonically!

$\leadsto$ Instead of concluding that humans do not reason logically,
we assume that humans do not reason in accordance with Classical Logic!

THE LIBRARY TASK (Byrne, 1989)

- If she has an essay to finish, then she will study late in the library
- If the library is open, then she will study late in the library
- She has an essay to finish

What follows?

1. She will study late in the library 38%
2. She will not study late in the library
3. She may or may not study late in the library

$\rightsquigarrow$ Humans seem to suppress previously drawn information. They reason non-monotonically!

$\rightsquigarrow$ Instead of concluding that humans do not reason logically,
we assume that humans do not reason in accordance with Classical Logic!

Cognitive Argumentation

$\mathcal{P}$ set of propositional variables, $\neg\mathcal{P} = \{\neg x \mid x \in \mathcal{P}\}$

$\mathcal{S} = (\mathcal{F}, \mathcal{A})$ cognitive state, with set of facts $\mathcal{F}$ and relevance set $\mathcal{A}$

Argument scheme AS is a pair of precondition and position of the form

$$\text{AS} \quad = \quad (\text{Pre}, \text{Pos})$$

where $\text{Pre}, \text{Pos} \subseteq (\mathcal{P} \cup \neg\mathcal{P})$

- Argument Δ is a set of argument schemes

If she has an essay to finish, then she will study late in the library $(e \rightsquigarrow \ell)$

She has an essay to finish (e)

- Argument Schemes $(e \rightsquigarrow \ell) = (\{e\}, \{\ell\})$ $\quad$ $\text{fact}(e) = (\emptyset, \{e\})$
- Argument $\Delta = \{\text{fact}(e), (e \rightsquigarrow \ell)\}$ is argument for ℓ given $\mathcal{S} = (\{e\}, \{e, \ell\})$

$\rightsquigarrow$ Evaluation of arguments as Dung [1995]

$\rightsquigarrow$ Applied to preference based structured argumentation

e.g. Kakas and Moraitis [2003], Modgil and Prakken [2013], Prakken and Sartor [1997]

Cognitive Principles in the Library Task

Maxim of Quality (Grice, 1975) (factual) information is assumed to be true $\Rightarrow \Delta^{fact}$
Maxim of Relevance (Grice, 1975) (mentioned) information is assumed to be relevant $\Rightarrow \Delta_{hyp}$

If she has an essay to finish, then she will study late in the library

- *She has an essay to finish* is sufficient support for *She will study late in the library*

$\rightsquigarrow$ *She has an essay to finish* is a **sufficient condition**! $\Rightarrow \Delta_{e \overset{s}{\rightsquigarrow} \ell}$

$\rightsquigarrow$ *She has an essay to finish* is also a **necessary condition**! $\Rightarrow \Delta_{\overline{e} \overset{n}{\rightsquigarrow} \overline{\ell}}$

If the library is open, then she will study late in the library

- *The library is open* is not sufficient support for *She will study late in the library*
- *The library is not open* plausibly explains *She will not study late in the library*

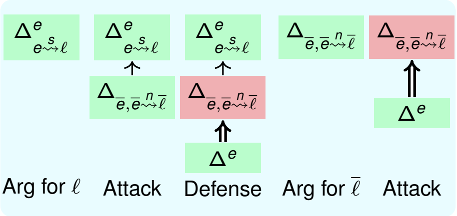
$\rightsquigarrow$ *The library is open* is a **necessary condition**! $\Rightarrow \Delta_{\overline{o} \overset{n}{\rightsquigarrow} \overline{\ell}}$

Relative strength relations

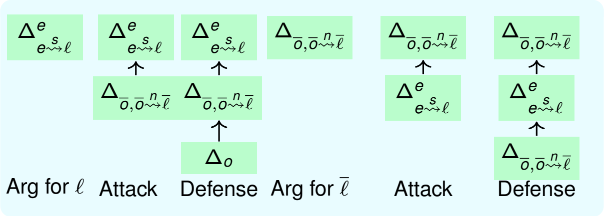
- Fact schemes are strongest schemes, hypothesis schemes are weakest schemes
- necessary schemes ($\overset{n}{\rightsquigarrow}$) are stronger than sufficient schemes ($\overset{s}{\rightsquigarrow}$)

What follows? Will she study late in the library? Will she not study late in the library?

For ℓ and $\overline{\ell}$ in Group I $\mathcal{S} = (\{e\}, \{e, \ell\})$



Construction for ℓ and $\overline{\ell}$ in Group III $\mathcal{S} = (\{e\}, \{e, \ell, o\})$



$\leadsto$ only ℓ is an acceptable conclusion

$\leadsto$ ℓ and $\overline{\ell}$ are acceptable conclusions

Argumentation works on a two-level decision procedure

Symbolic level What are the arguments for and against a certain position?

Meta-level What are their relative strength relations? Which argument wins?

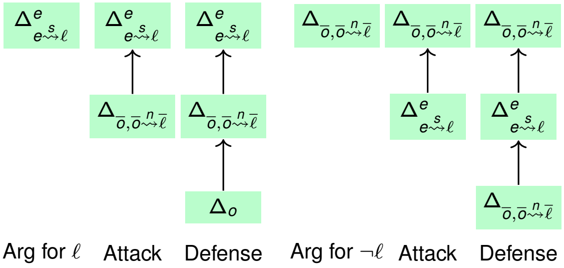
She has an essay to finish. Will she study late in the library?

Argument Construction What are the arguments for and against a position?

Preference-based decision What are their relative strength relations?

Group III, construct argument for library (ℓ) and not library ($\neg\ell$) given fact essay (e)

possible hypotheses: essay (e), not essay ($\neg e$), library (ℓ), not library ($\neg\ell$), open (o), not open ($\neg o$)



$\rightsquigarrow$ ℓ and $\overline{\ell}$ are acceptable conclusions
(only 38% concluded ℓ)

Person A if e then ℓ. e is fact.
Thus ℓ (Arg for ℓ).

Person B if $\neg o$ then $\neg\ell$ (necessary condition).
$\neg o$ is hypothesis. Thus $\neg\ell$ (Attack).

Person A o is equally strong to $\neg o$.
o is hypothesis (Defense).

Person B if $\neg o$ then $\neg\ell$. $\neg o$ is hypothesis.
Thus $\neg\ell$ (Arg for $\neg\ell$).

Person A if e then ℓ. e is fact.
Thus ℓ (Attack).

Person B ‘if $\neg o$ then $\neg\ell$’ (necessary) is stronger than ‘if e then ℓ’ (sufficient) (Defense).

Dietz and Kakas [2020]

Fact	Group	Predictive suff&necc	Predictive suff	Explanatory suff&necc	Explanatory suff	Experimental Results Byrne [1989]	Experimental Results Dieussaert et al. [2000]
e	I	ℓ	ℓ	-	-	96% ℓ	88% ℓ
e	II	-	ℓ	-	-	96% ℓ	93% ℓ
e	III	$\ell,\overline{\ell}$	$\ell, \overline{\ell}$	-	-	38% ℓ	60% ℓ
$\overline{e}$	I	$\overline{\ell}$	$\ell,\overline{\ell}$	-	-	46% $\overline{\ell}$	49% $\overline{\ell}$
$\overline{e}$	II	-	$\ell,\overline{\ell}$	-	-	4% $\overline{\ell}$	22% $\overline{\ell}$
$\overline{e}$	III	$\overline{\ell}$	$\ell,\overline{\ell}$	-	-	63% $\overline{\ell}$	49% $\overline{\ell}$
ℓ	I	e	$e, \overline{e}$	$e^\star$	$e,\overline{e}$	71% e	53% e
ℓ	II	-	$e, \overline{e}$	-	$e,\overline{e}$	13% e	16% e
ℓ	III	e	$e, \overline{e}$	$e^\star$	$e,\overline{e}$	54% e	55% e
$\overline{\ell}$	I	$\overline{e}$	$\overline{e}$	$\overline{e}^\star$ $e,\overline{e}$	$\overline{e}^\star$ $e,\overline{e}$	92% $\overline{e}$	69% $\overline{e}$
$\overline{\ell}$	II	-	$\overline{e}$	-	$\overline{e}^\star$ $e,\overline{e}$	96% $\overline{e}$	69% $\overline{e}$
$\overline{\ell}$	III	$\overline{e}$	$\overline{e}$	$e,\overline{e}$	$e,\overline{e}$	33% $\overline{e}$	44% $\overline{e}$

Summary on Cognitive Argumentation

- models all twelve cases of the suppression task accounting for different majorities (Dietz, Kakas 2020)
- generalizes from the specific case to general assumptions motivated from cognitive science
- models also other typical reasoning tasks (Dietz, Kakas 2019, 2020, 2021)

However, ...

$\rightsquigarrow$ it does not seem plausible that humans consider all arguments for and against a certain position

$\rightsquigarrow$ Can argument construction be guided by 'lower levels' of cognition implemented in a cognitive architecture?

Bridging to Lower Levels of Cognition

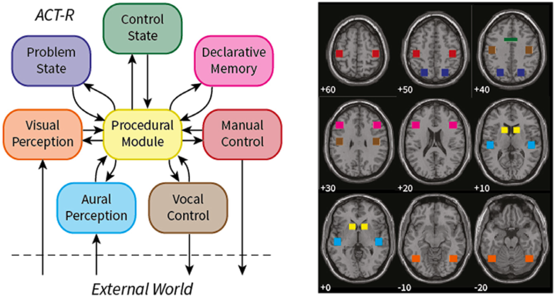


Image retrieved from [Borst and Anderson, 2017]

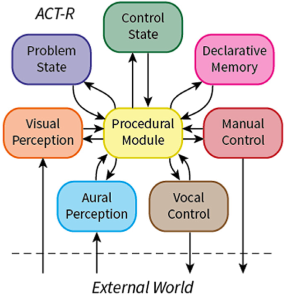
ACT-R: A THEORY ABOUT HOW HUMAN COGNITION WORKS (ANDERSON [2007])

Arguments as Chunks in Declarative Module

- ⇝ Model stores information as chunks
- ⇝ Each chunk has a name (used for reference)
- ⇝ A chunk possibly contains a set of named slots with single values

```
(chunk-type context value hypo)
(chunk-type argument fact hypo
            position context neg-position strength)
(add-dm
(SUF isa context value SUFFICIENT hypo ALTERNATIVE)
(NEC isa context value NECESSARY hypo DISABLER)
(ARG-E-SUF isa argument fact ESSAY hypo NONE
               position "YES" context SUF
               neg-position "UNKNOWN" strength 1)
)
```

Simulation of Cognitive Functions (Anderson [2007])



Functions as modules

- ► **Declarative memory**
- ► Procedural module

ACT-R: A THEORY ABOUT HOW HUMAN COGNITION WORKS (ANDERSON [2007])

Procedural System and Knowledge Retrieval

⇝ Modification of the system's state through execution of rules:

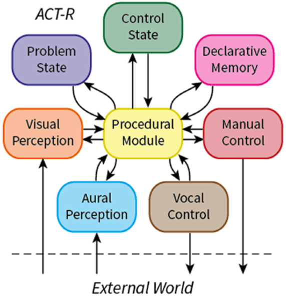
Procedural module, Utility module, Production-compilation module

```
(p retrieve-counter   (...)
   =goal>
     state           argue
   =retrieval>
     position        =position
   (...)
   ==>  (...)
   +retrieval>
   (...)
     neg-position    =position
   =goal>
     state           argue)
```

⇝ Retrieval of knowledge through chunk activation

spreading activation, base-level activation, noise, partial matching

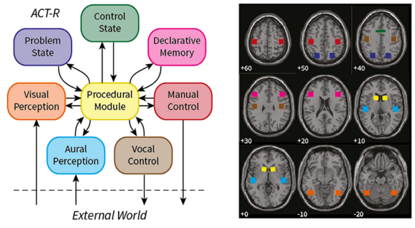
Simulation of Cognitive Functions (Anderson [2007])



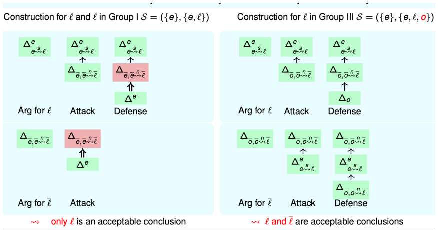
Functions as modules

- Declarative memory
- **Procedural module**

Demo



Cognitive Architecture

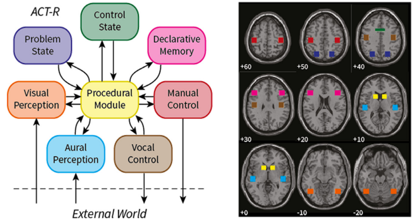


Cognitive Argumentation

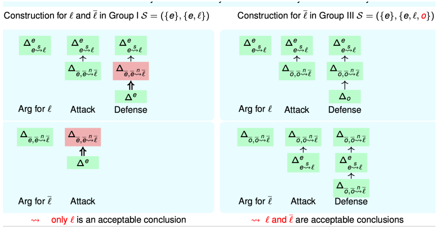
Cognitive Argumentation (Dietz and Kakas [2020])

Fact	Group	sufficient&necessary	sufficient	Byrne [1989]	**ACT-R (Dietz [2022])**
e	I	ℓ	ℓ	96% ℓ	**90% ℓ**
e	II	-	ℓ	96% ℓ	**90% ℓ**
e	III	$\ell, \overline{\ell}$	$\ell, \overline{\ell}$	38% ℓ	**37% ℓ**
$\overline{e}$	I	$\overline{\ell}$	$\ell, \overline{\ell}$	46% $\overline{\ell}$	**31% $\overline{\ell}$**
$\overline{e}$	II	-	$\ell, \overline{\ell}$	4% $\overline{\ell}$	**10% $\overline{\ell}$**
$\overline{e}$	III	$\overline{\ell}$	$\ell, \overline{\ell}$	63% $\overline{\ell}$	**65% $\overline{\ell}$**
ℓ	I	e	$e, \overline{e}$	71% e	**31% e**
ℓ	II	-	$e, \overline{e}$	13% e	**10% e**
ℓ	III	e	$e, \overline{e}$	54% e	**64% e**
$\overline{\ell}$	I	$\overline{e}$	$\overline{e}$	92% $\overline{e}$	**90% $\overline{e}$**
$\overline{\ell}$	II	-	$\overline{e}$	96% $\overline{e}$	**89% $\overline{e}$**
$\overline{\ell}$	III	$\overline{e}$	$\overline{e}$	33% $\overline{e}$	**37% $\overline{e}$**

Summary on Cognitive Argumentation in ACT-R



Cognitive Architecture



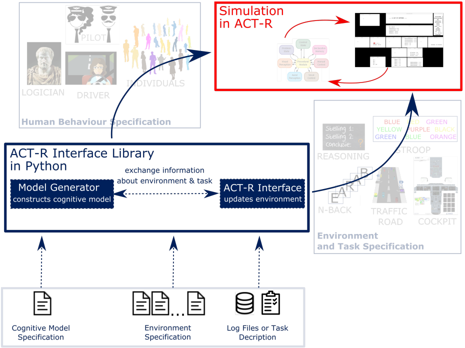
Cognitive Argumentation

First step towards reasoning with argumentation and bridging between different levels of cognition...

... argumentation provides contrastive explanations (why not choose the other answer ? ...)

... further development between cognitive argumentation, spreading activation and learning in ACT-R !

Benchmarking Cognitive Models



Criteria for a good model [Taatgen and Anderson, 2010]

1. Applicability to other tasks
2. Simplicity
3. Eventually, the ability to predict the outcome of new experiments

but ...

So far there are no criteria (...) to identify relevant problems
but this is a necessary condition to develop a generally accepted benchmark [Ragni, 2020]

Existing Idea applied to a Different Domain ⇝ **Develop benchmarks for tasks and cognitive models !**

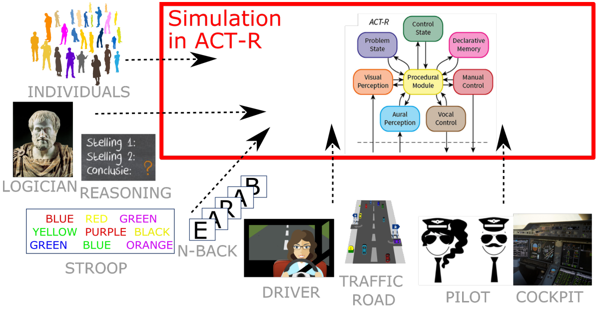
similar as PRECORE Challenge [Ragni, Riesterer, and Khemlani, 2019]

⇝ Parametrization of the task as modular task design through ACT-R interface

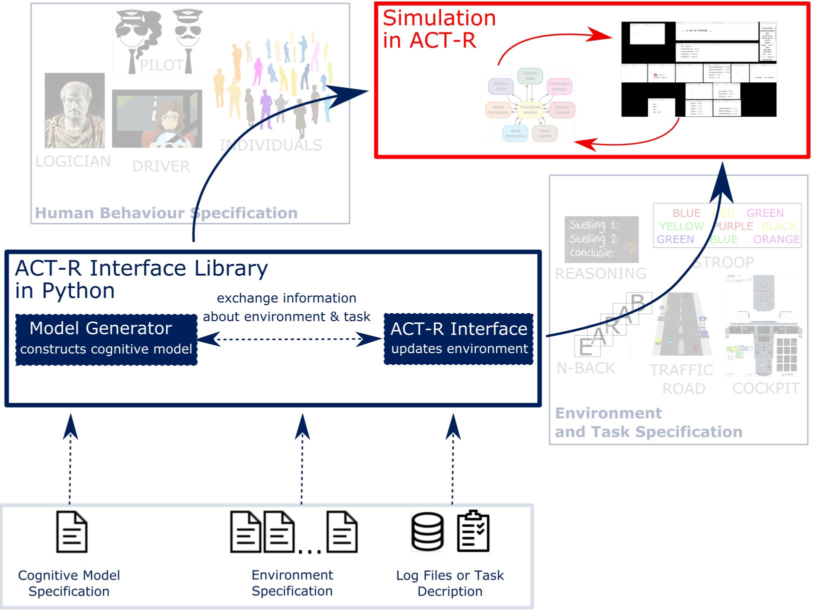
⇝ Parametrization of the model by modular and guided production and chunk engineering

Towards benchmarking cognitive models [Dietz and Klaproth, 2021]

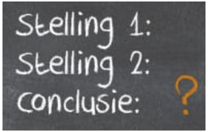
⇝ **A python library for partial model generation in ACT-R**



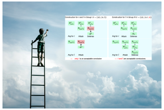
Simulation
in ACT-R
ACT-R
Control State
Problem State
Declarative Memory
Visual Perception
Procedural Module
Manual Control
Aural Perception
Vocal Control
INDIVIDUALS
LOGICIAN
Stelling 1:
Stelling 2:
Conclusie: ?
REASONING
BLUE RED GREEN
YELLOW PURPLE BLACK
GREEN BLUE ORANGE
STROOP
E A R A B
N-BACK
DRIVER
TRAFFIC
ROAD
PILOT
COCKPIT


Simulation
in ACT-R
PILOT
LOGICIAN
DRIVER
INDIVIDUALS
Human Behaviour Specification
ACT-R Interface Library
in Python
exchange information
about environment & task
Model Generator
constructs cognitive model
ACT-R Interface
updates environment
REASONING
STROOP
N-BACK
TRAFFIC
ROAD
COCKPIT
Environment
and Task Specification
Cognitive Model
Specification
Environment
Specification
Log Files or Task
Decription

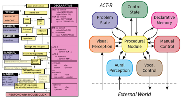
Take Home Message



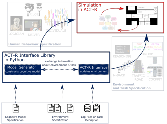
Human Reasoning



Cognitive Argumentation



Bridge to Lower Levels



Benchmarking

- Cognitive Principles in Argumentation seem to plausibly model episodes of human reasoning
- Heuristics in ACT-R can serve as a guidance for the selection of arguments
- A Unified benchmark catalogue of models and tasks could help to make

$\rightsquigarrow$ the research contributions of last decades accessible and visisble

References I

J. R. Anderson. How Can the Human Mind Occur in the Physical Universe? Oxford University Press, 2007.

J. P. Borst and J. R. Anderson. A step-by-step tutorial on using the cognitive architecture act-r in combination with fmri data. Journal of Mathematical Psychology, 76:94–103, 2017.

R. M. J. Byrne. Suppressing valid inferences with conditionals. Cognition, 31:61–83, 1989.

A. Costa, E.-A. Dietz, S. Hölldobler, and M. Ragni. A computational logic approach to human syllogistic reasoning. In TBA, editor, 39th Conference of the Cognitive Science Society, pages 883–888. Cognitive Science Society, 2017.

E. Dietz. Argumentation-based reasoning guided by chunk activation in act-r. In Proceedings of the 20th International Conference on Cognitive Modeling (ICCM 2022), 2022.

E. Dietz and A. C. Kakas. Cognitive argumentation and the selection task. In Proceedings of the Annual Meeting of the Cognitive Science Society, 43, pages 1588–1594. Cognitive Science Society, 2021.

E. Dietz and O. W. Klaproth. Towards benchmarking cognitive models: A python library for modular environment specification and partial model generation in act-r. In Proceedings of the 19th International Conference on Cognitive Modeling (ICCM 2021), Vienna, AUT, pages 50–56, 2021.

E.-A. Dietz and A. C. Kakas. Cognitive argumentation and the suppression task. CoRR, abs/2002.10149, 2020. URL `https://arxiv.org/abs/2002.10149`.

E.-A. Dietz Saldanha and A. Kakas. Cognitive argumentation for human syllogistic reasoning. KI - Künstliche Intelligenz, 33(3):229–242, 2019.

References II

E.-A. Dietz Saldanha and R. Schambach. Human Syllogistic Reasoning: Learning Individuals' Reasoning Behavior. In 7th Workshop on Formal and Cognitive Reasoning at the 42nd German Conference on Artificial Intelligence (KI 2019), 2019.

E.-A. Dietz Saldanha, S. Hölldobler, and R. Mörbitz. The syllogistic reasoning task: Reasoning principles and heuristic strategies in modeling human clusters. In D. Seipel, M. Hanus, and S. Abreu, editors, Declarative Programming and Knowledge Management, volume 10997 of Lecture Notes in Artificial Intelligence, pages 149–165. Springer Nature Switzerland AG, 2018.

K. Dieussaert, W. Schaeken, W. Schroyens, and G. D'Ydewalle. Strategies during complex conditional inferences. Thinking Reasoning, 6(2):125–161, 2000.

P. M. Dung. On the Acceptability of Arguments and its Fundamental Role in Nonmonotonic Reasoning, Logic Programming and n-person Games. Artificial Intelligence, 77:321–357, 1995.

H. P. Grice. Logic and conversation. In P. Cole and J. L. Morgan, editors, Syntax and semantics, volume 3. New York: Academic Press, 1975.

A. C. Kakas and P. Moraitis. Argumentation based decision making for autonomous agents. In Proc. of 2nd Int. Joint Conf. on Autonomous Agents & Multiagent Systems, AAMAS, pages 883–890. ACM, 2003.

S. Khemlani and P. N. Johnson-Laird. Theories of the syllogism: A meta-analysis. Psychological Bulletin, 138(3): 427–457, 2012.

H. Mercier and D. Sperber. Why do humans reason? arguments for an argumentative theory. Behavioral and Brain Sciences, 34(2):57–74, 2011.

References III

S. Modgil and H. Prakken. A general account of argumentation with preferences. Aritificial Intelligence, 195: 361–397, 2013.

J. L. Pollock. Cognitive Carpentry: A Blueprint for How to Build a Person. The MIT Press, 1995.

H. Prakken and G. Sartor. Argument-based extended logic programming with defeasible priorities. Journal of Applied non-classical Logics, 7(1):25–75, 1997.

M. Ragni. Artificial Intelligence and High-Level Cognition, volume 3, pages 457–486. Springer, Germany, 2020. ISBN 978-3-030-06170-8.

M. Ragni, N. Riesterer, and S. Khemlani. Predicting individual human reasoning: The precore-challenge. In A. K. Goel, C. M. Seifert, and C. Freksa, editors, Proceedings of the 41th Annual Meeting of the Cognitive Science Society, CogSci 2019: Creativity + Cognition + Computation, Montreal, Canada, July 24-27, 2019, pages 9–10. cognitivesciencesociety.org, 2019. URL `https://mindmodeling.org/cogsci2019/papers/0005/index.html`.

N. Taatgen and J. R. Anderson. The past, present, and future of cognitive architectures. Topics in Cognitive Science, 2(4):693–704, 2010.

D. N. Walton. Argumentation Schemes for Presumptive Reasoning. Lawrence Erlbaum Associates, 1996.