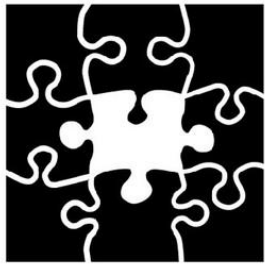
Abductive Conditionals as a Test Case for Inferentialism



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If the NL is a monarchy, then cats are felines.

- How to explain the strangeness of missing-link conditionals?

1.

Inferentialism

An inferential semantics of conditionals

A conditional is true iff:

there is a strong enough argument from antecedent to consequent, given background knowledge.

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there is a strong enough argument from antecedent to consequent, given background knowledge.

- Proposed by Krzyżanowska, Wenmackers and Douven (2014).
- The argument can include deductive steps and ampliative (inductive, abductive...) steps.
- Does not validate Centering.

(1) Truth of a conditional statement

- The strength of the inferential connection between antecedent and consequent predicts the endorsement rate of the conditional being true.

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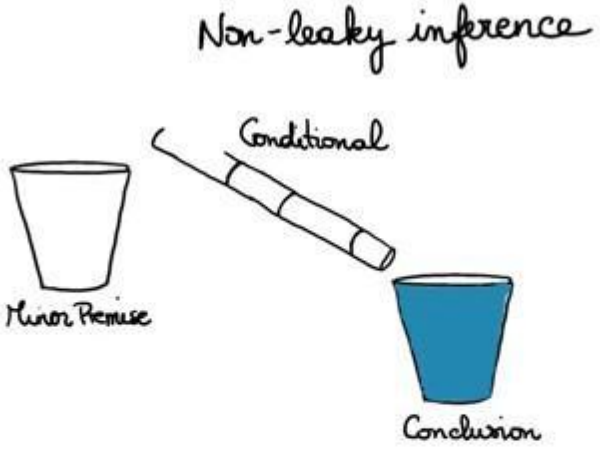
- The strength of the inferential connection between antecedent and consequent predicts the endorsement rate of the conditional being true.

(2) Modus Ponens argument

- The strength of the inferential connection between antecedent and consequent of the major premise predicts the endorsement rate of the conclusion, keeping the confidence in the minor premise fixed.

Conditionals as “leaky pipes”



2.

Abductive conditionals

If <event>, then <explanation>.

If the glass is broken, then the cat pushed it off the table.

- The inferential strength is determined by the quality of the explanation.

Hypotheses

H1. The explanation quality of the consequent, given the antecedent as explanandum, predicts the endorsement rate of the conditional as true.

H2. The explanation quality of the consequent, given the antecedent as explanandum, predicts the endorsement rate of the conclusion as true.

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H2. The explanation quality of the consequent, given the antecedent as explanandum, predicts the endorsement rate of the conclusion as true.

Materials

- Adapted from causal conditionals developed by Cummins, Lubart, Alksnis & Rist (1991) and by de Neys, Schaeken & d'Ydewalle (2003).

- 16 abductive conditionals referring to everyday situations of the form "*If* <**event**>, *then* <**explanation**>."

  ***If* John did well on his exam, *then* he studied hard.**

  ***If* the water is boiling, *then* it was heated to 100°C.**

Exp 1: Truth of a conditional

- We contrasted the predictions of inferentialism with predictions inspired from the mental models theory of conditionals (Johnson-Laird, 1983).
- According to MMT, we interpret a conditional by accessing structures with relevant information in semantic memory, which we use to build a mental model that represents the conditional.
- If the semantic search retrieves counter-examples (alternatives or disablers), further models are built, which lead to the (graded) rejection of the conditional (De Neys et al., 2003).

Hypotheses for Exp 1

INF. The explanation quality of the consequent, given the antecedent as explanandum, predicts the endorsement rate of the conditional as true.

MMT*. The number of retrieved counter-examples (alternatives and disablers) predicts the endorsement rate of the conditional as true.

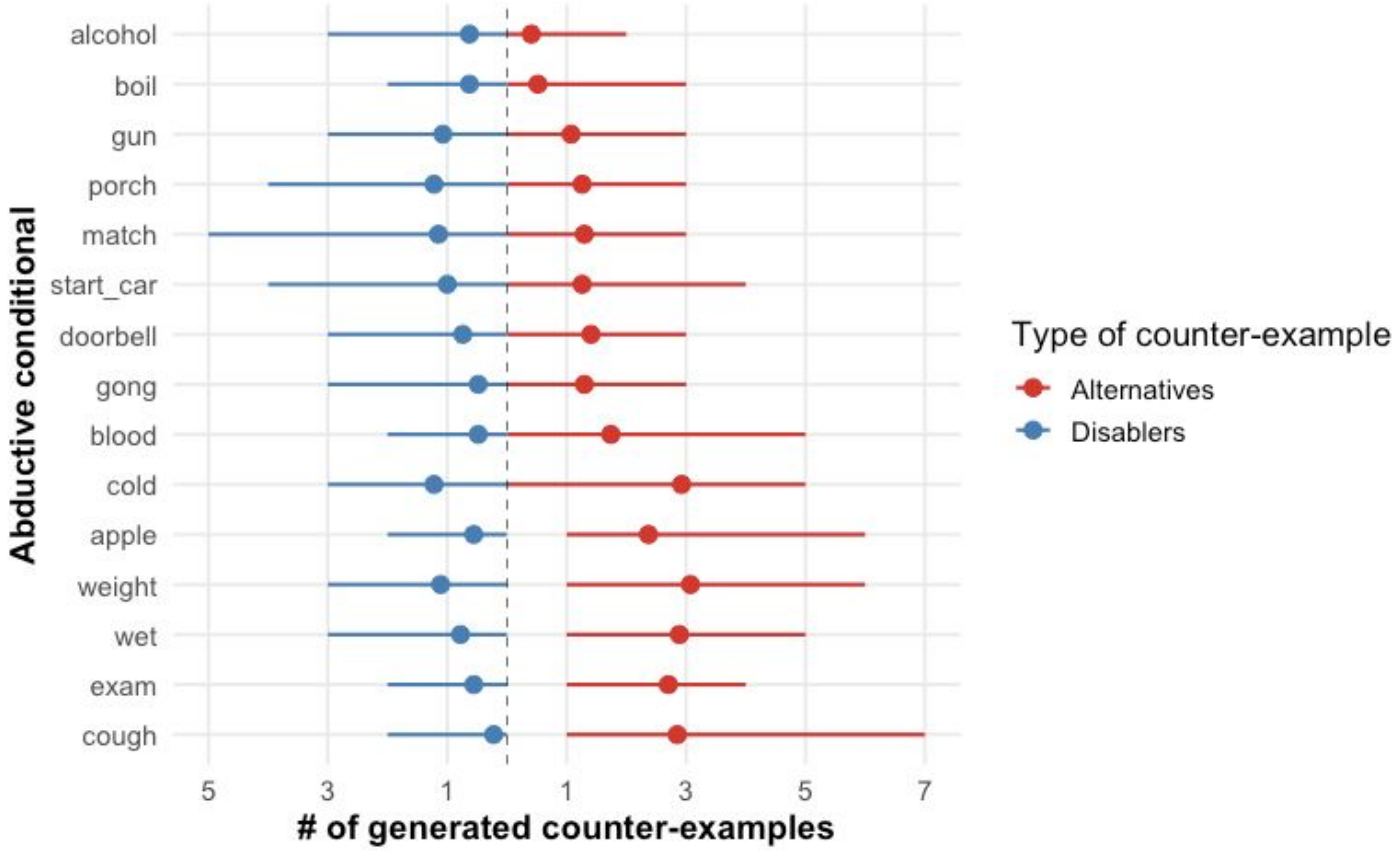
Exp 1: experimental design

- ‘Suppose we observe that φ. We propose to explain this by ψ.
  How would you rate the quality of this explanation?’ [11-point Likert scale]
- ‘How strongly do you agree that this statement is true?’ [11-point Likert scale]

Exp 1: experimental design

- ‘Suppose we observe that φ. We propose to explain this by ψ. How would you rate the quality of this explanation?’ [11-point Likert scale]
- ‘How strongly do you agree that this statement is true?’ [11-point Likert scale]

- ‘Can you find other possible explanations for this fact?’ [60s per item]
- ‘Can you find examples of events that could have prevented the explanation from producing this fact?’ [60s per item]
- We discarded repeat and absurd responses (3 independent coders).



Mean # of generated disablers and alternatives per participant (range = min/max; n =27, ♀: 19)

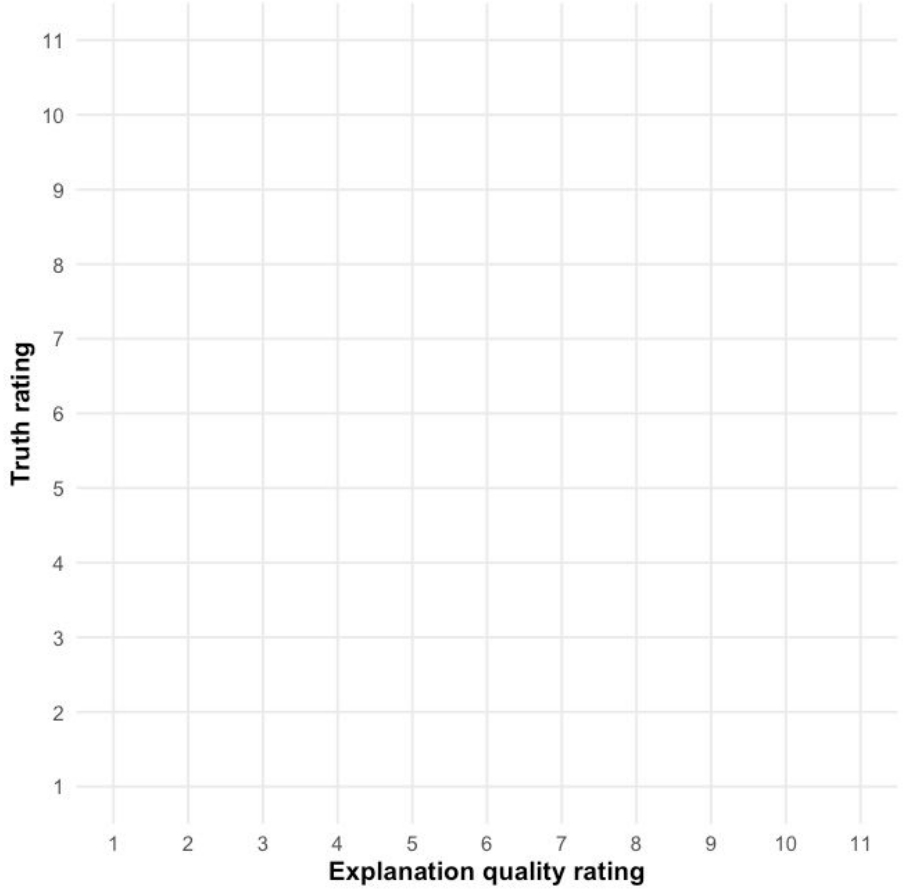
Exp 1: Statistical analysis

We fit three logistic ordinal regression multilevel models, fit using *brms*, with weakly informative priors:

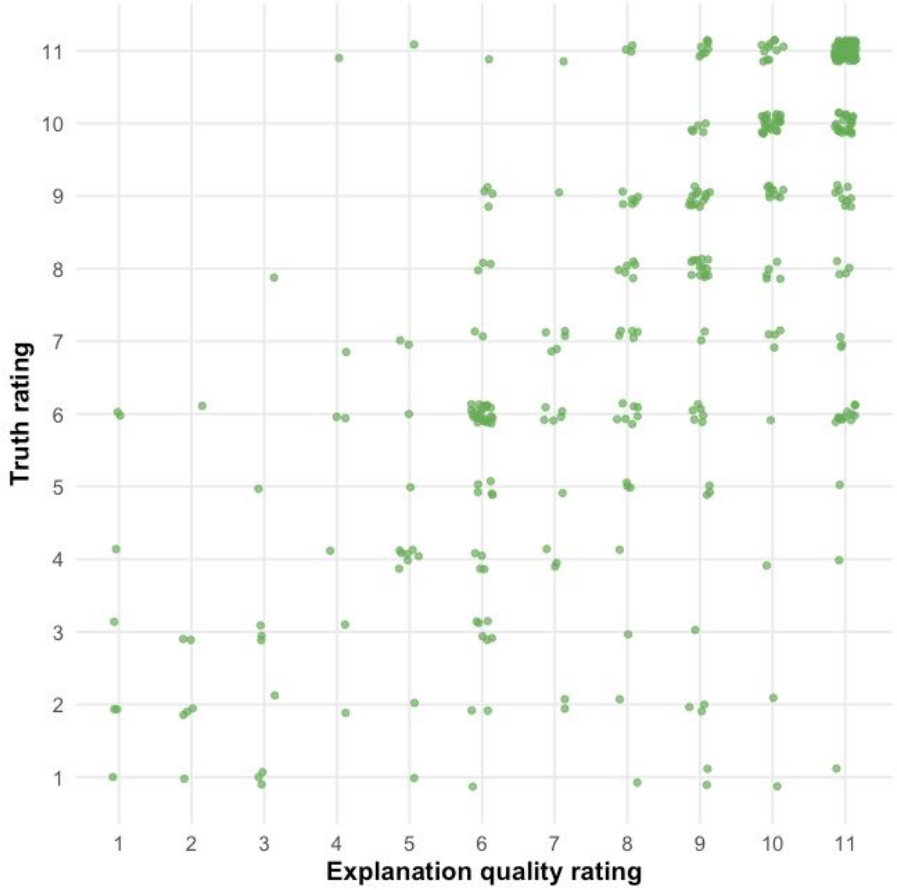
Full model: **Truth** ~ Quality + Alts + Disbs +
(Quality + Alts + Disbs|Subj) + (Quality + Alts + Disbs|Conditional)

INF model: **Truth** ~ Quality +
(Quality|Subj) + (Quality|Conditional)

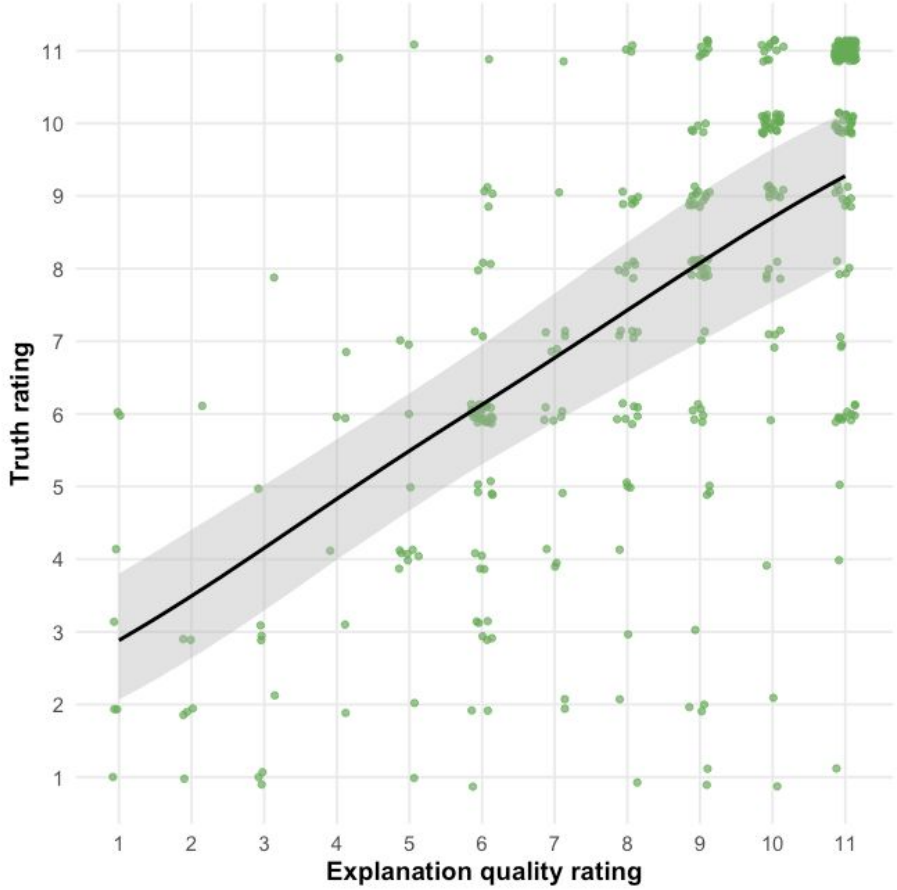
MMT* model: **Truth** ~ Alts + Disbs +
(Alts + Disbs|Subj) + (Alts + Disbs|Conditional)



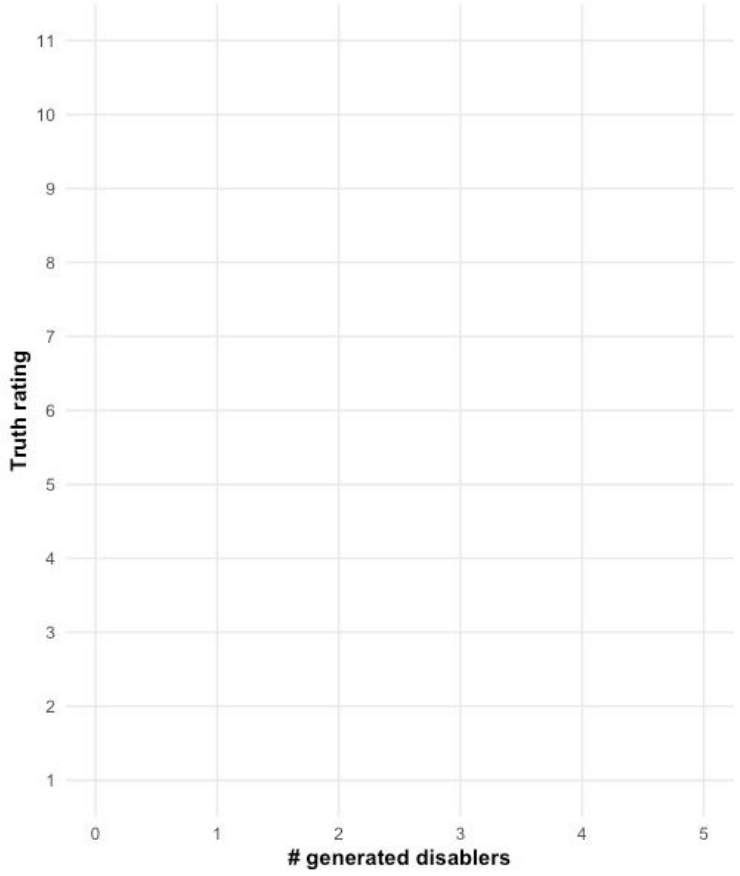
Truth vs quality judgments (*n* =27, ♀ : 19)

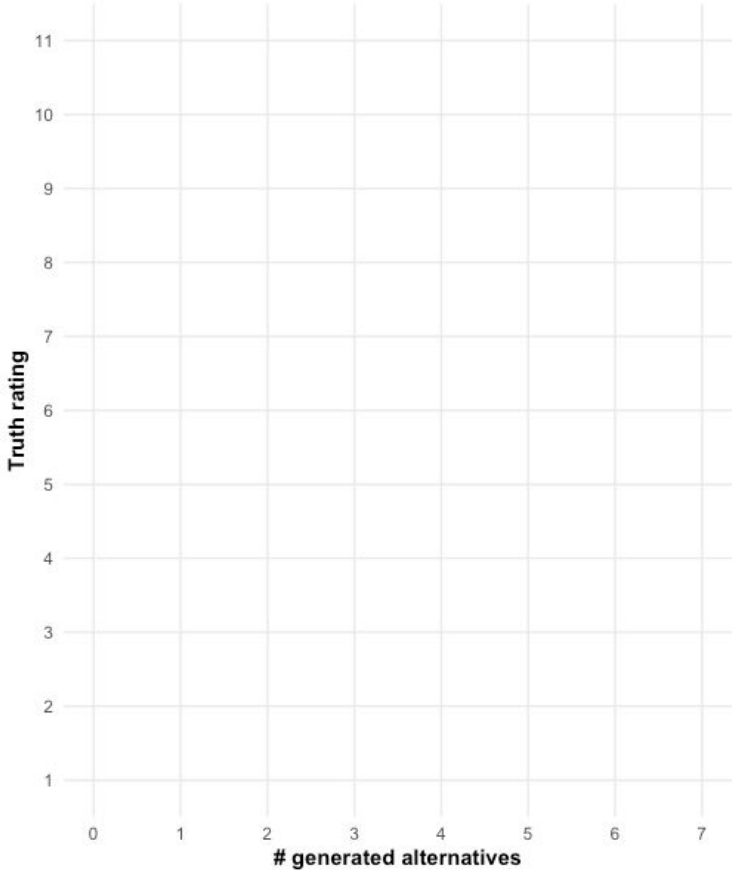


Truth vs quality judgments (*n =27, ♀: 19*)

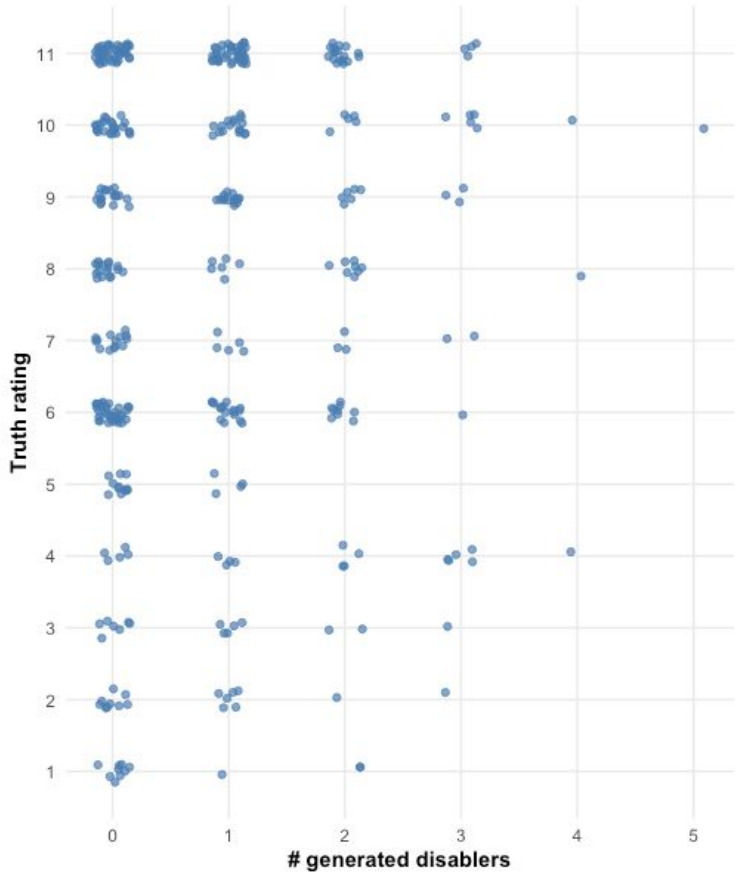


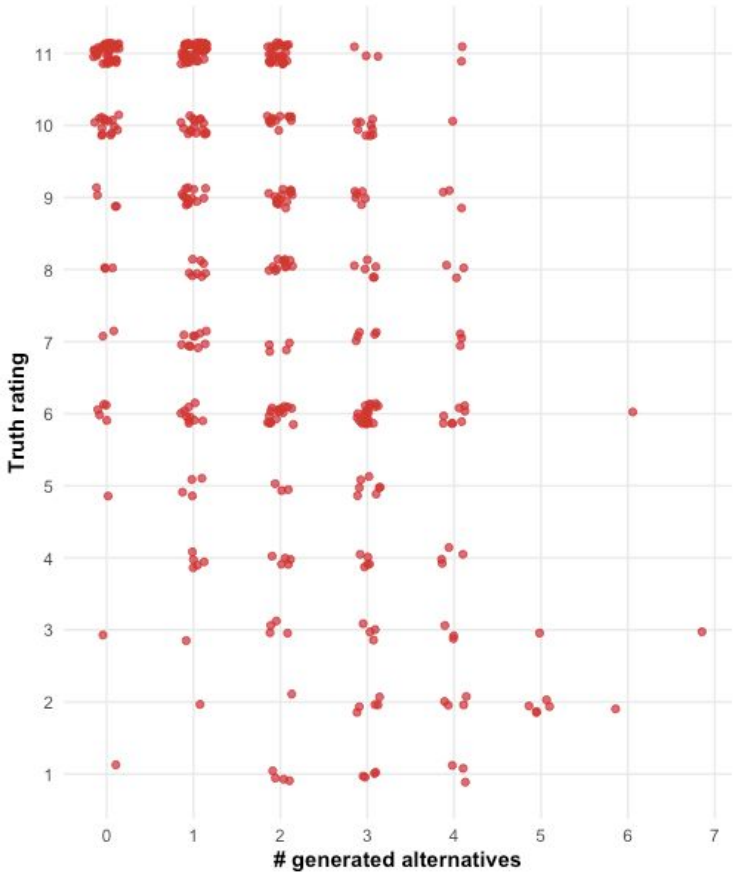
Conditional effects plot for ‘Quality’ with data over-layed
(full model estimate, CI: 95%)





Truth vs # generated counter-examples (*n =27,* ♀ *: 19*)





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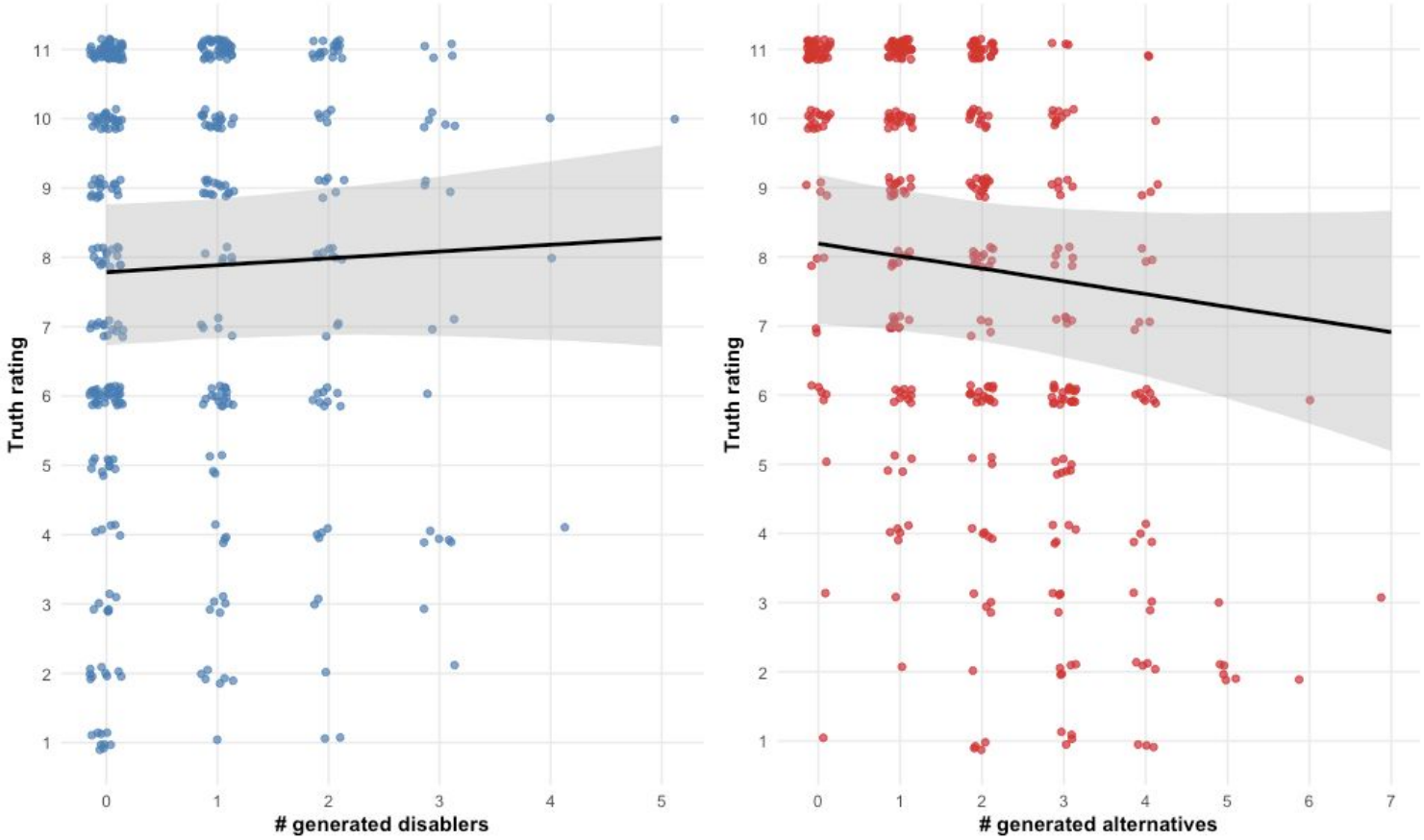
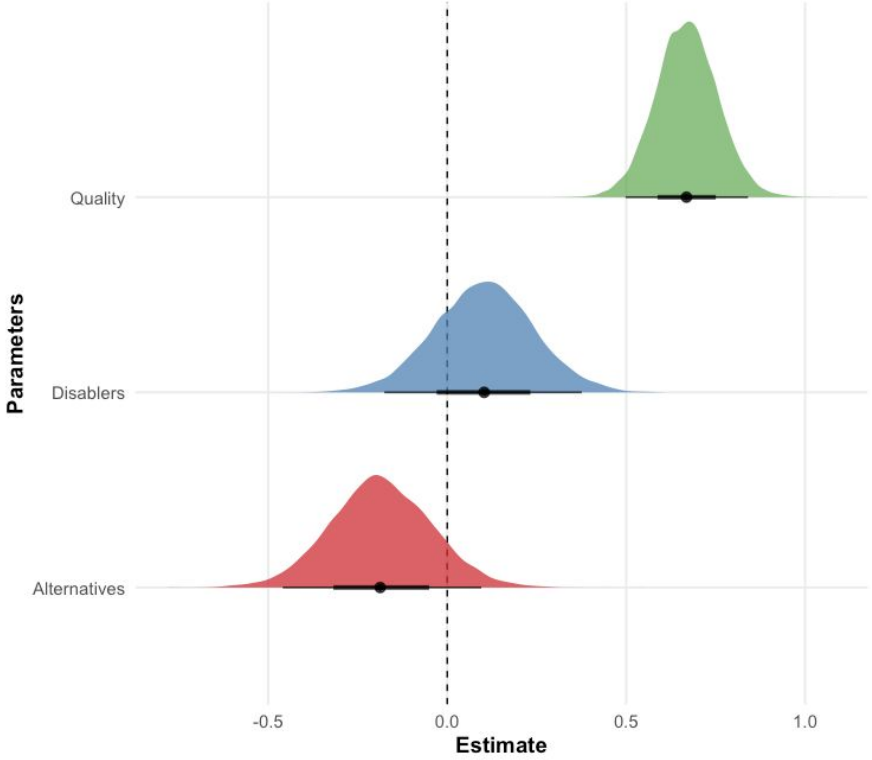


Conditional effects plots for ‘Alts’ and ‘Disbs’ with data over-layed
(full model estimates, CI: 95%)



Posterior distribution for the parameters in the full model

	Δ LOO-IC	SE
INF	0.0	--
Full	8.8	9.0
MMT*	-124.2	26.2

Table of model comparison (PSIS-LOO)

C1.

TRUTH OF AN ABDUCTIVE CONDITIONAL

Strong support for Inferentialism.
Compared with the number of generated counter-examples, explanation quality (determined by inferential strength) is a better predictor of the rate of endorsement of a conditional.

Exp 2: Modus Ponens arguments

- We contrasted the predictions of inferentialism with the predictions from the suppositional theory of conditionals.

- According to ST, we interpret a conditional by using the Ramsey test: Suppose *p* is true, and then evaluate your degree of belief in *q*.

- The endorsement rate of the conditional is predicted by the probability of the conditional, as measured by the Equation:

$$P(\text{If p, then q}) = P(q|p).$$

Hypotheses for Exp 2

INF. The explanation quality of the consequent, given the antecedent as explanandum, predicts the endorsement rate of the conclusion as true.

ST. The probability of the conditional, as given by the Equation, predicts the endorsement rate of the conclusion as true.

Exp 2: experimental design

- ‘How would you rate the quality of this explanation?’ [7-point Likert scale]

- Minor premise: Dennis tells you that φ. [4 “witnesses” with 100, 75, 50, 25% reliability]
  Major premise: Now suppose that if φ, then ψ.
  How strongly do you agree that it is true that ψ? [7-point Likert scale]

- Rate the probability of four situations: φ & ψ, φ & ¬ψ, ¬φ & ψ, ¬φ & ¬ψ.
  [Must sum to 100%; used to compute conditional probability as derived ratio
  as well as Δp, power PC and difference of confirmation measure.]

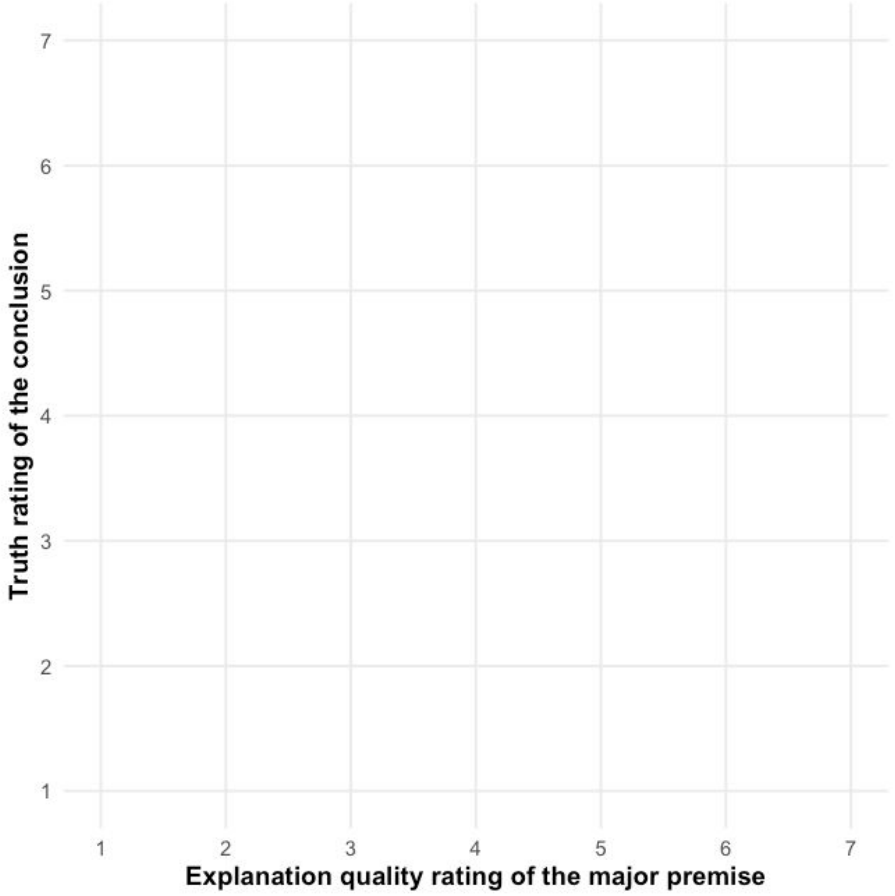
Exp 2: Statistical analysis

We fit 9 logistic ordinal regression multilevel models, fit using *brms*, with weakly informative priors and the parameters scaled (2 SDs) for ease of comparison:

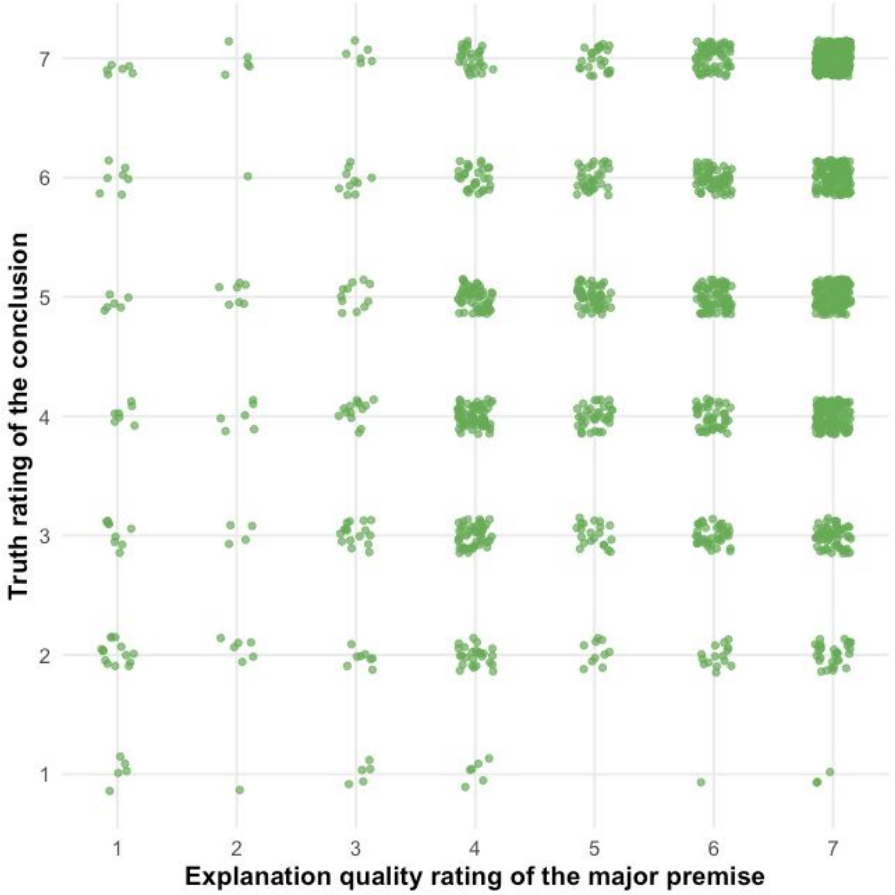
Full models: **Truth** ~ Quality + Prob + W +
(Quality + Prob +W|Subj) + (Quality + Prob + W|Conditional)

INF model: **Truth** ~ Quality + W +
(Quality + W|Subj) + (Quality +W|Conditional)

Prob models: **Truth** ~ Prob + W +
(Prob +W|Subj) + (Prob + W|Conditional)



Truth vs quality judgments ***(n =120, ♀:70)***



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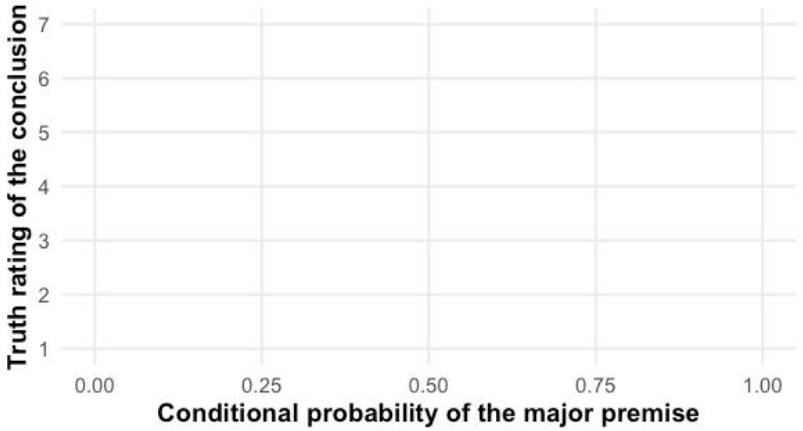
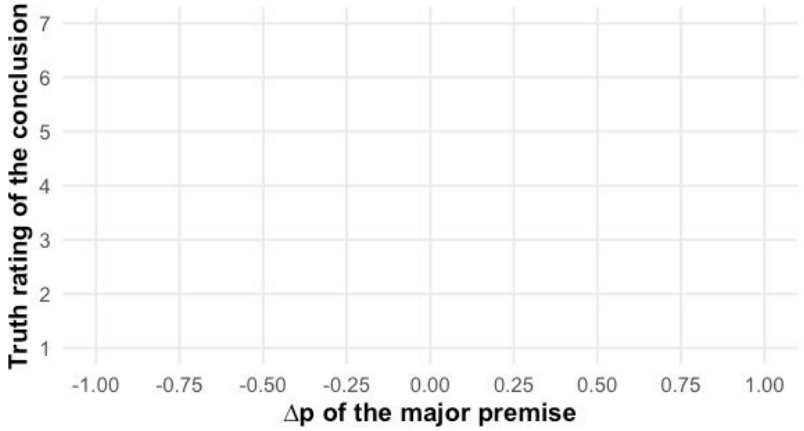
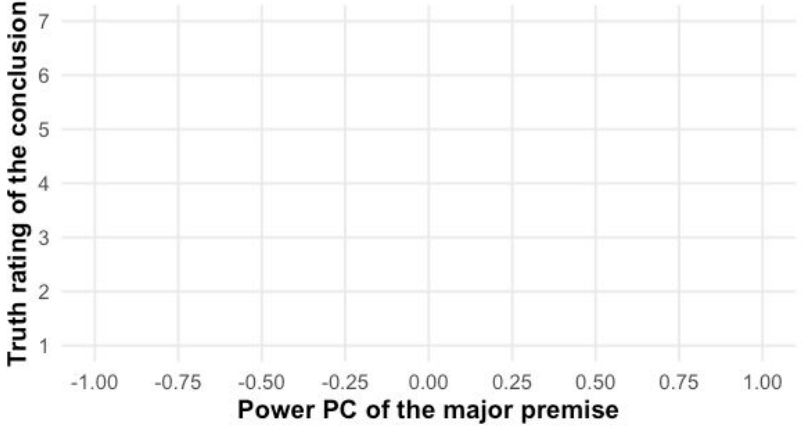
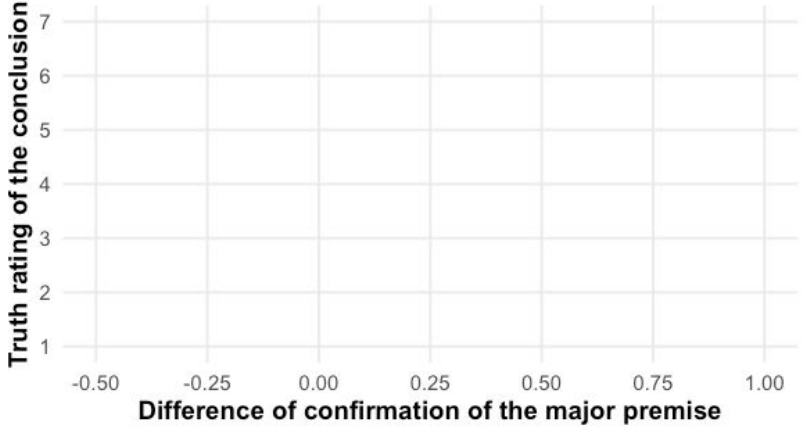
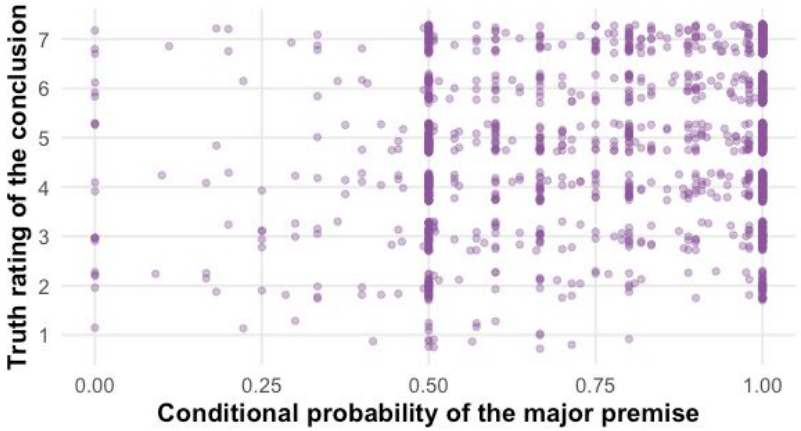


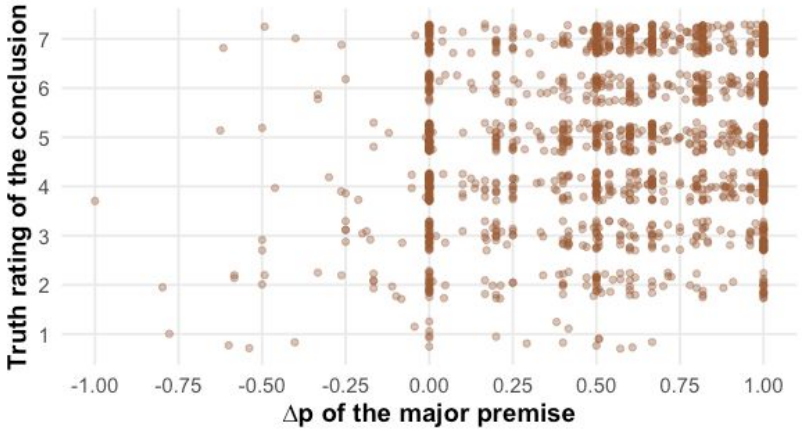


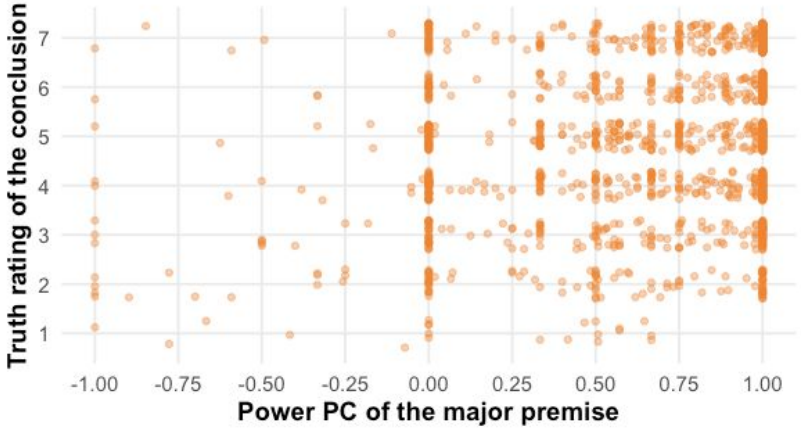


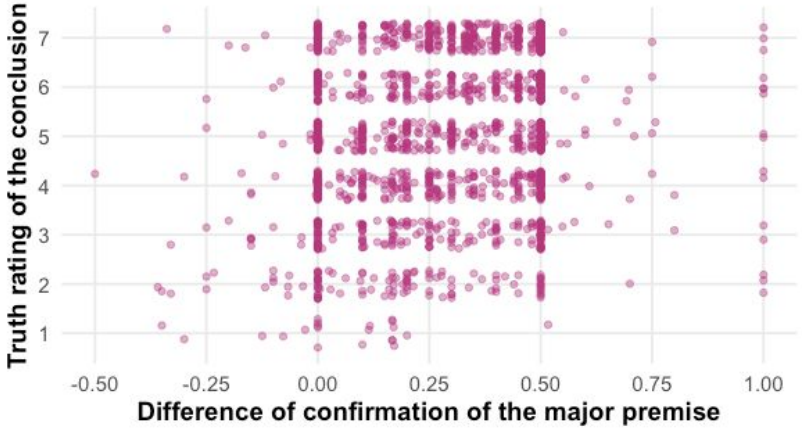


Truth vs probability judgments *(n =120, ♀:70)*





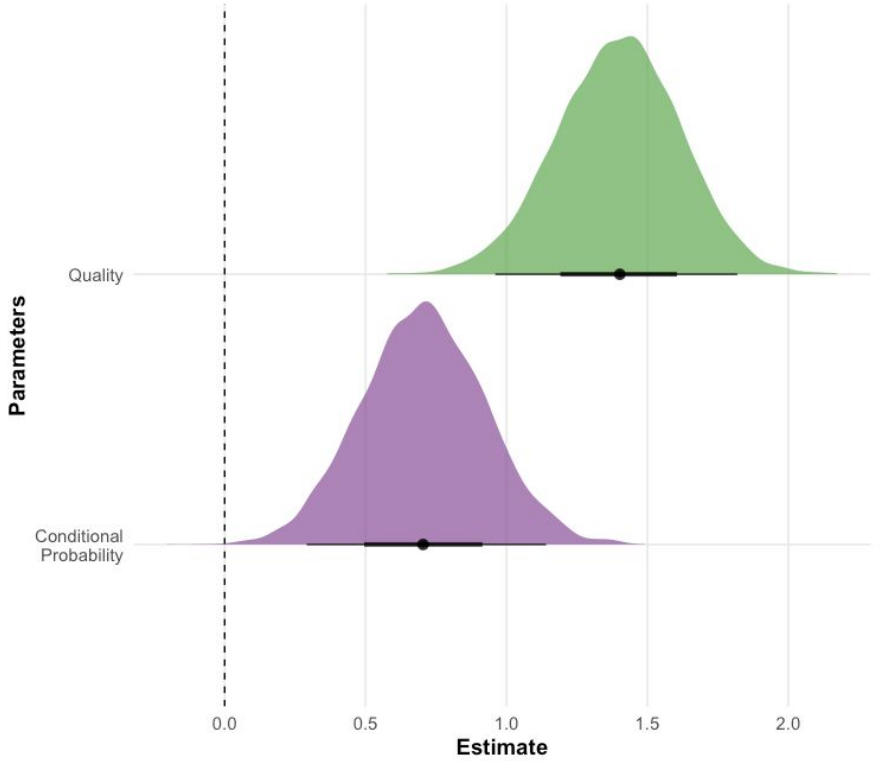




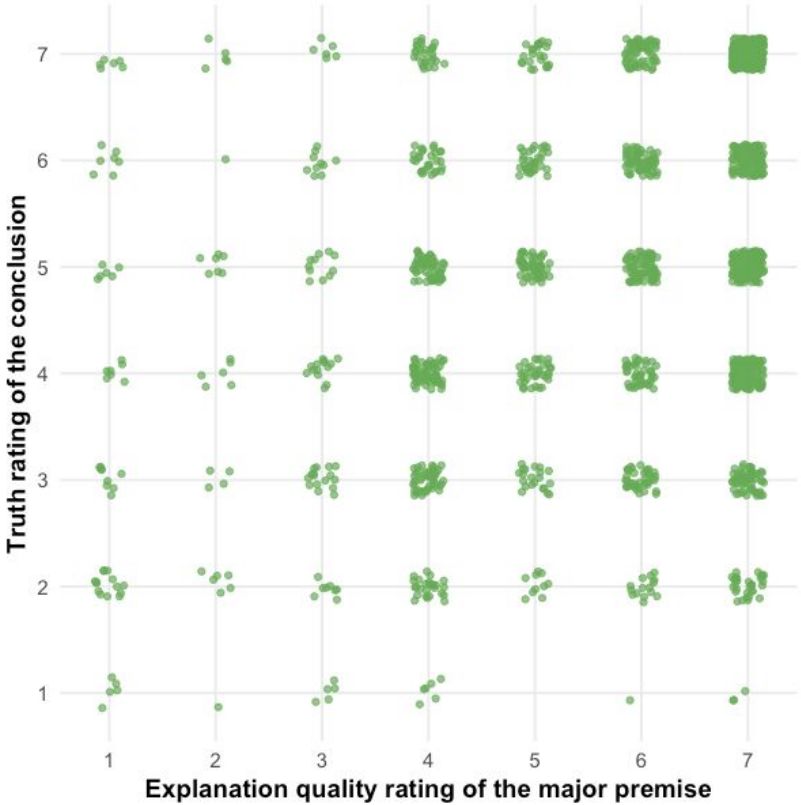
Truth vs probability judgments ***(n =120, ♀:70)***

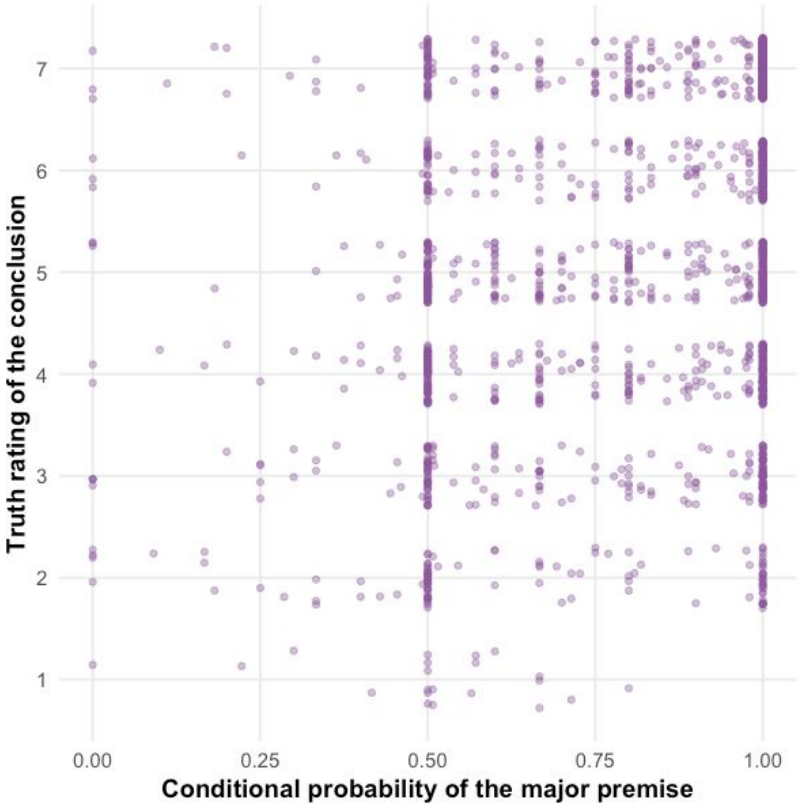
	Δ LOO-IC	SE
Full CP	0.0	--
Full PPC	11.4	8.2
Full Dif	22.2	12.6
Full Δp	27.4	12.0
INF	50.4	17.2
CP	115.6	29.0
PPC	151.8	31.4
Dif	169.0	33.4
Dif	188.6	34.2

Table of model comparison (PSIS-LOO)

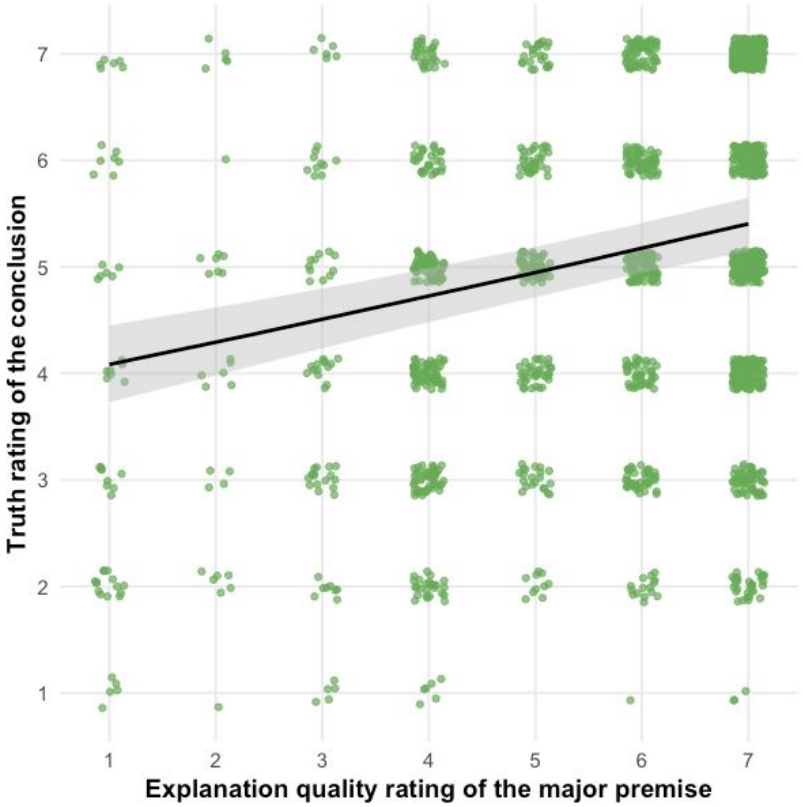


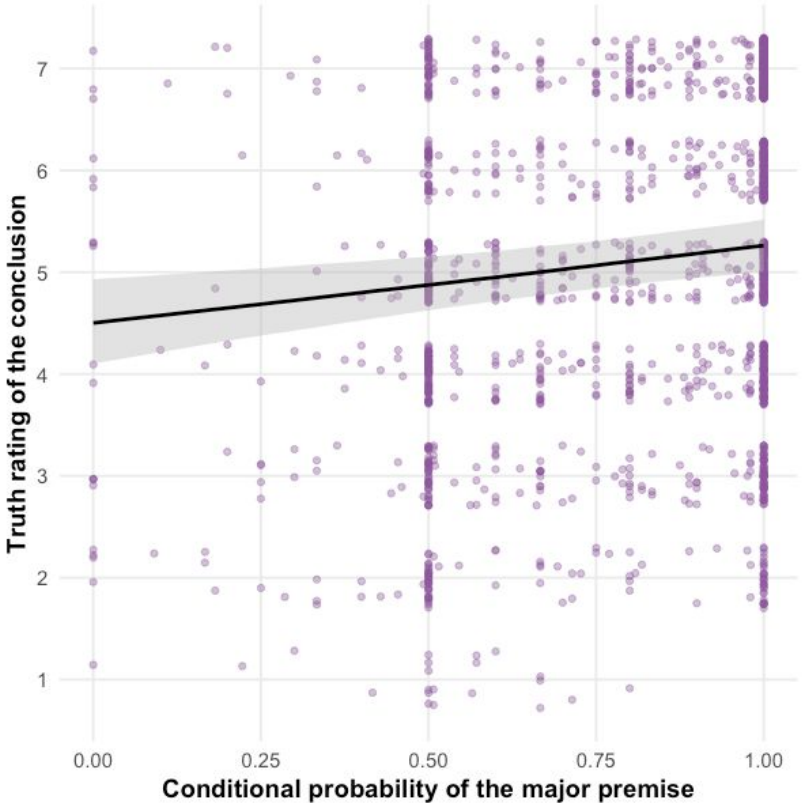
Posterior distribution for the parameters in the best model





Conditional effects plots for 'Quality' and 'Conditional Probability' with data over-layed (best model estimates, CI: 95%)





Conditional effects plots for 'Quality' and 'Conditional Probability' with data over-layed (best model estimates, CI: 95%)

C2.

MODUS PONENS ARGUMENTS

Again, strong support for Inferentialism. Explanation quality, which determines inferential strength of the major premise of an MP, is a stronger predictor of rate of endorsement of the conclusion, compared with a number of probabilistic measures.

PUTTING INFERENTIALISM TO THE TEST

- Inferentialism: requires a compelling argument from antecedent to consequent, with a broad notion of inference.
- Using realistic abductive conditionals, where the inferential connection is an explanatory relationship, we found strong support for inferentialism.
- Inferential connection in abductive conditionals is highly predictive of truth of conditionals and of endorsement of MP conclusions.

LIMITATIONS AND OPEN QUESTIONS

- Note that conditional probability remained a good predictor of truth ratings of the conclusion of MP arguments.
- The probabilistic truth-table task is not the most direct, or intuitive, measure of the results of the Ramsey test.
- Can inferentialism be used to predict the probability of a conditional?

Thanks!

Any questions?