

Best, second-best and good-enough explanations - How they matter to reasoning



Inference to the best explanation

 We infer to (the truth of) the best explanation of a given phenomenon





Douven & Schupbach (2015)

- Subjects use both explanatory considerations and conditional probabilities
- Difference in explanatory goodness also plays a role in belief updates
- But the experimental setup may have left little room for 'deep' explanatory thinking





Does the best explanation need Q2.' to be 'sufficiently better' than the second best?



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Hypotheses

H1. An explanation needs to be above a certain threshold in order to be accepted.

Lipton's 'good enough' criterion (Lipton, 2004). H2. If the difference in quality between best and second best explanation is small, then we are less inclined to infer to the best explanation.

Bird's 'sufficiently better' criterion (Bird, 2000).

Experiments 1 & 2A (between subjects)

intro 6 scenarios (quality) demographics

 'In your opinion, how good is (are) the following explanation(s) of the murder?' [7 points Likert-scale]

intro 6 scenarios (belief & probability) demographics

- 'Do you agree that it was X who committed the murder?'
- 'How likely do you think it is that X committed the murder?' [scale from 0 to 100]



Ex 1. Role of the absolute quality of an explanation

Strong explanation

"Lady Windermere was found murdered in her castle. A police investigation is under way to find the culprit.

Her sister had the following motive: not only did the two sisters hate each other since they were children, the sister would also inherit Lady Windermere's fortune of £5,000,000 if the latter died, money that the sister needed badly for a life-saving operation. According to the coroner, Lady Windermere died at 8 p.m. and the sister was seen near Lady Windermere's castle 20 minutes before by a trustworthy witness."



Ex 1. Role of the absolute quality of an explanation

Intermediate explanation

"Lady Windermere was found murdered in her castle. A police investigation is under way to find the culprit.

Jeeves, Lady Windermere's butler, had the following motive: he owed Lady Windermere £25,000, which he had borrowed from her, and which he would be able to reimburse within the next two years. Also, Jeeves has always been very fond of Lady Windermere, and his wife and a waiter testified that he spent the evening in a local restaurant, having dinner.



Ex 1. Role of the absolute quality of an explanation

Weak explanation

"Lady Windermere was found murdered in her castle. A police investigation is under way to find the culprit.

Lady Windermere's niece, who was visiting her during the week of the murder, likes to hunt. She was away the evening of the murder but left her hunting gun on the coffee table with the security on, but maybe the gun fired itself anyways and killed Lady Windermere.





Explanation quality judgments (mixed-effects models; n = 275,<math><math><math>: 158)





Acceptance and probability judgments (mixed-effects models, n = 275,?: 158)



Table 1: Comparison of the regression models from Experiment 1.

	k	LL	AIC	BIC	R^2
ME	3	-61.49	128.97	131.65	.95
MP	3	-68.76	143.51	146.18	.88

Linear models: acceptance as the dependent variable; explanation quality (ME) or probability (MP) as predictors



EXPLANATION QUALITY AND IBE

An explanation has to be **good enough** in order to be accepted. Under a certain threshold, we tend to not infer to an explanation.





Ex 2A. Role of the relative quality of an explanation

S-I⁺ condition "Lady Windermere was found murdered in her castle. A police investigation is under way to find the culprit.

- Her sister had the following motive: not only did the two sisters hate each other since they were children, the sister would also inherit Lady Windermere's fortune of £5,000,000 if the latter died, money that the sister needed badly for a life-saving operation. According to the coroner, Lady Windermere died at 8 p.m. and the sister was seen near Lady Windermere's castle 20 minutes before by a trustworthy witness.
- Jeeves, Lady Windermere's butler, had the following motive: he owed Lady Windermere £250,000, which he had borrowed from her, and which for him is an enormous amount of money. He had also occasionally complained to his friends about Lady Windermere being too strict. His wife was the only one who could testify that he spent the evening at home.



Ex 2A. Role of the relative quality of an explanation

S-I⁻ condition "Lady Windermere was found murdered in her castle. A police investigation is under way to find the culprit.

Her sister had the following motive: not only did the two sisters hate each other since they were children, the sister would also inherit Lady Windermere's fortune of £5,000,000 if the latter died, money that the sister needed badly for a life-saving operation. According to the coroner, Lady Windermere died at 8 p.m. and the sister was seen near Lady Windermere's castle 20 minutes before by a trustworthy witness.

Jeeves, Lady Windermere's butler, had the following motive: he owed Lady Windermere £25,000, which he had borrowed from her, and which he would be able to reimburse within the next two years. Also, Jeeves has always been very fond of Lady Windermere, and his wife and a waiter testified that he spent the evening in a local restaurant, having dinner.





Mean explanation quality judgments of target explanation (mixed-models analysis; n=187, Q: 101)





Mean acceptance and probability judgments of target explanation (mixed-models analysis; n=187, Q: 101)



Table 4: Comparison of the ordinary least squares models from Experiment 2A.

_	k	LL	AIC	ΔΑΙC	BIC	ΔBIC	R^2	BF
MTA	4	-39.72	87.45	1.09	89.38	1.57	.75	21.28
MT	3	-40.18	86.36	0.00	87.81	0.00	.73	57.59
MP	3	-41.05	88.09	1.73	89.55	1.74	.69	32.12
MD	3	-40.37	86.74	0.38	88.19	0.38	.72	50.61
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Table 6: Comparison of MDE and MPD.

	k	LL	AIC	BIC	R^2	BF
MDE	3	-36.65	79.31	80.76	.81	372.02
MDP	3	-42.43	90.85	92.31	.51	6.13

Linear models: 1. Acceptance as dependent variable 2. Decrease in acceptance as dependent variable.

C2A.

RELATIVE QUALITY AND IBE



The best explanation has to be sufficiently **better** than the second best explanation in order to be accepted.

When the difference in explanation quality is small, we are less inclined to infer to the best explanation.



But wait...

Possible objection. Are we sure that probabilities cannot predict acceptance just as well as quality?

We recorded quality judgments for both explanations, but probability judgments only for the target explanation. We should compare the models in 2A with a model that has the probabilities of both explanations as predictors.

Experiment 2B (*n*=77, **9**: 41)



intro 6 scenarios (probability) demographics

- 'How likely do you think it is that X committed the murder?'
- "How likely do you think it is that Y committed the murder?"

k	II	110	N 00000000				
		AIC	ΔAIC	BIC	ΔBIC	R^2	BF
4	-41.11	90.23	3.87	92.17	4.36	.68	9.65
3	-41.17	88.34	1.98	89.79	1.98	.68	29.60
3	-41.47	88.94	2.58	90.40	2.59	.67	24.21
4	-39.72	87.45	1.09	89.38	1.57	.75	21.28
3	-40.18	86.36	0.00	87.81	0.00	.73	57.59
3	-41.05	88.09	1.73	89.55	1.74	.69	32.12
3	-40.37	86.74	0.38	88.19	0.38	.72	50.61
	4 3 3 4 3 3 3	$\begin{array}{ccccccc} 4 & -41.11 \\ 3 & -41.17 \\ 3 & -41.47 \\ 4 & -39.72 \\ 3 & -40.18 \\ 3 & -41.05 \\ 3 & -40.37 \end{array}$	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$				

Table 7: Comparison of the regression models from Experiments 2A and 2B.

Linear models: Acceptance as dependent variable

QUALITY VS. PROBABILITY

Explanation quality judgments are a **better predictor** of agreement than probability judgments.

The models using the probability of both explanations do still worse than the best models from experiment 2A.



C2B



But why?

H3. The drop in agreement is caused by a drop in confidence in one's judgment of explanatory bestness.

Because explanation goodness is a vague concept.

A metacognitive process is a process which controls other cognitive processes.

A small difference in explanation quality could undermine people's confidence in the inference.



Ex 3. IBE at the individual level and role of meta-confidence



- 'In your opinion, how good are the following explanation(s) of the murder?' [scale from 0 to 100]
- 'Do you agree that it was X who committed the murder?'
- 'In providing my answer to the above question, I felt...'
 - ... Guessing / Fairly Certain / Certain I'm right [scale from 0 to 100]
- → Three scenarios with a strong alternative and three with a weak alternative.





Participants' agreement with the target explanations compared with their quality ratings (exploratory analysis; n=70, Q: 45)





quality ratings of...

Participants' metacognitive confidence compared with their quality ratings (exploratory analysis; n=70, Q: 45)

Table 8: Comparison of GLMMs from Experiment 3.



	k	LL	AIC	ΔΑΙC	BIC	ΔBIC	Count	R^2	D	AUC	BF
GLMTA	15	-132.79	295.57	1.51	356.18	29.80	.93	.46	.69	.89	1.7×10^{36}
GLMT	8	-182.71	381.42	87.36	413.73	87.35	.85	.26	.39	.77	2.5×10^{23}
GLMD	8	-139.03	294.06	0.00	326.38	0.00	.90	.43	.58	.85	2.5×10^{36}

Table 10: Comparison of LMMs from Experiment 3.

	k	LL	AIC	ΔΑΙC	BIC	ΔΒΙC	R^2	BF
LMTA	16	-474.15	980.30	21.64	1044.94	45.89	.75	4.1×10^{10}
LMT	9	-485.75	989.50	30.85	1025.86	26.80	.70	2.3×10^{8}
LMD	9	-480.47	978.93	20.28	1015.29	16.24	.71	7.5×10^{10}
LMTAQ	17	-467.82	969.64	10.99	1038.32	39.27	.76	1.9×10^{15}
LMTQ	10	-481.50	982.99	24.34	1023.40	24.34	.70	9×10^{12}
LMDQ	10	-469.33	958.65	0.00	999.06	0.00	.71	1.4×10^{18}

Binomial models, acceptance as dependent variable
Linear modes, metacognitive confidence as dependent variable.





Predictions of the two most successful models: GLMD for probability of agreement and LMDQ for metacognitive confidence



EXPLANATIONS AT THE INDIVIDUAL LEVEL

Both absolute and relative quality of an explanation matter at the individual level.

Difference in explanation quality of both explanations is the best predictor of a subject's agreement, as well as the best predictor of her metacognitive confidence.

REASONING ABOUT EXPLANATIONS



- We used experimental materials with rich content in order to prompt a deep notion of explanation.
- Explanation quality and difference in explanation quality matter to reasoning: the best explanation has to be 'good enough' and 'sufficiently better' for the inference to happen.
- Explanation quality is a better predictor of agreement than probability judgments.
- There is strong evidence that this is due to metacognitive processes.

Thanks!

Any questions?

You can reach us at

- mirabile.patricia@gmail.com
- igor.douven@gmail.com

