Modelling reasoning processes as a function of autistic-like traits[1]

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What's to come...

1. Post continuum-of-accuracy individual differences
2. Peering outside logic: autistic-like traits
3. Related to reasoning?
4. Cross-task homogeneity of interpretation

Illustrative example 1

Some elephants are mammals.
true/false/can't tell

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Why false?

- Assumptions of cooperativeness, informativeness, etc. (e.g., Mill, 1867; Grice, 1975)
- Also classical logic can still say false. . . depends how the sentence is interpreted

Illustrative example 2: the 'suppression' task
(Byrne, 1989)

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

Suppression: additional

If she has an essay to finish then she will study late in the library.
If the library stays open then she will study late in the library.
She has an essay to finish.

Inferences people draw

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	Simple	**Additional**
MP	76	34
Guarded MP	3	35
Pass over in silence	3	6
Other	2	9
n	84	84

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What's the correct model?!

Model 1: classical logic and modus ponens

Premises

1. **If she has an essay to finish then she will study late in the library.**
2. If the library stays open then she will study late in the library.
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Model 1: classical logic and modus ponens

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Conclusion (of the unsuppressed)

She will study late in the library (1 and 3 by modus ponens)

Model 2: closed world reasoning

Premises

1. If she has an essay to finish (and no exception) then she will study late in the library.
2. If the library stays open (and no exception) then she will study late in the library.
3. She has an essay to finish
4. Exceptions to 1: the library is closed, ...
5. Exceptions to 2: no essay, ...

Model 2: closed world reasoning

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Conclusion (of the suppressed)

- Library is closed, by CWR
- If the library is open, then she will study late in the library

Reasoning *to* and *from* interpretations
(Stenning & van Lambalgen, 2008)

The old

- To use a logic you must first formalize the task
- 'If A, then B' $\not\equiv A \Rightarrow B$ or even $B|A$ for every A, B.
- 'A and B' $\not\equiv A \wedge B$ for every A, B.

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The new

- Use logics (plural) to model interpretation in people
- Interpretation: choose logic, set parameters
- Derivation: inference once parameters set
- Correctness with respect to interpretation
- A logical way to model an old problem (e.g., Henle, 1962; Smedslund, 1970)

Broad organizing framework: interpretative stances
(Stenning & van Lambalgen, 2008)

Credulous

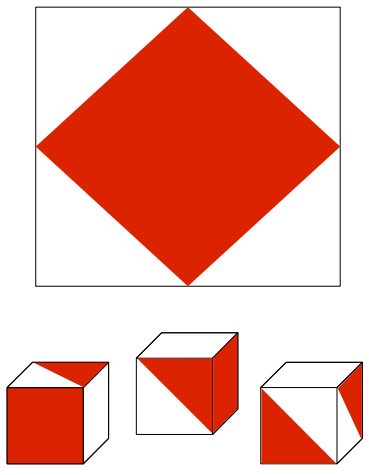
- Infer speaker's intended interpretation
- A single interpretation, if possible
- Accept the authority of the speaker
- Often depends on assumed mutual knowledge
- Relates to language pragmatics (Grice and co.)

Sceptical

- May be many interpretations
- Doubt the authority of the speaker
- Depend on as few assumptions as possible

Autism spectrum conditions

- Heterogenous set of clinical conditions
- Impairment, e.g., in pragmatic language
- Peaks of ability, e.g., in perceptual tasks
- Milder variants in typically developing individuals
- Hypothesized to relate to traits predicting success at humanities vs. scientific study
- Related to reasoning?



Self-reported autistic-like traits

Autism-Spectrum Quotient (Baron-Cohen et al., 2001)

- Designed for screening for ASC
- Continuously distributed in TDs
- Covaries with cognitive function related to ASC in TDs, e.g.,
  - 'Reading the mind in the eyes'
  - Joint attention (Bayliss et al., 2005)
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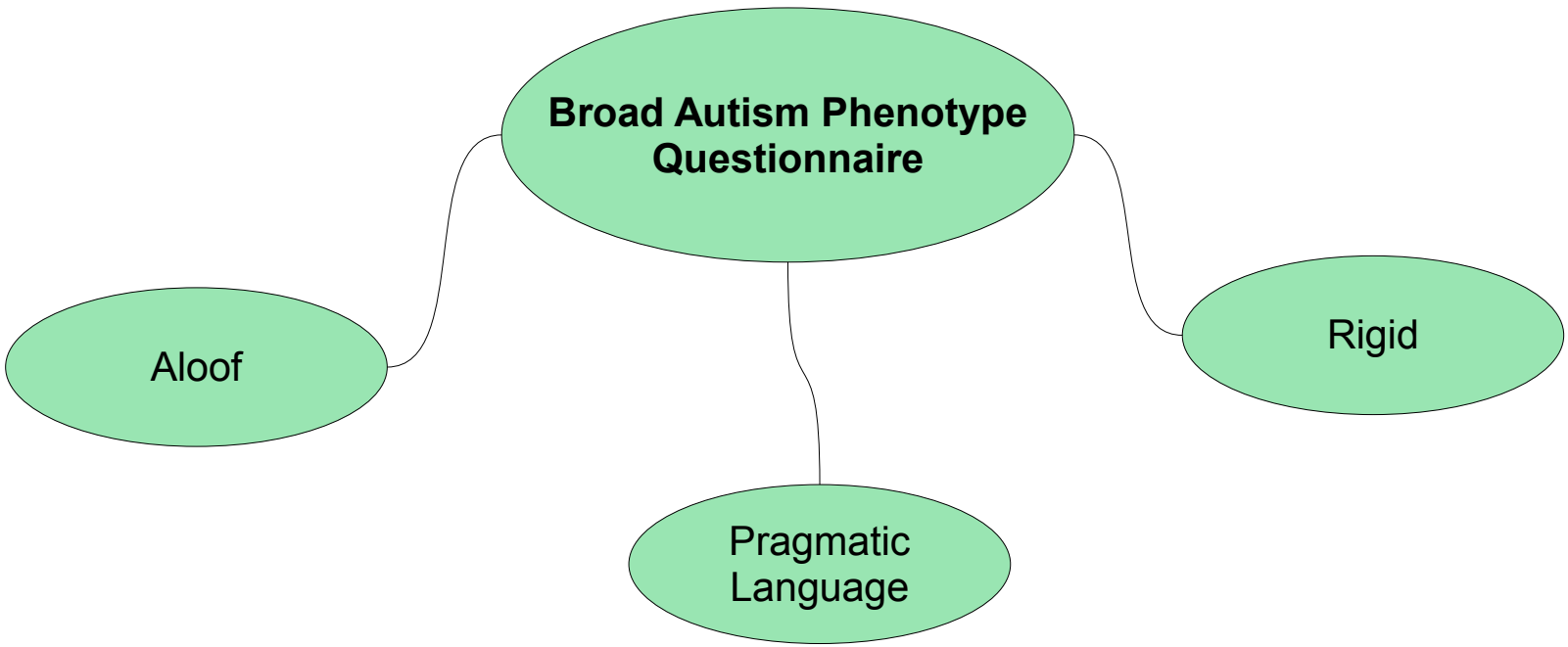
Both

- Personal-level trait descriptions
- Associated with (caused by?), e.g., cognitive mechanisms

Broad Autism Phenotype Questionnaire



Dataset

Questionnaires and tasks

- AQ and BAPQ: reconnect reasoning to life outside the lab
- Six reasoning tasks (2 hours over 2 sessions):
  tasks related to credulous vs. sceptical interpretation

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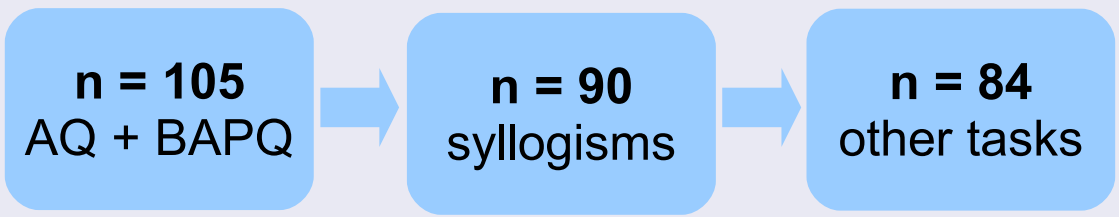
Flow



Do autistic-like traits predict interpretation?

Closed world reasoning and autistic-like traits

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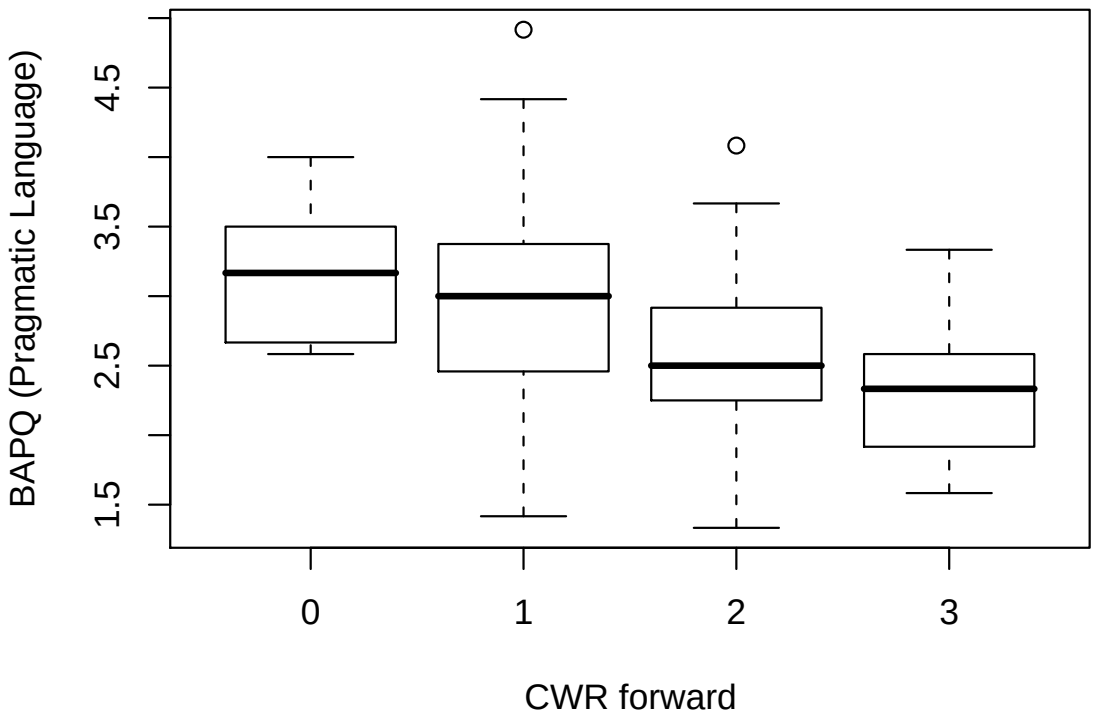

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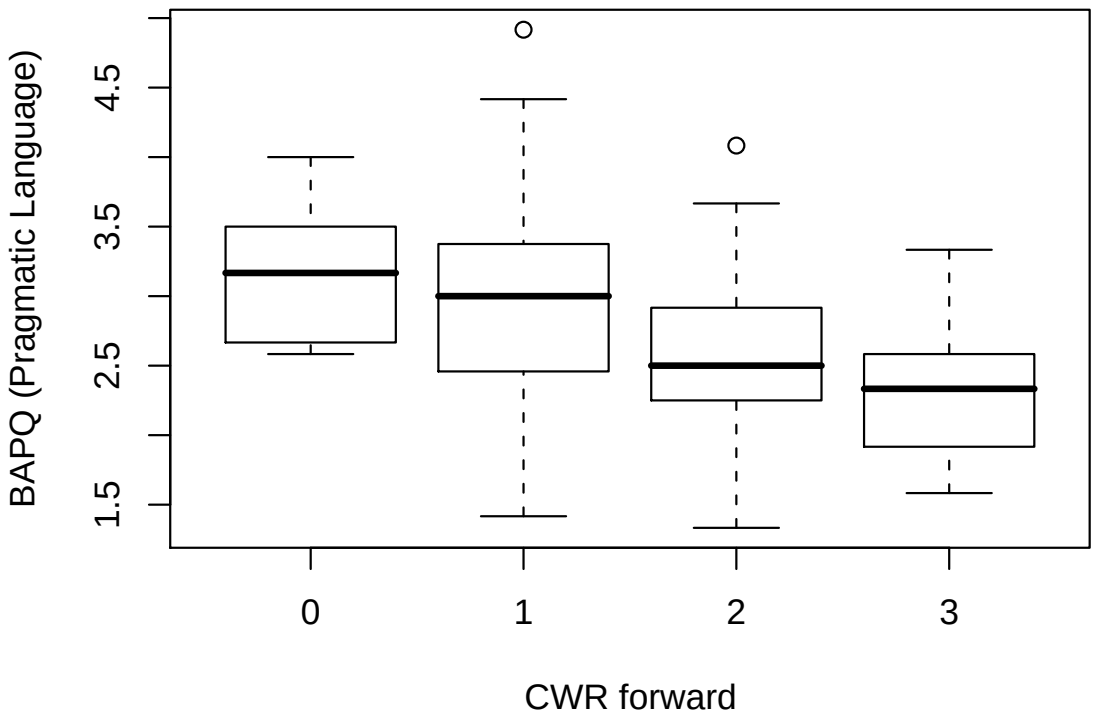

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See also van Lambalgen and Smid (2004); Pijnacker et al. (2009)

Immediate inference
(One premise monadic predicate logic)

Example

Assume *Some A are B* is true

Then *Some A are not B* is. . .

True / *False* / Could be *True* or *False*

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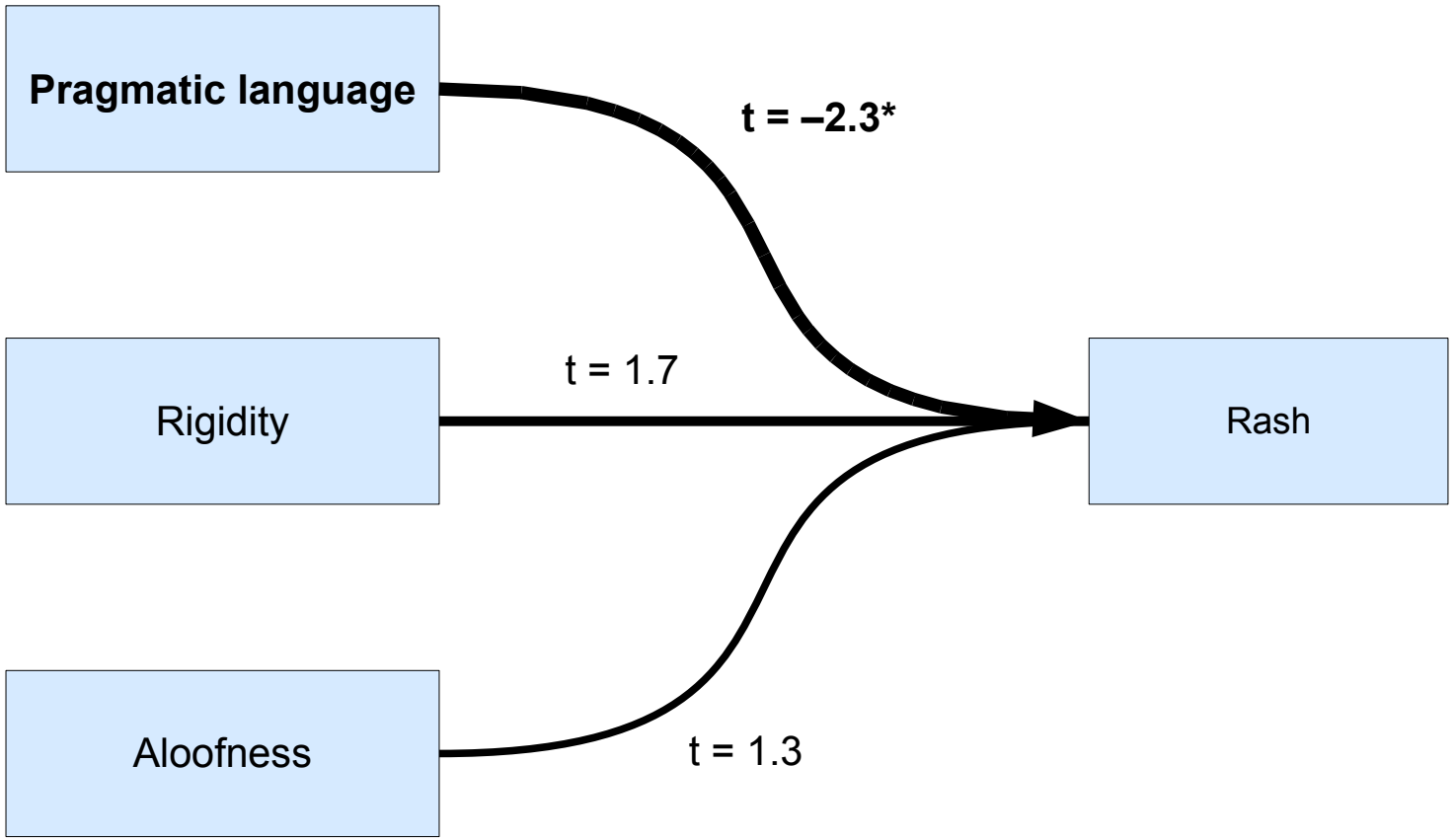
Classical-logically independent problems

Some A are B	$\Rightarrow$	All A are B	:	rash = false
Some A are not B	$\Rightarrow$	No A are B	:	rash = false
Some A are not B	$\Rightarrow$	Some A are B	:	rash = true
Some A are B	$\Rightarrow$	Some A are not B	:	rash = true

- Classical answer always 'can't tell' for these items
- A 'rash' response indicates credulous interpretation

Rashness and autistic-like traits

Proportional odds logistic regression model



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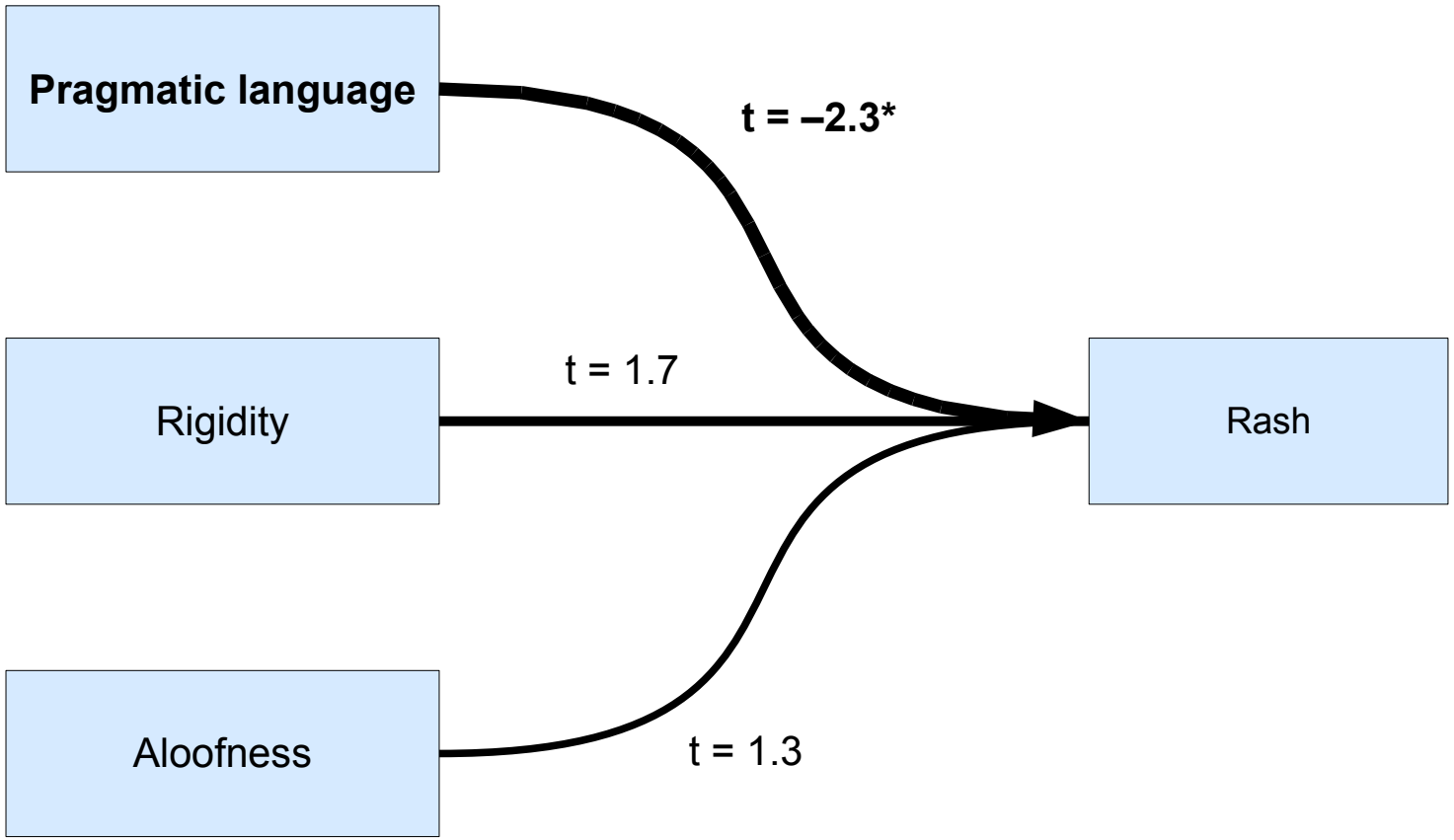

People who report being good at pragmatic language give a more credulous response

Into the swamp: categorical syllogisms
(Two-premise monadic predicate logic)

Example

Assume

All B are A

Some B are C

What follows?

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What follows?

- Favorite test case in psychology
- 64 items
- Individual differences galore

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Source-founding process model (e.g., Stenning & Cox, 2006)

- Related to Aristotle's proof by ecthesis
- More general than mental rules vs. models vs. Euler circles
- Traces in the Probability Heuristics Model (Oaksford & Chater, 2007)
- Response term-order leaks information about this process

Example

All B are A
Some B are C

Basic idea

- Try to construct an individual description
- $\exists x.\ A(x) \wedge B(x) \wedge C(x)$
- Read off the conclusion

Example

All B are A
Some B are C

Find premise to source from

Example

All B are A
Some **B** are **C**

Build individual description: $B(i) \wedge C(i)$

Example

All B are A
Some B are C

Feed middle-term through universal:
$B(i) \wedge C(i) \wedge A(i)$

Example

All B are A
Some B are C

Remove middle term: $C(i) \wedge A(i)$

Example

All B are A
Some B are C

Conclude: *some C are A*

Factors influencing term-order

1. *All A are B*
2. *Some B are C*

Premise order

More *AC*s on average

Factors influencing term-order

All B are **A**
Some **C** *are B*

Premise term-order

Same subjects and predicate order in conclusion (e.g., here *CA*)

Factors influencing term-order

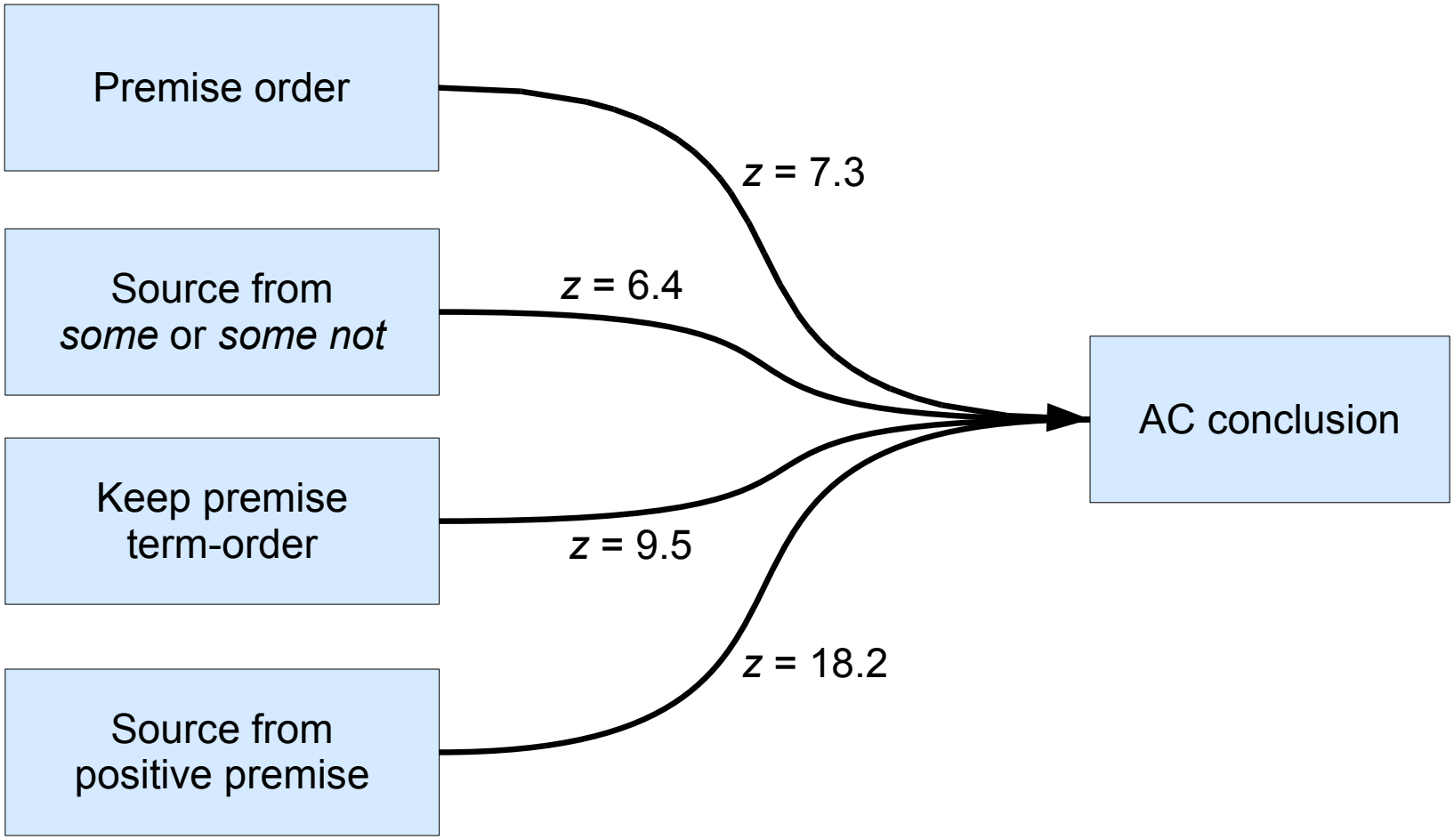
All B are A
Some *C are B*

Quantifiers

People tend to source from existentials (e.g., here *CA* again)

Basic model

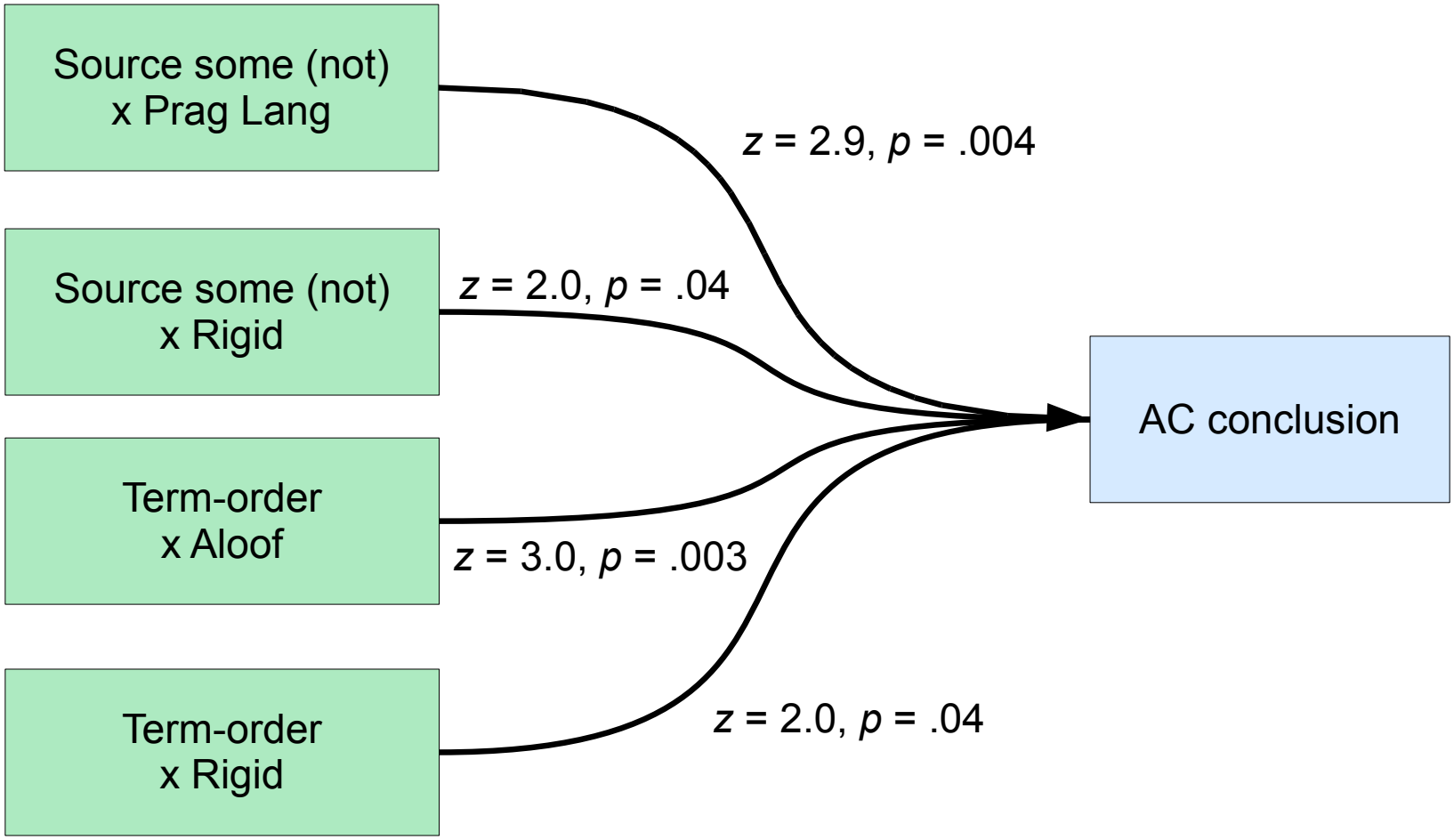
Mixed-effect logistic regression model



(all $p < 0.001$)

Interactions with BAPQ

Mixed-effect logistic regression model



(all $p < 0.05$)

How homogenous is interpretation cross-task?

Cross-task correlates: a pair of illustrative examples

Credulous reasoning crosses quantifier task boundaries

Rash on (in-place) immediate inference
(e.g., Some A are B $\Rightarrow$ All A are B)

$\leftrightsquigarrow$ Rash on double existential syllogistics
(e.g., Some A are B, Some B are C $\Rightarrow$ Some A are C)

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. . . and outside quantifiers

Closed-world reasoning on the suppression task
(libraries and co)

$\leftrightsquigarrow$ Rash on double existential syllogistics

Conclusions

1. Autistic traits predict interpretation in reasoning
2. Credulous/sceptical interpretations are more general than the individual tasks
3. People have different interpretations of discourse and tasks outside the lab, good to test this inside the lab too

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Thank you!

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