Triage Against the Machine: Can AI Reason Deliberatively?

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Large-Language Models (LLMs) Preview

Table 1: LLMs

	Provider	Model	Architecture	Version
1	anthropic	claude-3-5-haiku-20241022	transformer	2.0
2	anthropic	claude-3-5-sonnet-20241022	reason	2.0
3	anthropic	claude-3-7-sonnet-20250219	reason	3.0
4	anthropic	claude-3-haiku-20240307	NA	1.0
5	anthropic	claude-3-opus-20240229	NA	1.0
6	anthropic	claude-3-sonnet-20240229	NA	1.0
7	cohere	command	NA	NA
8	cohere	command-a-03-2025	NA	NA
9	cohere	command-r-08-2024	NA	NA
10	cohere	command-r-plus-08-2024	NA	NA
11	cohere	command-r7b-12-2024	open-weights	NA
12	deepseek	deepseek-chat	NA	NA
13	deepseek	deepseek-reasoner	MoE	NA
14	deepseek	deepseek-v2	NA	NA
15	deepseek	deepseek-v2.5	NA	NA
16	google	gemini-1.5-flash	NA	1.5
17	google	gemini-1.5-flash-8b	NA	1.5
18	google	gemini-1.5-pro	NA	1.5
19	google	gemini-2.0-flash	NA	2.0
20	google	gemma	NA	1.0
21	google	gemma2:27b	NA	2.0
22	google	gemma3:12b	NA	3.0
23	meta	llama2:13b	NA	2.0
24	meta	llama2:70b	NA	2.0
25	meta	llama3.1:405B-turbo	NA	3.1
26	meta	llama3.2	NA	3.1
27	meta	llama3.3:70b	NA	3.3
28	meta	llama3:70b	NA	3.0
29	meta	llama4-maverick	MoE	4.0
30	meta	llama4-scout	MoE	4.0
31	microsoft	phi	NA	1.0
32	microsoft	phi2	NA	2.0
33	microsoft	phi3	NA	3.0
34	microsoft	phi3.5	NA	3.5
35	microsoft	phi4	NA	4.0
36	mistralai	ministral-3b-latest	NA	NA

	Provider	Model	Architecture	Version
37	mistralai	ministral-8b-latest	NA	NA
38	mistralai	mistral-large-latest	reason	NA
39	mistralai	mistral-small-latest	NA	NA
40	mistralai	open-mistral-7b	NA	NA
41	mistralai	open-mistral-nemo	NA	NA
42	mistralai	open-mixtral-8x22b	SMoE	NA
43	mistralai	open-mixtral-8x7b	SMoE	NA
44	openai	gpt-3.5-turbo	NA	NA
45	openai	gpt-4	NA	NA
46	openai	gpt-4-turbo	NA	NA
47	openai	gpt-4.5-preview	NA	NA
48	openai	gpt-4o	NA	NA
49	openai	gpt-4o-mini	NA	NA
50	openai	o1	reason	NA
51	openai	o1-mini	reason	NA
52	openai	o3-mini	reason	NA
53	qwen	qwen-max	NA	NA
54	qwen	qwen-plus	NA	NA
55	qwen	qwen-turbo	NA	NA
56	qwen	qwen1.5-110b-chat	NA	1.5
57	qwen	qwen1.5-72b-chat	NA	1.5
58	qwen	qwen2-72b-instruct	NA	2.0
59	qwen	qwen2.5-72b-instruct	NA	2.5
60	qwen	qwq-plus	reason	NA
61	xai	grok-2-1212	NA	NA

We started the analysis with 61 models, but some models were dropped after data collection. The models and reason for dropping are discussed later on Excluded Models.

Surveys

Table 2: Surveys

	survey	considerations	policies	scale_max	q_method
1	acp	48	5	11	FALSE
2	auscj	45	8	7	FALSE
3	bep	43	7	7	FALSE
4	biobanking_mayo_ubc	38	7	11	FALSE
5	biobanking_wa	49	7	11	FALSE
6	ccps	33	7	11	FALSE
7	ds_aargau	33	7	7	FALSE
8	ds_bellinzona	32	7	7	FALSE
9	energy_futures	45	9	11	FALSE
10	fnqcj	42	5	12	FALSE
11	forestera	45	7	11	FALSE
12	fremantle	36	6	11	TRUE
13	gbr	35	7	7	FALSE
14	swiss_health	24	6	7	FALSE
15	uppsala_speaks	42	7	7	FALSE
16	valsamoggia	36	4	11	TRUE

	survey	considerations	policies	scale_max	q_method
17	zh_thalwil	31	7	7	FALSE
18	zh_uster	31	7	7	FALSE
19	zh_winterthur	30	6	7	FALSE
20	zukunft	20	7	7	FALSE

LLM Data Collection

We collected a total of 32738 valid LLM responses across 20 surveys.

Cost

We spent a total of 383.71 USD. The cost breakdown per API is below.

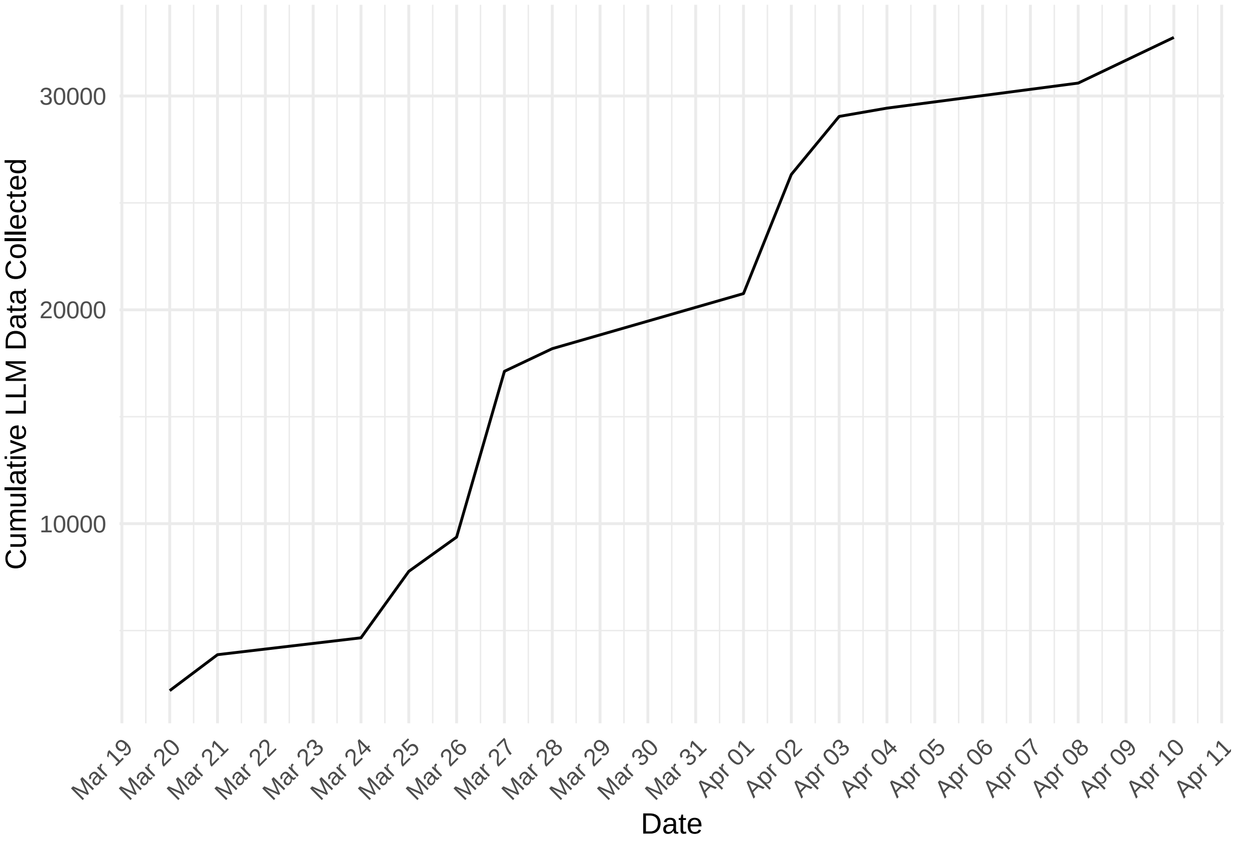
Table 3: Costs by API

api	num_models	credits_paid
OpenAI API	9	225.52
Anthropic API	6	75.00
Mistral AI API	8	20.00
Alibaba Cloud	8	17.49
Together AI	8	13.00
Cohere API	5	12.70
DeepSeek API	2	10.00
xAI API	1	10.00
Google Could	4	NA
ollama	9	NA

Time

It took a total of 157 hours[1] across 21 days to complete data collection. Most of it was done in parallel. The first LLM response was collected on Thursday, Mar 20, 2025 and latest on Thursday, Apr 10, 2025.

[1] Execution data is mostly accurate. Only a few (3-5) executions failed and, as a result, we have no record of it.



Excluded Models

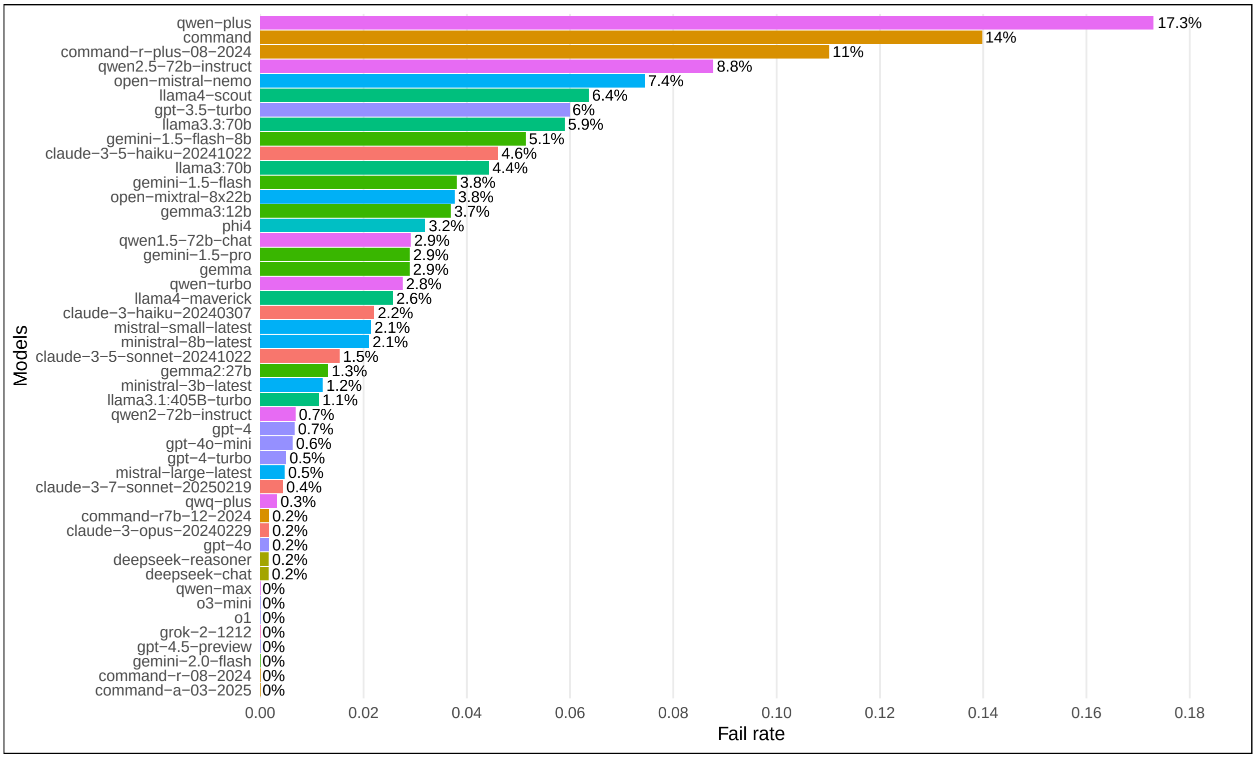
14 out of 63 were excluded from the analysis for the following reasons.

Table 4: Excluded models and reasons

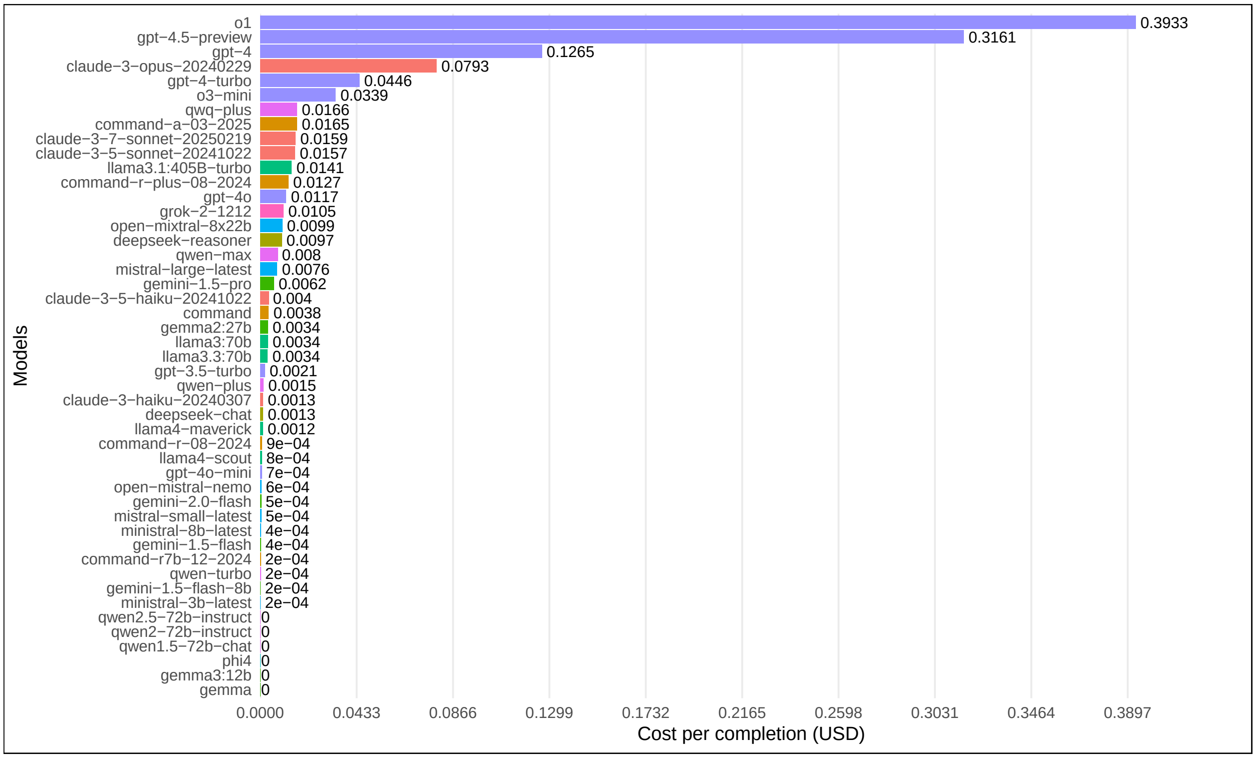
provider	model	reason
anthropic	claude-3-sonnet-20240229	not available in Anthropic API anymore
deepseek	deepseek-v2	high fail rate (85%)
deepseek	deepseek-v2.5	too big to run locally; not available through APIs
meta	llama2:13b	does not respond to prompts correctly
meta	llama2:70b	does not respond to prompts correctly
meta	llama3.2	3% success rate on auscj
microsoft	phi	does not respond to prompts correctly
microsoft	phi2	same model as phi
microsoft	phi3	does not respond to prompts correctly
microsoft	phi3.5	10% success rate for biobanking_wa
mistralai	open-mistral-7b	11% success rate for auscj, uppsala_speaks, and biobanking_wa
mistralai	open-mixtral-8x7b	6% success rate on fremantle only
openai	o1-mini	0% success rate on uppsala_speaks only; responds with "I'm sorry, but I can't help with that."
qwen	qwen1.5-110b-chat	has API limit of 10 RPM; too slow

Execution Summary Plots

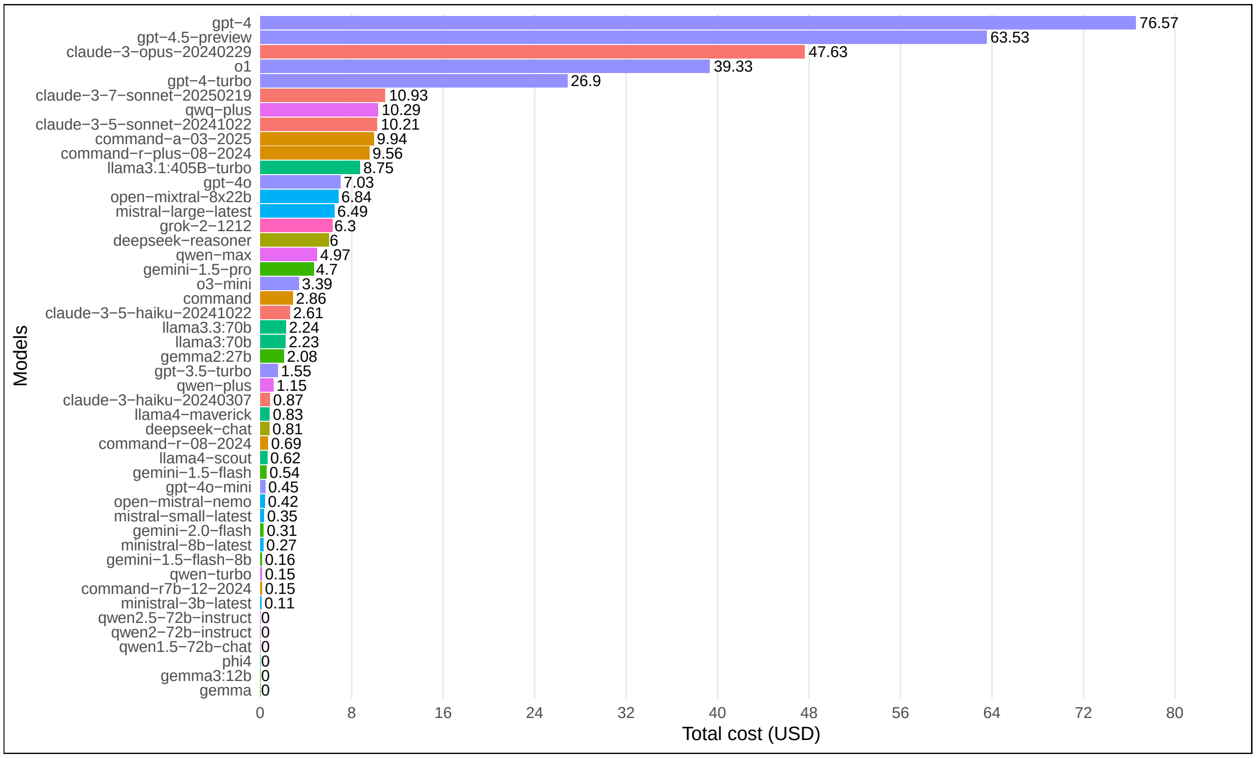
Fail rate



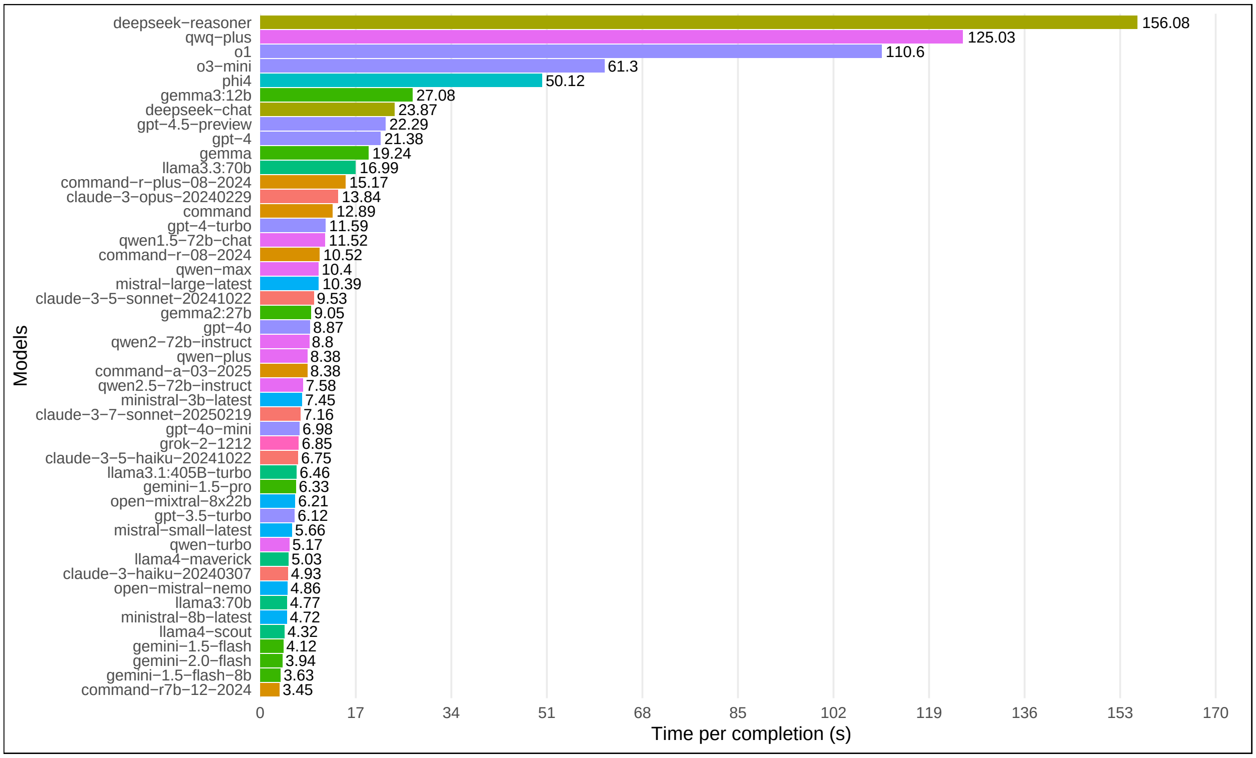
Cost per completion



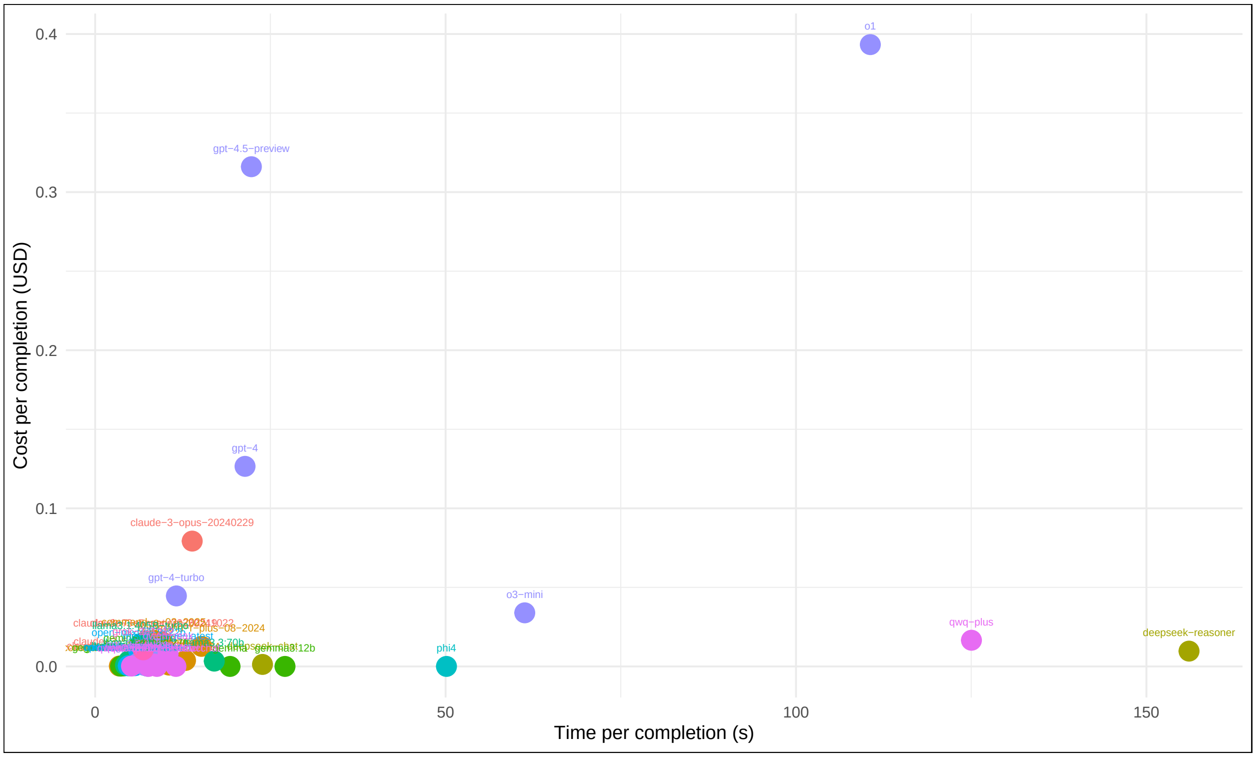
Total cost



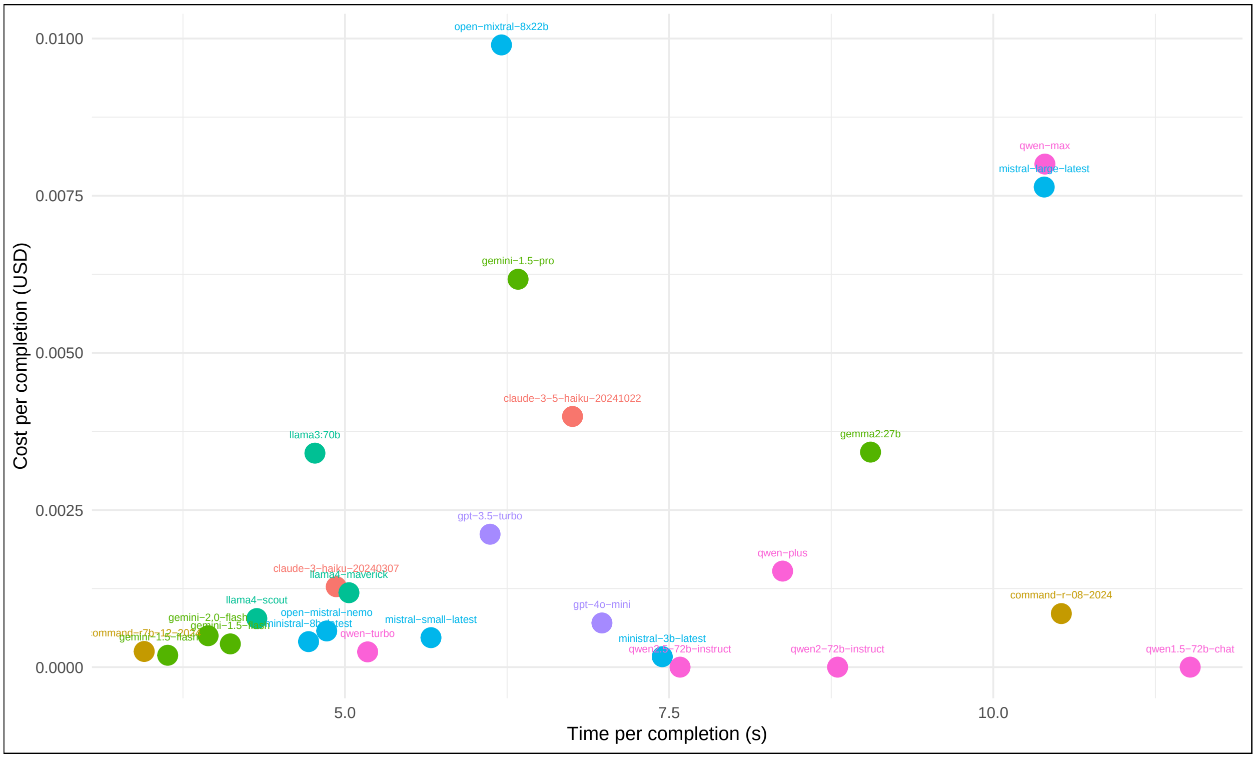
Time per completion



Cost/Time per completion



Zoomed in to cost < 0.01 USD and time < 12 s.



Internal Consistency of Responses

We calculate Cronbach's Alpha from the top 30 iterations.

Check alpha results per model

Table 5: Alpha summary across models, mean across surveys

	provider	model	N	all	considerations	policies
1	qwen	qwen1.5-72b-chat	600	0.70	0.75	0.49
2	google	gemma2:27b	600	0.71	0.75	0.50
3	meta	llama4-maverick	600	0.71	0.78	0.44
4	openai	gpt-4o-mini	600	0.72	0.74	0.45
5	anthropic	claude-3-haiku-20240307	600	0.74	0.82	0.44
6	google	gemini-1.5-flash	600	0.74	0.76	0.52
7	anthropic	claude-3-5-sonnet-20241022	600	0.75	0.81	0.58
8	deepseek	deepseek-reasoner	600	0.75	0.79	0.55
9	openai	gpt-4	600	0.75	0.82	0.52
10	openai	gpt-4-turbo	600	0.75	0.82	0.53
11	google	gemini-1.5-pro	600	0.76	0.78	0.57
12	openai	gpt-4o	600	0.76	0.86	0.50
13	cohere	command	600	0.78	0.78	0.44
14	google	gemma	600	0.78	0.80	0.45
15	meta	llama3.3:70b	600	0.78	0.82	0.52
16	mistralai	mistral-small-latest	600	0.78	0.84	0.52
17	mistralai	open-mistral-nemo	600	0.78	0.80	0.49
18	qwen	qwq-plus	600	0.78	0.79	0.58
19	xai	grok-2-1212	600	0.78	0.89	0.47
20	cohere	command-a-03-2025	600	0.79	0.86	0.51
21	cohere	command-r-08-2024	600	0.79	0.81	0.50
22	deepseek	deepseek-chat	600	0.79	0.86	0.52
23	google	gemini-1.5-flash-8b	600	0.79	0.84	0.50
24	meta	llama3:70b	600	0.79	0.79	0.52
25	qwen	qwen-turbo	600	0.79	0.83	0.48
26	anthropic	claude-3-7-sonnet-20250219	600	0.80	0.84	0.53
27	meta	llama4-scout	600	0.80	0.85	0.51
28	qwen	qwen-plus	600	0.80	0.82	0.49
29	qwen	qwen2-72b-instruct	600	0.80	0.86	0.48
30	qwen	qwen2.5-72b-instruct	600	0.80	0.84	0.51
31	anthropic	claude-3-5-haiku-20241022	600	0.81	0.86	0.47
32	google	gemma3:12b	600	0.81	0.81	0.47
33	microsoft	phi4	600	0.81	0.82	0.55
34	mistralai	ministral-8b-latest	600	0.82	0.83	0.51
35	qwen	qwen-max	600	0.82	0.84	0.51
36	anthropic	claude-3-opus-20240229	600	0.83	0.87	0.50
37	mistralai	mistral-large-latest	600	0.83	0.86	0.54
38	google	gemini-2.0-flash	600	0.84	0.84	0.62
39	openai	gpt-3.5-turbo	600	0.84	0.87	0.48
40	openai	gpt-4.5-preview	201	0.84	0.87	0.70
41	meta	llama3.1:405B-turbo	600	0.85	0.88	0.49
42	mistralai	ministral-3b-latest	600	0.85	0.86	0.53
43	cohere	command-r7b-12-2024	600	0.86	0.87	0.46
44	cohere	command-r-plus-08-2024	600	0.87	0.89	0.49
45	mistralai	open-mixtral-8x22b	600	0.87	0.90	0.52

	provider	model	N	all	considerations	policies
46	openai	o1	100	0.92	0.92	0.77
47	openai	o3-mini	100	0.92	0.91	0.80

Aggregation

We then aggregated LLM data into 1 response per model/survey. Based on (Motoki, Pinho Neto, and Rodrigues 2024), we bootstrap considerations 1000 times.

Aggregate considerations and preferences

We aggregated 32738 LLM responses into 1048 responses: 1 response per model per survey.

WARNING! All considerations of cohere/command-r-plus-08-2024/fnqcj were aggregated as 1

WARNING! All considerations of google/gemma3:12b/valsamoggia were aggregated as 1

Human Data

Table 6: Number of participants in each case study

	Case	survey	participants
1	Citizen Parliamentarian	acp	45
2	HGE Control Group	auscj	19
3	HGE Deliberative Group	auscj	23
4	BEP	bep	16
5	Mayo	biobanking_mayo_ubc	17
6	UBC Bio	biobanking_mayo_ubc	17
7	WA Citizens	biobanking_wa	9
8	WA Stakeholder	biobanking_wa	15
9	CCPS ACT Deliberative	ccps	31
10	Aargau	ds_aargau	16
11	Bellinzona	ds_bellinzona	8
12	CSIRO NSW	energy_futures	12
13	CSIRO WA	energy_futures	17
14	FNQCJ	fnqcj	11
15	Forest Lay Citizen	forestera	9
16	Forest Stakeholder	forestera	11
17	Fremantle	fremantle	41
18	GBR	gbr	7
19	Activate	uppsala_speaks	26
20	Standard	uppsala_speaks	22
21	UPSA Control Group	uppsala_speaks	20
22	Valsamoggia	valsamoggia	16
23	Thalwill	zh_thalwil	14
24	USTER	zh_uster	15
25	Winterthur	zh_winterthur	16
26	Zukunft	zukunft	63

We collected 1032 human responses across 26 case studies, including pre-post deliberation responses.

Randomly Generated Data

Then, we generated 20 random reseponses for each survey.

DRI Analysis

We begin by defining DRI calculation functions.

```r
# original DRI formula
dri_calc <- function(data, v1, v2) {
  lambda <- 1 - (sqrt(2) / 2)
  dri <- 2 * (((1 - mean(abs((data[[v1]] - data[[v2]]) / sqrt(2)
  ))) - (lambda)) / (1 - (lambda))) - 1

  return(dri)
}

# updated DRI formula
# FIXME: only accounts for negligible positive correlations, but not negative ones
dri_calc_v2 <- function(data, v1, v2) {
  # Calculate orthogonal distance for each pair
  d <- abs((data[[v1]] - data[[v2]]) / sqrt(2))

  # Define lambda as in the original
  lambda <- 1 - (sqrt(2) / 2)

  # Calculate penalty: 0.5 if both correlations are in [0, 0.2], 1 otherwise
  penalty <- ifelse(data[[v1]] >= 0 & data[[v1]] <= 0.2 & #0.3
                      data[[v2]] >= 0 & data[[v2]] <= 0.2, # 0.3
                    0, 1)

  # Adjusted consistency per pair
  consistency <- (1 - d) * penalty

  # Average consistency across all pairs
  avg_consistency <- mean(consistency)

  # Scale to [-1, 1] as in the original
  dri <- 2 * ((avg_consistency - lambda) / (1 - lambda)) - 1

  return(dri)
}

# updated DRI formula: penalizes both negligible positive and negative correlations in a scalar way.
dri_calc_v3 <- function(data, v1, v2){
  d <- abs((data[[v1]] - data[[v2]]) / sqrt(2))
  lambda <- 1 - (sqrt(2) / 2)

  # Scalar penalty based on strength of signal (|r| and |q|)
  penalty <- ifelse(pmax(abs(data[[v1]]), abs(data[[v2]])) <= 0.2,
                    pmax(abs(data[[v1]]), abs(data[[v2]])) / 0.2,
                    1)

  consistency <- (1 - d) * penalty
  avg_consistency <- mean(consistency)

  dri <- 2 * ((avg_consistency - lambda) / (1 - lambda)) - 1
  return(dri)
}
```

```
## Warning in cor(Q, method = "spearman"): the standard deviation is zero
## Warning in cor(Q, method = "spearman"): the standard deviation is zero
## Warning in cor(Q, method = "spearman"): the standard deviation is zero
## Warning in cor(Q, method = "spearman"): the standard deviation is zero
```

```
## Warning: Missing swiss_health from DRIInd.LLMs!
```

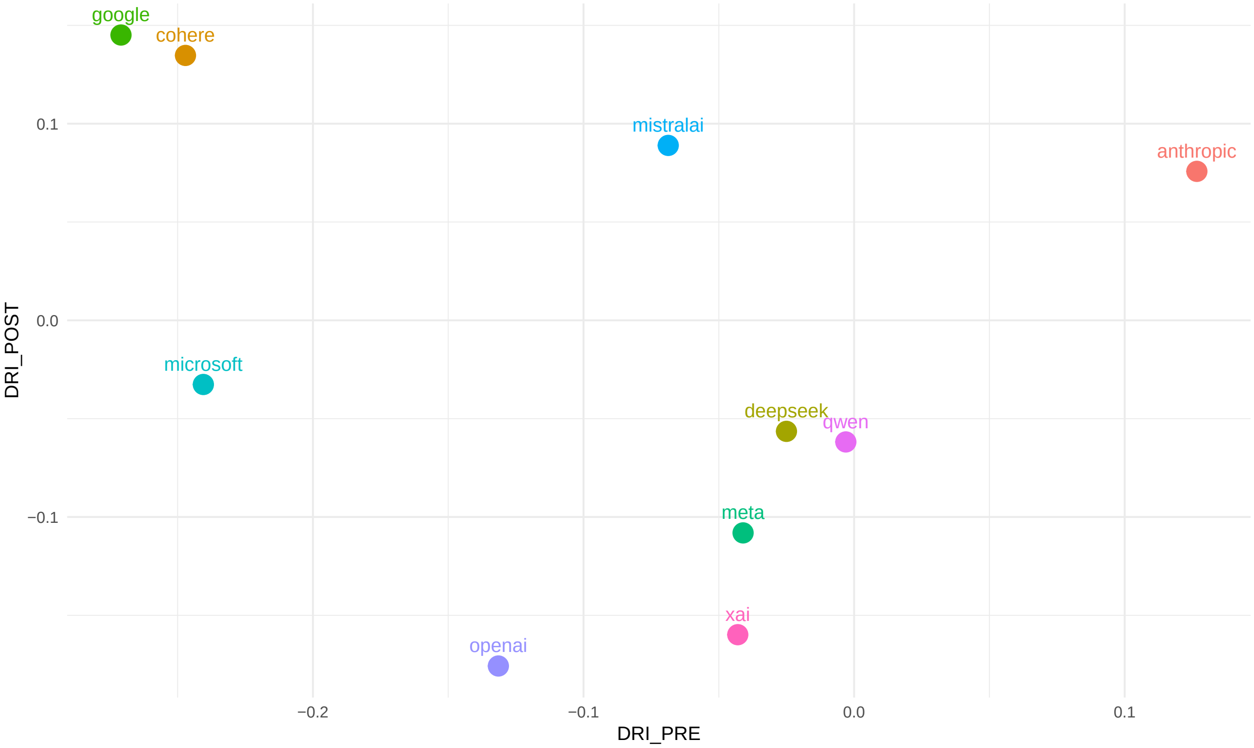
DRI Benchmark

```
## `summarise()` has grouped output by 'provider', 'model'. You can override using
## the `.groups` argument.
```

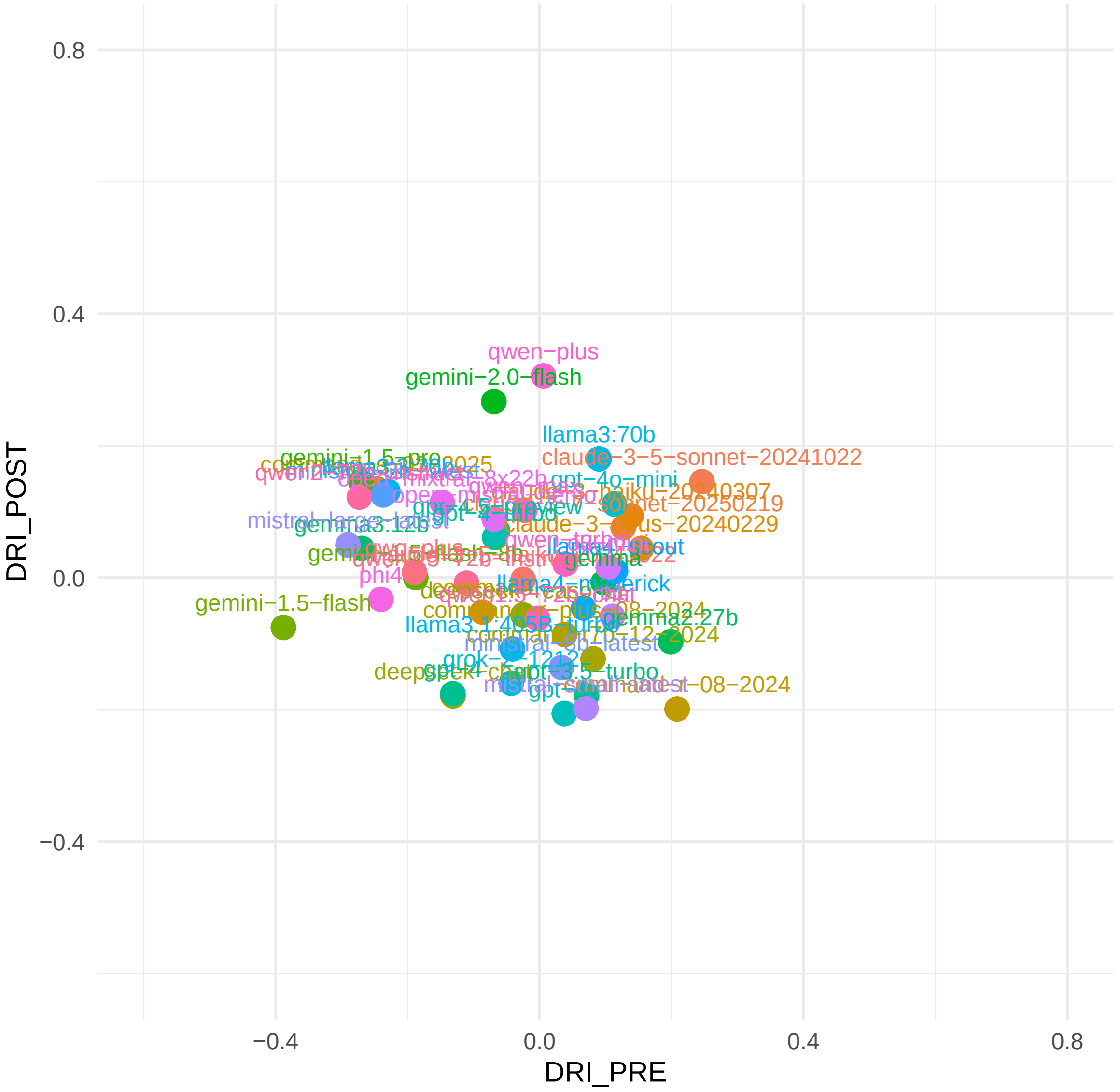
```
##
## Attaching package: 'Metrics'
```

```
## The following object is masked from 'package:rlang':
##
##     ll
```

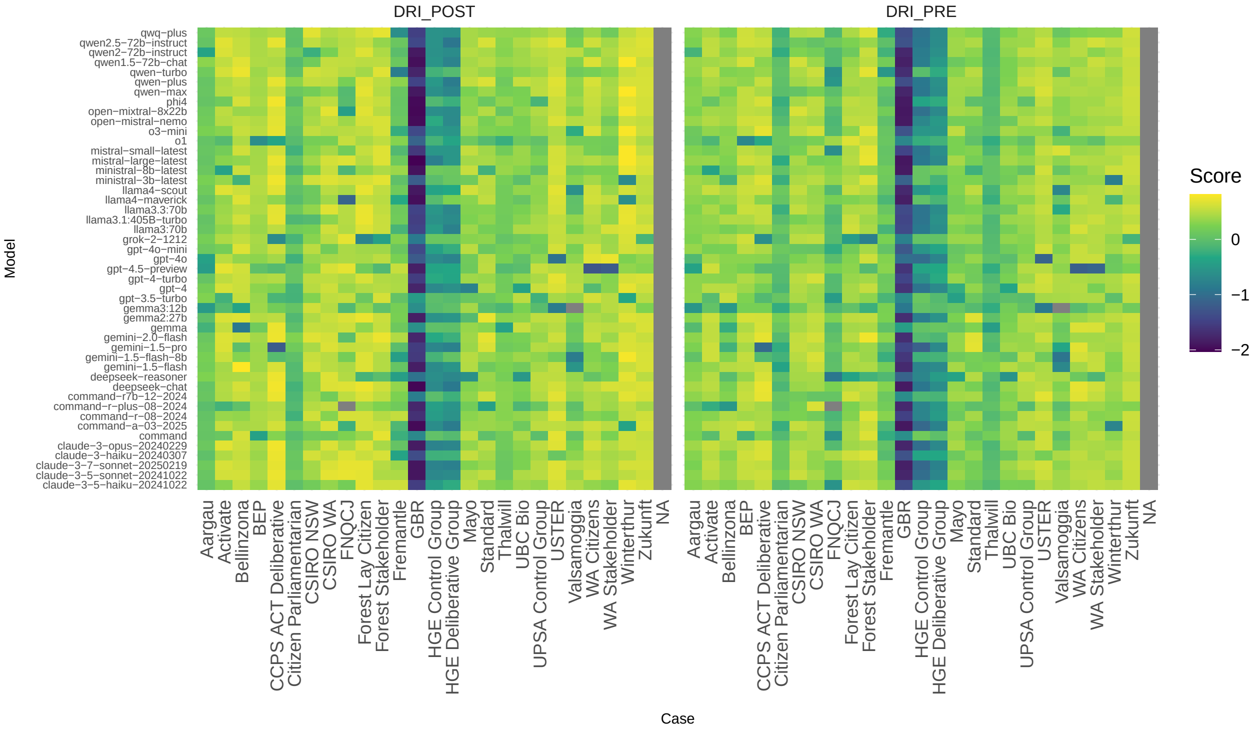
Comparison PRE and POST DRI by Provider



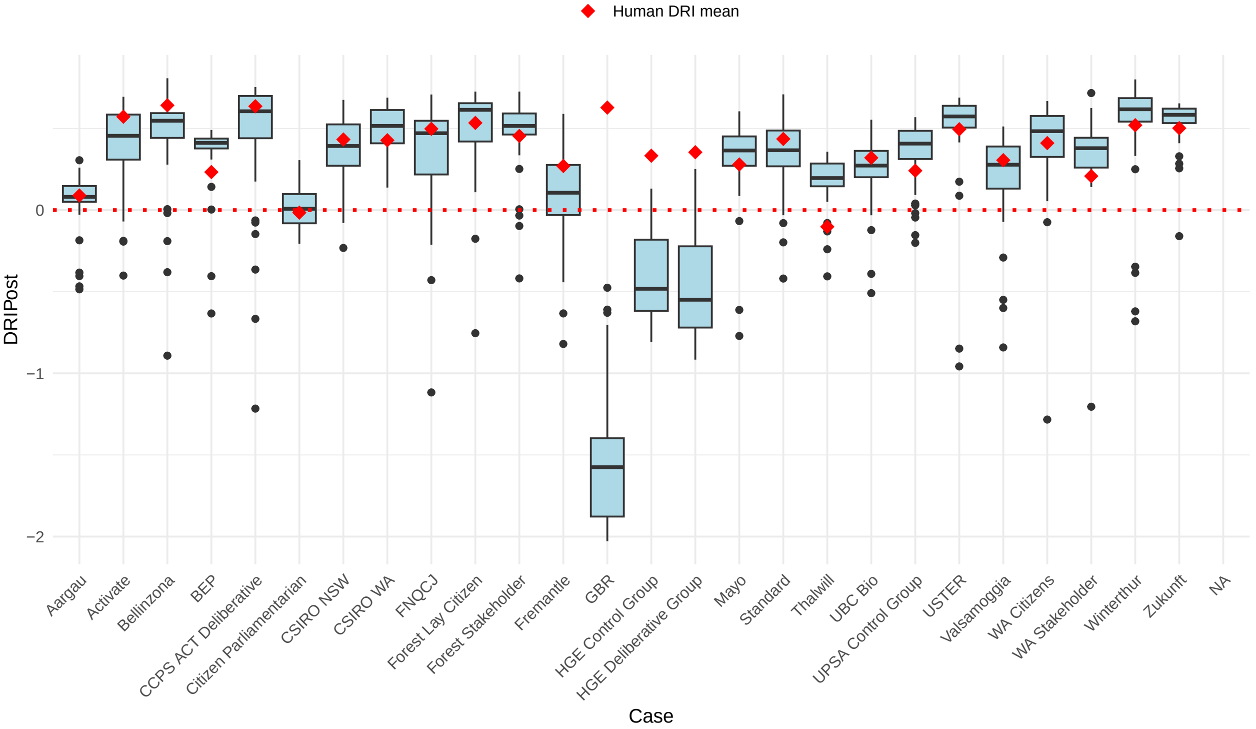
Comparison PRE and POST DRI by Model



Heatmap of DRI Scores by Case and Model



Boxplot of LLM DRI Post by Case



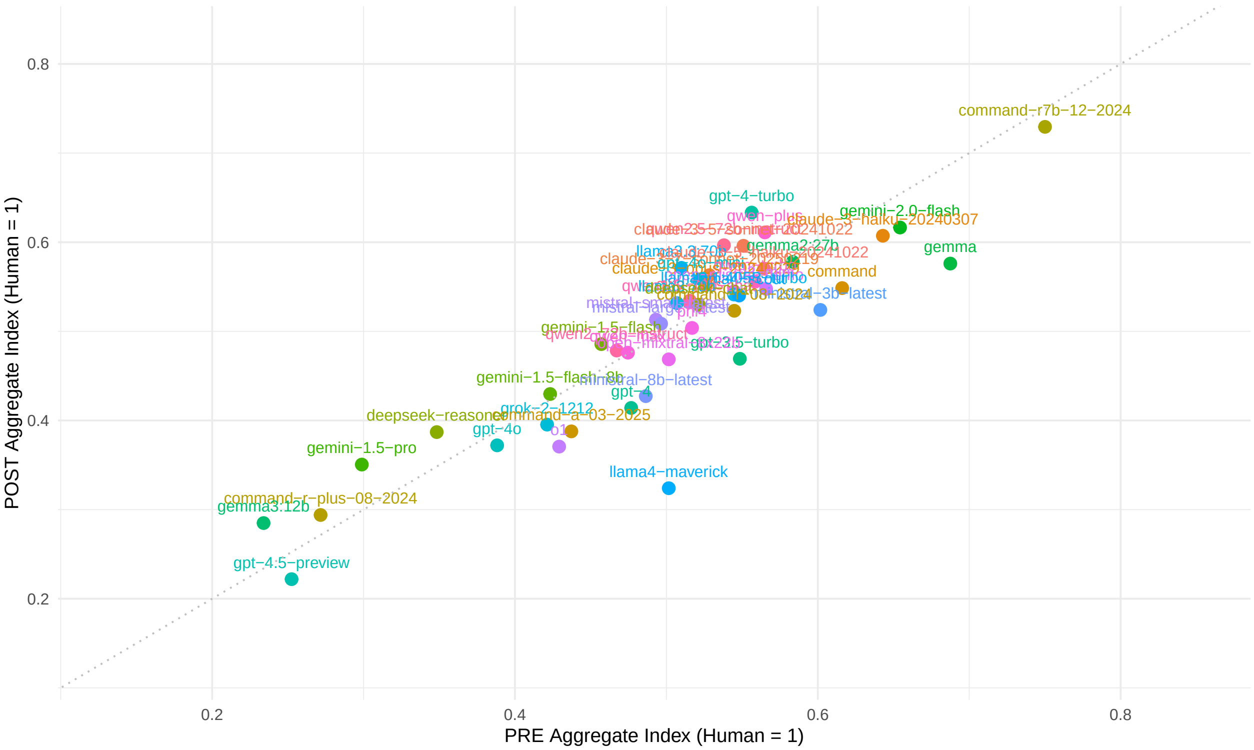
LLM Performance Metrics Against Human DRI Post-Scores

Table 7: LLM Performance Metrics Against Human DRI Post-Scores

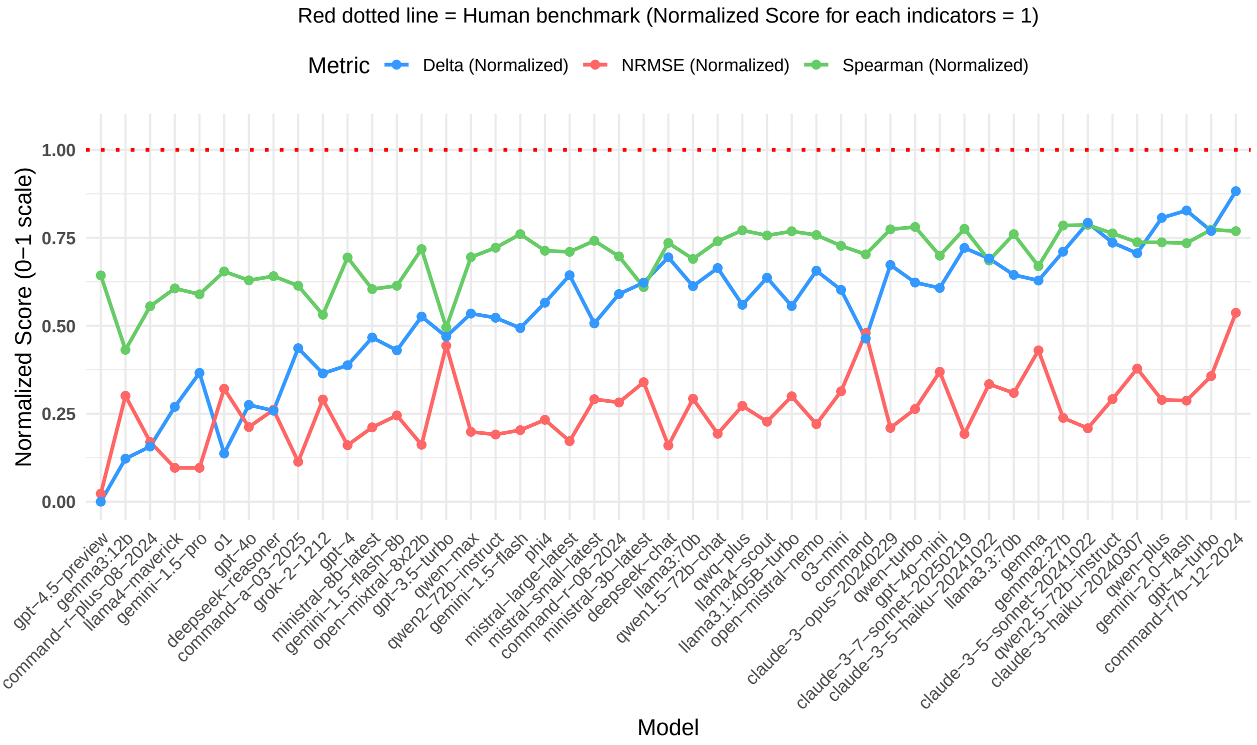
			MAPE	Human				
Model	MAE	RMSE	(%)	Range	NMAE	NRMSE	Spearman	Delta
command-r7b-12-2024	0.197	0.344	85.810	0.744	0.265	0.463	0.538	-0.041
command	0.283	0.387	89.798	0.744	0.381	0.521	0.406	-0.187
gpt-3.5-turbo	0.310	0.414	128.487	0.744	0.417	0.557	-0.010	-0.185
gemma	0.245	0.424	76.739	0.744	0.330	0.570	0.339	-0.129
claude-3-haiku-20240307	0.254	0.462	98.213	0.744	0.341	0.622	0.475	-0.102
gpt-4o-mini	0.255	0.469	100.318	0.744	0.342	0.631	0.398	-0.137
gpt-4-turbo	0.227	0.478	80.697	0.744	0.306	0.643	0.547	-0.080
ministral-3b-latest	0.289	0.491	111.081	0.744	0.388	0.660	0.220	-0.131
claude-3-5-haiku-20241022	0.268	0.495	76.615	0.744	0.360	0.666	0.371	-0.108
o1	0.318	0.505	92.257	0.744	0.427	0.679	0.309	-0.301
o3-mini	0.292	0.510	95.798	0.744	0.393	0.686	0.454	-0.139
llama3.3:70b	0.275	0.514	111.403	0.744	0.369	0.691	0.521	-0.124
gemma3:12b	0.374	0.520	118.761	0.744	0.502	0.699	-0.137	-0.306
llama3.1:405B-turbo	0.260	0.521	92.533	0.744	0.349	0.701	0.537	-0.155
llama3:70b	0.298	0.526	129.718	0.744	0.400	0.707	0.380	-0.135
qwen2.5-72b-instruct	0.277	0.527	84.711	0.744	0.373	0.709	0.525	-0.092
mistral-small-latest	0.284	0.527	119.671	0.744	0.382	0.709	0.483	-0.172
grok-2-1212	0.317	0.528	109.056	0.744	0.426	0.710	0.063	-0.221
qwen-plus	0.293	0.529	157.093	0.744	0.395	0.711	0.474	-0.067
gemini-2.0-flash	0.283	0.530	142.756	0.744	0.381	0.713	0.469	-0.060
command-r-08-2024	0.279	0.534	122.313	0.744	0.375	0.718	0.394	-0.143
qwq-plus	0.282	0.541	90.107	0.744	0.379	0.728	0.543	-0.153
qwen-turbo	0.267	0.548	85.491	0.744	0.360	0.737	0.562	-0.131
deepseek-reasoner	0.375	0.549	123.108	0.744	0.504	0.739	0.282	-0.258
gemini-1.5-flash-8b	0.328	0.561	97.684	0.744	0.442	0.755	0.227	-0.198
gemma2:27b	0.285	0.567	103.724	0.744	0.383	0.762	0.570	-0.101
phi4	0.287	0.571	83.983	0.744	0.385	0.767	0.426	-0.151
llama4-scout	0.287	0.575	86.507	0.744	0.386	0.773	0.513	-0.127
open-mistral-nemo	0.276	0.580	104.933	0.744	0.371	0.780	0.516	-0.120
gpt-4o	0.357	0.586	158.169	0.744	0.481	0.788	0.258	-0.252
ministral-8b-latest	0.309	0.587	109.421	0.744	0.415	0.789	0.208	-0.186
claude-3-opus-20240229	0.284	0.588	92.192	0.744	0.382	0.790	0.548	-0.114
claude-3-5-sonnet-20241022	0.289	0.589	115.990	0.744	0.388	0.791	0.573	-0.072
gemini-1.5-flash	0.307	0.592	102.964	0.744	0.413	0.797	0.521	-0.176
qwen-max	0.313	0.596	111.424	0.744	0.420	0.801	0.390	-0.162
qwen1.5-72b-chat	0.298	0.600	103.533	0.744	0.400	0.807	0.480	-0.117
claude-3-7-sonnet-20250219	0.291	0.601	99.713	0.744	0.391	0.808	0.551	-0.097
qwen2-72b-instruct	0.331	0.602	142.072	0.744	0.445	0.809	0.443	-0.166
mistral-large-latest	0.305	0.616	99.385	0.744	0.410	0.828	0.420	-0.124
command-r-plus-08-2024	0.369	0.617	119.389	0.744	0.497	0.830	0.111	-0.294
open-mixtral-8x22b	0.308	0.623	108.671	0.744	0.415	0.838	0.436	-0.165
gpt-4	0.360	0.624	141.193	0.744	0.484	0.839	0.388	-0.213
deepseek-chat	0.315	0.625	129.052	0.744	0.423	0.840	0.471	-0.106
command-a-03-2025	0.375	0.659	140.325	0.744	0.504	0.887	0.227	-0.196
llama4-maverick	0.358	0.672	98.374	0.744	0.482	0.904	0.212	-0.254
gemini-1.5-pro	0.389	0.672	138.578	0.744	0.524	0.904	0.179	-0.221
gpt-4.5-preview	0.459	0.727	160.975	0.744	0.617	0.977	0.286	-0.348

Model	MAE	RMSE	MAPE (%)	Human Range	NMAE	NRMSE	Spearman	Delta

PRE vs. POST Aggregate Scores Correlation Across LLMs



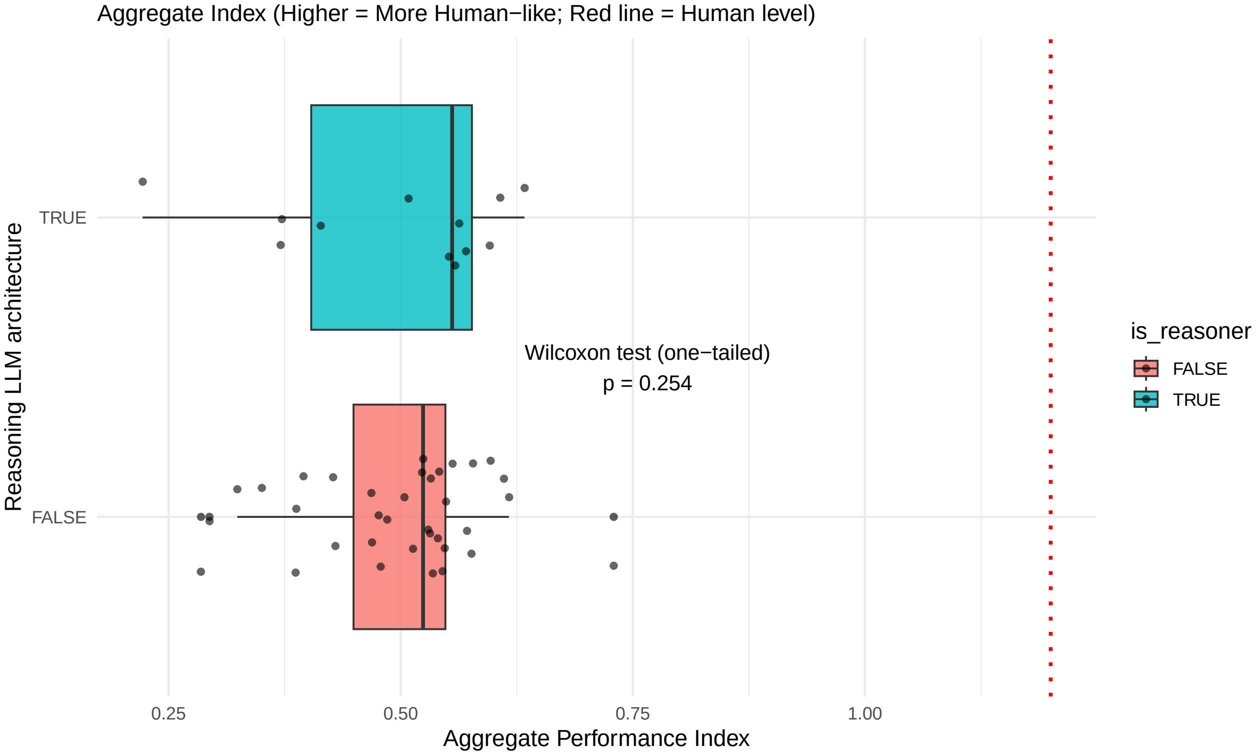
Human-Normalized Performance



LLM Performance by Reasoner Classification

Architecture types:

- Transformer-based models (Vaswani et al. 2017).



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Vaswani, Ashish, Noam Shazeer, Niki Parmar, Jakob Uszkoreit, Llion Jones, Aidan N Gomez, Ł ukasz Kaiser, and Illia Polosukhin. 2017. "Attention Is All You Need." In Curran Associates, Inc. https://papers.nips.cc/paper_files/paper/2017/hash/3f5ee243547dee91fbd053c1c4a845aa-Abstract.html.