

Artificial Phantasia: Evidence for Propositional Reasoning-Based Mental Imagery in Large Language Models

Anonymous Authors

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Summary

This R Markdown document reproduces the analyses reported in [Author Names Removed for Anonymized Peer Review]. *Artificial Phantasia: Evidence for Propositional Reasoning-Based Mental Imagery in Large Language Models*.

Please use the provided Conda environment .yaml file to set up an appropriate R environment to run this R markdown file.

```
llm_data_finke <- read.csv("output_csvs/llm_graded_results_finke.csv")
llm_data_novel <- read.csv("output_csvs/llm_graded_results_novel.csv")
```

```
human_data_finke <- read.csv("output_csvs/h_graded_results_finke.csv")
human_data_novel <- read.csv("output_csvs/h_graded_results_novel.csv")
```

```
llm_data_sc_mc <- read.csv("output_csvs/single_vs_multiple_context_results.csv")
```

```
aphant_data <- read.csv("output_csvs/aphant.csv")
```

```
# Data
```

```
## Finke et al. Tasks - for reasoning models, only the high reasoning conditions
```

```
humans_finke_score <- sum(human_data_finke$overall_score)
```

```
humans_finke_max_score <- sum(human_data_finke$n_total) * 5
```

```
o3_finke_score <- llm_data_finke[llm_data_finke$Model == "OpenAI: o3 - Single Context - High Reasoning (2025-07-21)", "score"]
llm_data_finke[llm_data_finke$Model == "OpenAI: o3 - Single Context - High Reasoning (2025-07-21)", "score"]
llm_data_finke[llm_data_finke$Model == "OpenAI: o3 - Multiple Context - High Reasoning (2025-09-15)", "score"]
o3_finke_max_score <- (12 + 12 + 12) * 5
```

```
o3_images_finke_score <- llm_data_finke[llm_data_finke$Model == "OpenAI: o3 w/ GPT-image-1 - Multiple Context - High Reasoning (2025-07-21)", "score"]
llm_data_finke[llm_data_finke$Model == "OpenAI: o3 w/ GPT-image-1 - Multiple Context - High Reasoning (2025-07-21)", "score"]
llm_data_finke[llm_data_finke$Model == "OpenAI: o3 w/ GPT-image-1 - Multiple Context - High Reasoning (2025-09-15)", "score"]
llm_data_finke[llm_data_finke$Model == "OpenAI: o3 w/ GPT-image-1 - Multiple Context - High Reasoning (2025-09-15)", "score"]
o3_images_finke_max_score <- (12 + 12 + 12 + 12) * 5
```

```
o3_pro_finke_score <- llm_data_finke[llm_data_finke$Model == "OpenAI: o3 Pro - Multiple Context - High Reasoning (2025-07-21)", "score"]
llm_data_finke[llm_data_finke$Model == "OpenAI: o3 Pro - Multiple Context - High Reasoning (2025-07-21)", "score"]
llm_data_finke[llm_data_finke$Model == "OpenAI: o3 Pro - Multiple Context - High Reasoning (2025-09-15)", "score"]
o3_pro_finke_max_score <- (12 + 12 + 12) * 5
```

```
o4_mini_finke_score <- llm_data_finke[llm_data_finke$Model == "OpenAI: o4-mini - Multiple Context - High Reasoning (2025-07-21)", "score"]
llm_data_finke[llm_data_finke$Model == "OpenAI: o4-mini - Single Context - High Reasoning (2025-07-21)", "score"]
```

```

o4_mini_finke_max_score <- (12 + 12) * 5

chatgpt_4o_finke_score <- llm_data_finke[llm_data_finke$Model == "OpenAI: ChatGPT-4o - Multiple Context" |
  llm_data_finke[llm_data_finke$Model == "OpenAI: ChatGPT-4o - Single Context (2025-07-25)", "overall_score"]
chatgpt_4o_finke_max_score <- (12 + 12) * 5

gpt4_1_finke_score <- llm_data_finke[llm_data_finke$Model == "OpenAI: GPT 4.1 - Multiple Context (2025-07-21)" |
  llm_data_finke[llm_data_finke$Model == "OpenAI: GPT 4.1 - Single Context (2025-07-21)", "overall_score"]
gpt4_1_finke_max_score <- (12 + 12) * 5

gpt4_1_images_finke_score <- llm_data_finke[llm_data_finke$Model == "OpenAI: GPT 4.1 w/ GPT-image-1 - Multiple Context (2025-07-21)" |
  llm_data_finke[llm_data_finke$Model == "OpenAI: GPT 4.1 w/ GPT-Image-1 - Single Context (2025-07-21)", "overall_score"]
gpt4_1_images_finke_max_score <- (12 + 12) * 5

gpt5_finke_score <- llm_data_finke[llm_data_finke$Model == "OpenAI: GPT 5 - Multiple Context - High Reasoning (2025-09-15)" |
  llm_data_finke[llm_data_finke$Model == "OpenAI: GPT 5 - Multiple Context - High Reasoning (2025-09-15)", "overall_score"]
gpt5_finke_max_score <- (12 + 12) * 5

gemini2_5_finke_score <- llm_data_finke[llm_data_finke$Model == "DeepMind: Gemini 2.5 Pro - Multiple Context (2025-07-21)" |
  llm_data_finke[llm_data_finke$Model == "DeepMind: Gemini 2.5 Pro - Single Context - Dynamic Thinking (2025-07-21)", "overall_score"]
gemini2_5_finke_max_score <- (12 + 12) * 5

gemini2_0_flash_finke_score <- llm_data_finke[llm_data_finke$Model == "DeepMind: Gemini 2.0 Flash - Multiple Context (2025-07-21)" |
  llm_data_finke[llm_data_finke$Model == "DeepMind: Gemini 2.0 Flash - Single Context (2025-07-21)", "overall_score"]
gemini2_0_flash_finke_max_score <- (12 + 12) * 5

gemini2_0_flash_images_finke_score <- llm_data_finke[llm_data_finke$Model == "DeepMind: Gemini 2.0 Flash - Multiple Context (2025-07-21)" |
  llm_data_finke[llm_data_finke$Model == "DeepMind: Gemini 2.0 Flash - Single Context (2025-07-21)", "overall_score"]
gemini2_0_flash_images_finke_max_score <- (12) * 5

opus4_1_finke_score <- llm_data_finke[llm_data_finke$Model == "Anthropic: Claude Opus 4.1 - Multiple Context (2025-07-21)" |
  llm_data_finke[llm_data_finke$Model == "Anthropic: Claude Opus 4.1 - Single Context (2025-07-21)", "overall_score"]
opus4_1_finke_max_score <- (12) * 5

sonnet4_finke_score <- llm_data_finke[llm_data_finke$Model == "Anthropic: Claude Sonnet 4 - Multiple Context (2025-07-21)" |
  llm_data_finke[llm_data_finke$Model == "Anthropic: Claude Sonnet 4 - Single Context - Extended Thinking (2025-07-21)", "overall_score"]
sonnet4_finke_max_score <- (12 + 12) * 5

## Finke Tasks - Minimal, Low, Medium Reasoning Models
medium_gpt5_finke_score <- llm_data_finke[llm_data_finke$Model == "OpenAI: GPT 5 - Multiple Context - Low Reasoning (2025-09-15)" |
  llm_data_finke[llm_data_finke$Model == "OpenAI: GPT 5 - Multiple Context - Low Reasoning (2025-09-15)", "overall_score"]
medium_gpt5_finke_max_score <- (12) * 5

low_gpt5_finke_score <- llm_data_finke[llm_data_finke$Model == "OpenAI: GPT 5 - Multiple Context - Low Reasoning (2025-09-15)" |
  llm_data_finke[llm_data_finke$Model == "OpenAI: GPT 5 - Multiple Context - Low Reasoning (2025-09-15)", "overall_score"]
low_gpt5_finke_max_score <- (12) * 5

minimal_gpt5_finke_score <- llm_data_finke[llm_data_finke$Model == "OpenAI: GPT 5 - Multiple Context - Low Reasoning (2025-09-15)" |
  llm_data_finke[llm_data_finke$Model == "OpenAI: GPT 5 - Multiple Context - Low Reasoning (2025-09-15)", "overall_score"]
minimal_gpt5_finke_max_score <- (12) * 5

medium_o3_finke_score <- llm_data_finke[llm_data_finke$Model == "OpenAI: o3 - Multiple Context - Medium Reasoning (2025-09-15)" |
  llm_data_finke[llm_data_finke$Model == "OpenAI: o3 - Multiple Context - Medium Reasoning (2025-09-15)", "overall_score"]
medium_o3_finke_max_score <- (12) * 5

low_o3_finke_score <- llm_data_finke[llm_data_finke$Model == "OpenAI: o3 - Multiple Context - Low Reasoning (2025-09-15)" |
  llm_data_finke[llm_data_finke$Model == "OpenAI: o3 - Multiple Context - Low Reasoning (2025-09-15)", "overall_score"]
low_o3_finke_max_score <- (12) * 5

medium_o3_images_finke_score <- llm_data_finke[llm_data_finke$Model == "OpenAI: o3 w/ GPT-image-1 - Multiple Context (2025-09-15)" |
  llm_data_finke[llm_data_finke$Model == "OpenAI: o3 w/ GPT-image-1 - Multiple Context (2025-09-15)", "overall_score"]
medium_o3_images_finke_max_score <- (12) * 5

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medium_o4_mini_finke_score <- llm_data_finke[llm_data_finke$Model == "OpenAI: o4-mini - Multiple Context - High Reasoning (2025-07-21)", "overall_score"]
llm_data_finke[llm_data_finke$Model == "OpenAI: o4-mini - Single Context - Medium Reasoning (2025-07-21)", "overall_score"]
medium_o4_mini_finke_max_score <- (12 + 12) * 5

## Novel 48 Tasks
humans_novel_score <- sum(human_data_novel$overall_score)
humans_novel_max_score <- sum(human_data_novel$n_total) * 5

o3_novel_score <- llm_data_novel[llm_data_novel$Model == "OpenAI: o3 - Single Context - High Reasoning (2025-07-21)", "overall_score"]
llm_data_novel[llm_data_novel$Model == "OpenAI: o3 - Single Context - High Reasoning (2025-07-21)", "overall_score"]
llm_data_novel[llm_data_novel$Model == "OpenAI: o3 - Multiple Context - High Reasoning (2025-09-15)", "overall_score"]
o3_novel_max_score <- (48 + 48 + 48) * 5

o3_images_novel_score <- llm_data_novel[llm_data_novel$Model == "OpenAI: o3 w/ GPT-image-1 - Multiple Context - High Reasoning (2025-07-21)", "overall_score"]
llm_data_novel[llm_data_novel$Model == "OpenAI: o3 w/ GPT-image-1 - Multiple Context - High Reasoning (2025-07-21)", "overall_score"]
llm_data_novel[llm_data_novel$Model == "OpenAI: o3 w/ GPT-image-1 - Multiple Context - High Reasoning (2025-09-15)", "overall_score"]
llm_data_novel[llm_data_novel$Model == "OpenAI: o3 w/ GPT-image-1 - Multiple Context - High Reasoning (2025-09-15)", "overall_score"]
o3_images_novel_max_score <- (48 + 48 + 48 + 48) * 5

o3_pro_novel_score <- llm_data_novel[llm_data_novel$Model == "OpenAI: o3 Pro - Multiple Context - High Reasoning (2025-07-21)", "overall_score"]
llm_data_novel[llm_data_novel$Model == "OpenAI: o3 Pro - Multiple Context - High Reasoning (2025-07-21)", "overall_score"]
llm_data_novel[llm_data_novel$Model == "OpenAI: o3 Pro - Multiple Context - High Reasoning (2025-09-15)", "overall_score"]
o3_pro_novel_max_score <- (48 + 48 + 48) * 5

o4_mini_novel_score <- llm_data_novel[llm_data_novel$Model == "OpenAI: o4-mini - Multiple Context - High Reasoning (2025-07-21)", "overall_score"]
llm_data_novel[llm_data_novel$Model == "OpenAI: o4-mini - Single Context - High Reasoning (2025-07-21)", "overall_score"]
o4_mini_novel_max_score <- (48 + 48) * 5

chatgpt_4o_novel_score <- llm_data_novel[llm_data_novel$Model == "OpenAI: ChatGPT-4o - Multiple Context - High Reasoning (2025-07-25)", "overall_score"]
llm_data_novel[llm_data_novel$Model == "OpenAI: ChatGPT-4o - Single Context (2025-07-25)", "overall_score"]
chatgpt_4o_novel_max_score <- (48 + 48) * 5

gpt4_1_novel_score <- llm_data_novel[llm_data_novel$Model == "OpenAI: GPT 4.1 - Multiple Context (2025-07-21)", "overall_score"]
llm_data_novel[llm_data_novel$Model == "OpenAI: GPT 4.1 - Single Context (2025-07-21)", "overall_score"]
gpt4_1_novel_max_score <- (48 + 48) * 5

gpt4_1_images_novel_score <- llm_data_novel[llm_data_novel$Model == "OpenAI: GPT 4.1 w/ GPT-image-1 - Multiple Context - High Reasoning (2025-07-21)", "overall_score"]
llm_data_novel[llm_data_novel$Model == "OpenAI: GPT 4.1 w/ GPT-Image-1 - Single Context (2025-07-21)", "overall_score"]
gpt4_1_images_novel_max_score <- (48 + 48) * 5

gpt5_novel_score <- llm_data_novel[llm_data_novel$Model == "OpenAI: GPT 5 - Multiple Context - High Reasoning (2025-09-15)", "overall_score"]
llm_data_novel[llm_data_novel$Model == "OpenAI: GPT 5 - Multiple Context - High Reasoning (2025-09-15)", "overall_score"]
gpt5_novel_max_score <- (48 + 48) * 5

gemini2_5_novel_score <- llm_data_novel[llm_data_novel$Model == "DeepMind: Gemini 2.5 Pro - Multiple Context - High Reasoning (2025-07-21)", "overall_score"]
llm_data_novel[llm_data_novel$Model == "DeepMind: Gemini 2.5 Pro - Single Context - Dynamic Thinking (2025-07-21)", "overall_score"]
gemini2_5_novel_max_score <- (48 + 48) * 5

gemini2_0_flash_novel_score <- llm_data_novel[llm_data_novel$Model == "DeepMind: Gemini 2.0 Flash - Multiple Context - High Reasoning (2025-07-21)", "overall_score"]
llm_data_novel[llm_data_novel$Model == "DeepMind: Gemini 2.0 Flash - Single Context (2025-07-21)", "overall_score"]
gemini2_0_flash_novel_max_score <- (48 + 48) * 5

gemini2_0_flash_images_novel_score <- llm_data_novel[llm_data_novel$Model == "DeepMind: Gemini 2.0 Flash - Multiple Context - High Reasoning (2025-07-21)", "overall_score"]
llm_data_novel[llm_data_novel$Model == "DeepMind: Gemini 2.0 Flash - Single Context (2025-07-21)", "overall_score"]
gemini2_0_flash_images_novel_max_score <- (48 + 48) * 5

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gemini2_0_flash_images_novel_max_score <- (48) * 5

opus4_1_novel_score <- llm_data_novel[llm_data_novel$Model == "Anthropic: Claude Opus 4.1 - Multiple Context - Extended Thinking"]
opus4_1_novel_max_score <- (48) * 5

sonnet4_novel_score <- llm_data_novel[llm_data_novel$Model == "Anthropic: Claude Sonnet 4 - Multiple Context - Extended Thinking"]
  llm_data_novel[llm_data_novel$Model == "Anthropic: Claude Sonnet 4 - Single Context - Extended Thinking"]
sonnet4_novel_max_score <- (48 + 48) * 5

## Novel Tasks - Minimal, Low, Medium Reasoning Models
medium_gpt5_novel_score <- llm_data_novel[llm_data_novel$Model == "OpenAI: GPT 5 - Multiple Context - Medium Reasoning"]
medium_gpt5_novel_max_score <- (48) * 5

low_gpt5_novel_score <- llm_data_novel[llm_data_novel$Model == "OpenAI: GPT 5 - Multiple Context - Low Reasoning"]
low_gpt5_novel_max_score <- (48) * 5

minimal_gpt5_novel_score <- llm_data_novel[llm_data_novel$Model == "OpenAI: GPT 5 - Multiple Context - Minimal Reasoning"]
minimal_gpt5_novel_max_score <- (48) * 5

medium_o3_novel_score <- llm_data_novel[llm_data_novel$Model == "OpenAI: o3 - Multiple Context - Medium Reasoning"]
medium_o3_novel_max_score <- (48) * 5

low_o3_novel_score <- llm_data_novel[llm_data_novel$Model == "OpenAI: o3 - Multiple Context - Low Reasoning"]
low_o3_novel_max_score <- (48) * 5

medium_o3_images_novel_score <- llm_data_novel[llm_data_novel$Model == "OpenAI: o3 w/ GPT-image-1 - Multiple Context - Medium Reasoning"]
medium_o3_images_novel_max_score <- (48) * 5

medium_o4_mini_novel_score <- llm_data_novel[llm_data_novel$Model == "OpenAI: o4-mini - Multiple Context - Medium Reasoning (2025-07-05)"]
  llm_data_novel[llm_data_novel$Model == "OpenAI: o4-mini - Single Context - Medium Reasoning (2025-07-05)"]
medium_o4_mini_novel_max_score <- (48 + 48) * 5

o3_collapsed_sc <- llm_data_sc_mc[llm_data_sc_mc$Model == "o3_sc", "overall_score"]
o3_collapsed_sc_max <- (llm_data_sc_mc[llm_data_sc_mc$Model == "o3_sc", "n_total"]) * 5

o3_collapsed_mc <- llm_data_sc_mc[llm_data_sc_mc$Model == "o3_mc", "overall_score"]
o3_collapsed_mc_max <- (llm_data_sc_mc[llm_data_sc_mc$Model == "o3_mc", "n_total"]) * 5

o3_pro_collapsed_sc <- llm_data_sc_mc[llm_data_sc_mc$Model == "o3_pro_sc", "overall_score"]
o3_pro_collapsed_sc_max <- (llm_data_sc_mc[llm_data_sc_mc$Model == "o3_pro_sc", "n_total"]) * 5

o3_pro_collapsed_mc <- llm_data_sc_mc[llm_data_sc_mc$Model == "o3_pro_mc", "overall_score"]
o3_pro_collapsed_mc_max <- (llm_data_sc_mc[llm_data_sc_mc$Model == "o3_pro_mc", "n_total"]) * 5

o4_mini_collapsed_sc <- llm_data_sc_mc[llm_data_sc_mc$Model == "o4_mini_sc", "overall_score"]
o4_mini_collapsed_sc_max <- (llm_data_sc_mc[llm_data_sc_mc$Model == "o4_mini_sc", "n_total"]) * 5

o4_mini_collapsed_mc <- llm_data_sc_mc[llm_data_sc_mc$Model == "o4_mini_mc", "overall_score"]
o4_mini_collapsed_mc_max <- (llm_data_sc_mc[llm_data_sc_mc$Model == "o4_mini_mc", "n_total"]) * 5

sonnet_collapsed_sc <- llm_data_sc_mc[llm_data_sc_mc$Model == "sonnet_sc", "overall_score"]

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sonnet_collapsed_sc_max <- (llm_data_sc_mc[llm_data_sc_mc$Model == "sonnet_sc", "n_total"]) * 5

sonnet_collapsed_mc <- llm_data_sc_mc[llm_data_sc_mc$Model == "sonnet_mc", "overall_score"]
sonnet_collapsed_mc_max <- (llm_data_sc_mc[llm_data_sc_mc$Model == "sonnet_mc", "n_total"]) * 5

gemini2_0_flash_sc <- llm_data_sc_mc[llm_data_sc_mc$Model == "gemini_2.0_flash_sc", "overall_score"]
gemini2_0_flash_sc_max <- (llm_data_sc_mc[llm_data_sc_mc$Model == "gemini_2.0_flash_sc", "n_total"]) * 5

gemini2_0_flash_mc <- llm_data_sc_mc[llm_data_sc_mc$Model == "gemini_2.0_flash_mc", "overall_score"]
gemini2_0_flash_mc_max <- (llm_data_sc_mc[llm_data_sc_mc$Model == "gemini_2.0_flash_mc", "n_total"]) * 5

gemini2_5_pro_sc <- llm_data_sc_mc[llm_data_sc_mc$Model == "gemini_2.5_pro_sc", "overall_score"]
gemini2_5_pro_sc_max <- (llm_data_sc_mc[llm_data_sc_mc$Model == "gemini_2.5_pro_sc", "n_total"]) * 5

gemini2_5_pro_mc <- llm_data_sc_mc[llm_data_sc_mc$Model == "gemini_2.5_pro_mc", "overall_score"]
gemini2_5_pro_mc_max <- (llm_data_sc_mc[llm_data_sc_mc$Model == "gemini_2.5_pro_mc", "n_total"]) * 5

chatgpt4o_collapsed_sc <- llm_data_sc_mc[llm_data_sc_mc$Model == "chatgpt4o_sc", "overall_score"]
chatgpt4o_collapsed_sc_max <- (llm_data_sc_mc[llm_data_sc_mc$Model == "chatgpt4o_sc", "n_total"]) * 5

chatgpt4o_collapsed_mc <- llm_data_sc_mc[llm_data_sc_mc$Model == "chatgpt4o_mc", "overall_score"]
chatgpt4o_collapsed_mc_max <- (llm_data_sc_mc[llm_data_sc_mc$Model == "chatgpt4o_mc", "n_total"]) * 5

gpt4_1_collapsed_sc <- llm_data_sc_mc[llm_data_sc_mc$Model == "gpt4.1_sc", "overall_score"]
gpt4_1_collapsed_sc_max <- (llm_data_sc_mc[llm_data_sc_mc$Model == "gpt4.1_sc", "n_total"]) * 5

gpt4_1_collapsed_mc <- llm_data_sc_mc[llm_data_sc_mc$Model == "gpt4.1_mc", "overall_score"]
gpt4_1_collapsed_mc_max <- (llm_data_sc_mc[llm_data_sc_mc$Model == "gpt4.1_mc", "n_total"]) * 5

gpt_4_1_images_collapsed_sc <- llm_data_sc_mc[llm_data_sc_mc$Model == "gpt4.1_images_sc", "overall_score"]
gpt_4_1_images_collapsed_sc_max <- (llm_data_sc_mc[llm_data_sc_mc$Model == "gpt4.1_images_sc", "n_total"]) * 5

gpt_4_1_images_collapsed_mc <- llm_data_sc_mc[llm_data_sc_mc$Model == "gpt4.1_images_mc", "overall_score"]
gpt_4_1_images_collapsed_mc_max <- (llm_data_sc_mc[llm_data_sc_mc$Model == "gpt4.1_images_mc", "n_total"]) * 5

total_collapsed_sc <- o3_collapsed_sc +
  o3_pro_collapsed_sc +
  o4_mini_collapsed_sc +
  sonnet_collapsed_sc +
  gemini2_0_flash_sc +
  gemini2_5_pro_sc +
  chatgpt4o_collapsed_sc +
  gpt4_1_collapsed_sc +
  gpt_4_1_images_collapsed_sc
total_collapsed_sc_max <- o3_collapsed_sc_max +
  o3_pro_collapsed_sc_max +

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o4_mini_collapsed_sc_max +
sonnet_collapsed_sc_max +
gemini2_0_flash_sc_max +
gemini2_5_pro_sc_max +
chatgpt4o_collapsed_sc_max +
gpt4_1_collapsed_sc_max +
gpt_4_1_images_collapsed_sc_max

total_collapsed_mc <- o3_collapsed_mc +
  o3_pro_collapsed_mc +
  o4_mini_collapsed_mc +
  sonnet_collapsed_mc +
  gemini2_0_flash_mc +
  gemini2_5_pro_mc +
  chatgpt4o_collapsed_mc +
  gpt4_1_collapsed_mc +
  gpt_4_1_images_collapsed_mc
total_collapsed_mc_max <- o3_collapsed_mc_max +
  o3_pro_collapsed_mc_max +
  o4_mini_collapsed_mc_max +
  sonnet_collapsed_mc_max +
  gemini2_0_flash_mc_max +
  gemini2_5_pro_mc_max +
  chatgpt4o_collapsed_mc_max +
  gpt4_1_collapsed_mc_max +
  gpt_4_1_images_collapsed_mc_max

## Collapsed Data (Finke + 48 Novel)
humans_total_score <- humans_finke_score + humans_novel_score
humans_total_max_score <- humans_finke_max_score + humans_novel_max_score

o3_total_score <- o3_finke_score + o3_novel_score
o3_total_max_score <- o3_finke_max_score + o3_novel_max_score

o3_images_total_score <- o3_images_finke_score + o3_images_novel_score
o3_images_total_max_score <- o3_images_finke_max_score + o3_images_novel_max_score

o3_pro_total_score <- o3_pro_finke_score + o3_pro_novel_score
o3_pro_total_max_score <- o3_pro_finke_max_score + o3_pro_novel_max_score

o4_mini_total_score <- o4_mini_finke_score + o4_mini_novel_score
o4_mini_total_max_score <- o4_mini_finke_max_score + o4_mini_novel_max_score

chatgpt_4o_total_score <- chatgpt_4o_finke_score + chatgpt_4o_novel_score
chatgpt_4o_total_max_score <- chatgpt_4o_finke_max_score + chatgpt_4o_novel_max_score

gpt4_1_total_score <- gpt4_1_finke_score + gpt4_1_novel_score
gpt4_1_total_max_score <- gpt4_1_finke_max_score + gpt4_1_novel_max_score

gpt4_1_images_total_score <- gpt4_1_images_finke_score + gpt4_1_images_novel_score
gpt4_1_images_total_max_score <- gpt4_1_images_finke_max_score + gpt4_1_images_novel_max_score

gpt5_total_score <- gpt5_finke_score + gpt5_novel_score
gpt5_total_max_score <- gpt5_finke_max_score + gpt5_novel_max_score

```



```

gemini2_5_total_score <- gemini2_5_finke_score + gemini2_5_novel_score
gemini2_5_total_max_score <- gemini2_5_finke_max_score + gemini2_5_novel_max_score

gemini2_0_flash_total_score <- gemini2_0_flash_finke_score + gemini2_0_flash_novel_score
gemini2_0_flash_total_max_score <- gemini2_0_flash_finke_max_score + gemini2_0_flash_novel_max_score

gemini2_0_flash_images_total_score <- gemini2_0_flash_images_finke_score + gemini2_0_flash_images_novel_score
gemini2_0_flash_images_total_max_score <- gemini2_0_flash_images_finke_max_score + gemini2_0_flash_images_novel_max_score

opus4_1_total_score <- opus4_1_finke_score + opus4_1_novel_score
opus4_1_total_max_score <- opus4_1_finke_max_score + opus4_1_novel_max_score

sonnet4_total_score <- sonnet4_finke_score + sonnet4_novel_score
sonnet4_total_max_score <- sonnet4_finke_max_score + sonnet4_novel_max_score

## Original Finke Data - modified towards the new scoring system
original_finke_exp2_correct <- 37 * 5 + 72 - 37
original_finke_exp2_total <- 72 * 5

original_finke_exp3_correct <- 28 * 5 + 72 - 28
original_finke_exp3_total <- 72 * 5

# Collapsed Original Finke (Exp 2 + Exp 3)
original_finke_correct <- original_finke_exp2_correct + original_finke_exp3_correct
original_finke_total <- original_finke_exp2_total + original_finke_exp3_total

## Collapsed Data - Minimal, Low, Medium Reasoning Models
medium_gpt5_total_score <- medium_gpt5_finke_score + medium_gpt5_novel_score
medium_gpt5_total_max_score <- medium_gpt5_finke_max_score + medium_gpt5_novel_max_score

low_gpt5_total_score <- low_gpt5_finke_score + low_gpt5_novel_score
low_gpt5_total_max_score <- low_gpt5_finke_max_score + low_gpt5_novel_max_score

minimal_gpt5_total_score <- minimal_gpt5_finke_score + minimal_gpt5_novel_score
minimal_gpt5_total_max_score <- minimal_gpt5_finke_max_score + minimal_gpt5_novel_max_score

medium_o3_total_score <- medium_o3_finke_score + medium_o3_novel_score
medium_o3_total_max_score <- medium_o3_finke_max_score + medium_o3_novel_max_score

low_o3_total_score <- low_o3_finke_score + low_o3_novel_score
low_o3_total_max_score <- low_o3_finke_max_score + low_o3_novel_max_score

medium_o3_images_total_score <- medium_o3_images_finke_score + medium_o3_images_novel_score
medium_o3_images_total_max_score <- medium_o3_images_finke_max_score + medium_o3_images_novel_max_score

medium_o4_mini_total_score <- medium_o4_mini_finke_score + medium_o4_mini_novel_score
medium_o4_mini_total_max_score <- medium_o4_mini_finke_max_score + medium_o4_mini_novel_max_score

aphant_total_score <- as.numeric(aphant_data["overall_score"])
aphant_total_max_score <- as.numeric(aphant_data["n_total"]) * 5

# Create data frames for easier manipulation
sc_mc_data <- data.frame(

```

```

model = c("o3-SC", "o3-MC",
          "o3-Pro-SC", "o3-Pro-MC",
          "o4-mini-SC", "o4-mini-MC",
          "Sonnet-4-SC", "Sonnet-4-MC",
          "Gemini-2.0-Flash-SC", "Gemini-2.0-Flash-MC",
          "Gemini-2.5-Pro-SC", "Gemini-2.5-Pro-MC",
          "ChatGPT-4o-SC", "ChatGPT-4o-MC",
          "GPT-4.1-SC", "GPT-4.1-MC",
          "GPT-4.1-GPT-Image-SC", "GPT-4.1-GPT-Image-MC"),
score = c(o3_collapsed_sc, o3_collapsed_mc,
          o3_pro_collapsed_sc, o3_pro_collapsed_mc,
          o4_mini_collapsed_sc, o4_mini_collapsed_mc,
          sonnet_collapsed_sc, sonnet_collapsed_mc,
          gemini2_0_flash_sc, gemini2_0_flash_mc,
          gemini2_5_pro_sc, gemini2_5_pro_mc,
          chatgpt4o_collapsed_sc, chatgpt4o_collapsed_mc,
          gpt4_1_collapsed_sc, gpt4_1_collapsed_mc,
          gpt_4_1_images_collapsed_sc, gpt_4_1_images_collapsed_mc),
max_score = c(o3_collapsed_sc_max, o3_collapsed_mc_max,
              o3_pro_collapsed_sc_max, o3_pro_collapsed_mc_max,
              o4_mini_collapsed_sc_max, o4_mini_collapsed_mc_max,
              sonnet_collapsed_sc_max, sonnet_collapsed_mc_max,
              gemini2_0_flash_sc_max, gemini2_0_flash_mc_max,
              gemini2_5_pro_sc_max, gemini2_5_pro_mc_max,
              chatgpt4o_collapsed_sc_max, chatgpt4o_collapsed_mc_max,
              gpt4_1_collapsed_sc_max, gpt4_1_collapsed_mc_max,
              gpt_4_1_images_collapsed_sc_max, gpt_4_1_images_collapsed_mc_max),
color = c("#fc8d62", "#fc8d62",
          "#fc8d62", "#fc8d62",
          "#fc8d62", "#fc8d62",
          "#e78ac3", "#e78ac3",
          "#8da0cb", "#8da0cb",
          "#8da0cb", "#8da0cb",
          "#fc8d62", "#fc8d62",
          "#fc8d62", "#fc8d62",
          "#fc8d62", "#fc8d62"),

shape = c(16, 18,
          16, 18,
          16, 18,
          16, 18,
          16, 18,
          16, 18,
          16, 18,
          16, 18,
          16, 18)

)

# Calculate proportions from correct/total
sc_mc_data$proportion <- sc_mc_data$score / sc_mc_data$max_score

# Create data frames for easier manipulation
finke_data <- data.frame(
  model = c("Humans", "o3", "o3-GPT-Image",
            "o3-Pro", "GPT-4.1", "GPT-4.1-GPT-Image",

```



```

    "ChatGPT-4o", "o4-mini", "Gemini-2.5",
    "Gemini-2.0-Flash", "Gemini-2.0-Flash-Images",
    "Sonnet-4", "Opus-4.1", "GPT-5"),
score = c(humans_finke_score, o3_finke_score, o3_images_finke_score,
o3_pro_finke_score, gpt4_1_finke_score, gpt4_1_images_finke_score,
chatgpt_4o_finke_score, o4_mini_finke_score, gemini2_5_finke_score,
gemini2_0_flash_finke_score, gemini2_0_flash_images_finke_score,
sonnet4_finke_score, opus4_1_finke_score, gpt5_finke_score),
max_score = c(humans_finke_max_score, o3_finke_max_score, o3_images_finke_max_score,
o3_pro_finke_max_score, gpt4_1_finke_max_score, gpt4_1_images_finke_max_score,
chatgpt_4o_finke_max_score, o4_mini_finke_max_score, gemini2_5_finke_max_score,
gemini2_0_flash_finke_max_score, gemini2_0_flash_images_finke_max_score,
sonnet4_finke_max_score, opus4_1_finke_max_score, gpt5_finke_max_score),
color = c("#66c2a5", "#fc8d62", "#fc8d62",
"#fc8d62", "#fc8d62", "#fc8d62",
"#fc8d62", "#fc8d62", "#8da0cb",
"#8da0cb", "#8da0cb", "#e78ac3", "#e78ac3", "#fc8d62")

# human #66c2a5
# openai #fc8d62
# gemini #8da0cb
# claude #e78ac3
)

# Calculate proportions from correct/total
finke_data$proportion <- finke_data$score / finke_data$max_score

novel_data <- data.frame(
  model = c("Humans", "o3", "o3-GPT-Image",
    "o3-Pro", "GPT-4.1", "GPT-4.1-GPT-Image",
    "ChatGPT-4o", "o4-mini", "Gemini-2.5",
    "Gemini-2.0-Flash", "Gemini-2.0-Flash-Images",
    "Sonnet-4", "Opus-4.1", "GPT-5"),
  score = c(humans_novel_score, o3_novel_score, o3_images_novel_score,
o3_pro_novel_score, gpt4_1_novel_score, gpt4_1_images_novel_score,
chatgpt_4o_novel_score, o4_mini_novel_score, gemini2_5_novel_score,
gemini2_0_flash_novel_score, gemini2_0_flash_images_novel_score,
sonnet4_novel_score, opus4_1_novel_score, gpt5_novel_score),
  max_score = c(humans_novel_max_score, o3_novel_max_score, o3_images_novel_max_score,
o3_pro_novel_max_score, gpt4_1_novel_max_score, gpt4_1_images_novel_max_score,
chatgpt_4o_novel_max_score, o4_mini_novel_max_score, gemini2_5_novel_max_score,
gemini2_0_flash_novel_max_score, gemini2_0_flash_images_novel_max_score,
sonnet4_novel_max_score, opus4_1_novel_max_score, gpt5_novel_max_score),
  color = c("#66c2a5", "#fc8d62", "#fc8d62",
"#fc8d62", "#fc8d62", "#fc8d62",
"#fc8d62", "#fc8d62", "#8da0cb",
"#8da0cb", "#8da0cb", "#e78ac3", "#e78ac3", "#fc8d62")
)

# Calculate proportions from correct/total
novel_data$proportion <- novel_data$score / novel_data$max_score

```

```

collapsed_data <- data.frame(
  model = c("Humans", "o3", "o3-GPT-Image",
            "o3-Pro", "GPT-4.1", "GPT-4.1-GPT-Image",
            "ChatGPT-4o", "o4-mini", "Gemini-2.5",
            "Gemini-2.0-Flash", "Gemini-2.0-Flash-Images",
            "Sonnet-4", "Opus-4.1", "GPT-5"),
  score = c(humans_total_score, o3_total_score, o3_images_total_score,
            o3_pro_total_score, gpt4_1_total_score, gpt4_1_images_total_score,
            chatgpt_4o_total_score, o4_mini_total_score, gemini2_5_total_score,
            gemini2_0_flash_total_score, gemini2_0_flash_images_total_score,
            sonnet4_total_score, opus4_1_total_score, gpt5_total_score),
  max_score = c(humans_total_max_score, o3_total_max_score, o3_images_total_max_score,
                o3_pro_total_max_score, gpt4_1_total_max_score, gpt4_1_images_total_max_score,
                chatgpt_4o_total_max_score, o4_mini_total_max_score, gemini2_5_total_max_score,
                gemini2_0_flash_total_max_score, gemini2_0_flash_images_total_max_score,
                sonnet4_total_max_score, opus4_1_total_max_score, gpt5_total_max_score),
  color = c("#66c2a5", "#fc8d62", "#fc8d62",
            "#fc8d62", "#fc8d62", "#fc8d62",
            "#fc8d62", "#fc8d62", "#8da0cb",
            "#8da0cb", "#8da0cb", "#e78ac3", "#e78ac3", "#fc8d62")
)

# Calculate proportions from correct/total
collapsed_data$proportion <- collapsed_data$score / collapsed_data$max_score

```

Set-up Data for Reasoning Variations

```

# Prepare data for reasoning variations analysis
finke_reasoning_data <- data.frame(
  model = c("Humans", "o3-High", "o3-Medium",
            "o3-Low", "GPT-5-High", "o3-Pro",
            "GPT-5-Medium", "GPT-5-Low", "GPT-5-Minimal",
            "o4-mini-High", "o4-mini-Medium", "o3-GPT-Image-High",
            "o3-GPT-Image-Medium"),
  score = c(humans_finke_score, o3_finke_score, medium_o3_finke_score,
            low_o3_finke_score, gpt5_finke_score, o3_pro_finke_score,
            medium_gpt5_finke_score, low_gpt5_finke_score, minimal_gpt5_finke_score,
            o4_mini_finke_score, medium_o4_mini_finke_score, o3_images_finke_score,
            medium_o3_images_finke_score),
  max_score = c(humans_finke_max_score, o3_finke_max_score, medium_o3_finke_max_score,
                low_o3_finke_max_score, gpt5_finke_max_score, o3_pro_finke_max_score,
                medium_gpt5_finke_max_score, low_gpt5_finke_max_score,
                minimal_gpt5_finke_max_score, o4_mini_finke_max_score, medium_o4_mini_finke_max_score,
                medium_o3_images_finke_max_score),
  color = c("#66c2a5", "#980043", "#dd1c77",
            "#df65b0", "#980043", "#980043",
            "#dd1c77", "#df65b0",
            "#d7b5d8", "#980043", "#dd1c77", "#980043", "#dd1c77")
)

# Calculate proportions from score/max_score
finke_reasoning_data$proportion <- finke_reasoning_data$score / finke_reasoning_data$max_score

```

```

novel_reasoning_data <- data.frame(
  model = c("Humans", "o3-High", "o3-Medium",
            "o3-Low", 'GPT-5-High', 'o3-Pro',
            "GPT-5-Medium", "GPT-5-Low", "GPT-5-Minimal",
            "o4-mini-High", "o4-mini-Medium", "o3-GPT-Image-High",
            "o3-GPT-Image-Medium"),
  score = c(humans_novel_score, o3_novel_score, medium_o3_novel_score,
            low_o3_novel_score,
            gpt5_novel_score, medium_gpt5_novel_score, o3_pro_novel_score, low_gpt5_novel_score,
            minimal_gpt5_novel_score, o4_mini_novel_score, medium_o4_mini_novel_score,
            o3_images_novel_score, medium_o3_images_novel_score),
  max_score = c(humans_novel_max_score, o3_novel_max_score, medium_o3_novel_max_score,
                low_o3_novel_max_score,
                gpt5_novel_max_score, medium_gpt5_novel_max_score, o3_pro_novel_max_score, low_gpt5_novel_max_score,
                minimal_gpt5_novel_max_score, o4_mini_novel_max_score, medium_o4_mini_novel_max_score,
                o3_images_novel_max_score, medium_o3_images_novel_max_score),
  color = c("#66c2a5", "#980043", "#dd1c77",
            "#df65b0", "#980043", "#980043",
            "#dd1c77", "#df65b0",
            "#d7b5d8", "#980043", "#dd1c77", "#980043", "#dd1c77")
)
# Calculate proportions from score/max_score
novel_reasoning_data$proportion <- novel_reasoning_data$score / novel_reasoning_data$max_score

collapsed_reasoning_data <- data.frame(
  model = c("Humans", "o3-High", "o3-Medium",
            "o3-Low", 'GPT-5-High', 'o3-Pro',
            "GPT-5-Medium", "GPT-5-Low", "GPT-5-Minimal",
            "o4-mini-High", "o4-mini-Medium", "o3-GPT-Image-High",
            "o3-GPT-Image-Medium"),
  score = c(humans_total_score, o3_total_score, medium_o3_total_score,
            low_o3_total_score,
            gpt5_total_score, o3_pro_total_score, medium_gpt5_total_score, low_gpt5_total_score,
            minimal_gpt5_total_score, o4_mini_total_score, medium_o4_mini_total_score,
            o3_images_total_score, medium_o3_images_total_score),
  max_score = c(humans_total_max_score, o3_total_max_score, medium_o3_total_max_score,
                low_o3_total_max_score,
                gpt5_total_max_score, o3_pro_total_max_score, medium_gpt5_total_max_score, low_gpt5_total_max_score,
                minimal_gpt5_total_max_score, o4_mini_total_max_score, medium_o4_mini_total_max_score,
                o3_images_total_max_score, medium_o3_images_total_max_score),
  color = c("#66c2a5", "#980043", "#dd1c77",
            "#df65b0", "#980043", "#980043",
            "#dd1c77", "#df65b0",
            "#d7b5d8", "#980043", "#dd1c77", "#980043", "#dd1c77")
)
# Calculate proportions from score/max_score
collapsed_reasoning_data$proportion <- collapsed_reasoning_data$score / collapsed_reasoning_data$max_score

aphant_collapsed_data <- data.frame(
  model = c("Aphant", "Humans", "o3", "o3-GPT-Image",
            "o3-Pro", "GPT-4.1", "GPT-4.1-GPT-Image",
            "ChatGPT-4o", "o4-mini", "Gemini-2.5",
            "Gemini-2.0-Flash", "Gemini-2.0-Flash-Images",
            "Sonnet-4", "Opus-4.1", "GPT-5"),

```

```

score = c(aphant_total_score, humans_total_score, o3_total_score, o3_images_total_score,
o3_pro_total_score, gpt4_1_total_score, gpt4_1_images_total_score,
chatgpt_4o_total_score, o4_mini_total_score, gemini2_5_total_score,
gemini2_0_flash_total_score, gemini2_0_flash_images_total_score,
sonnet4_total_score, opus4_1_total_score, gpt5_total_score),
max_score = c(aphant_total_max_score, humans_total_max_score, o3_total_max_score, o3_images_total_max_score,
o3_pro_total_max_score, gpt4_1_total_max_score, gpt4_1_images_total_max_score,
chatgpt_4o_total_max_score, o4_mini_total_max_score, gemini2_5_total_max_score,
gemini2_0_flash_total_max_score, gemini2_0_flash_images_total_max_score,
sonnet4_total_max_score, opus4_1_total_max_score, gpt5_total_max_score),
color = c("#ccccff", "#66c2a5", "#fc8d62", "#fc8d62",
"#fc8d62", "#fc8d62", "#fc8d62", "#fc8d62",
"#fc8d62", "#fc8d62", "#8da0cb",
"#8da0cb", "#8da0cb", "#e78ac3", "#e78ac3", "#fc8d62")
)
# Calculate proportions from correct/total
aphant_collapsed_data$proportion <- aphant_collapsed_data$score / aphant_collapsed_data$max_score

```

```

# Display the data
cat("Finke et al. Tasks Data:\n")

```

```
## Finke et al. Tasks Data:
```

```
print(finke_data)
```

##	model	score	max_score	color	proportion
## 1	Humans	961.09643	1525	#66c2a5	0.6302272
## 2	o3	109.90000	180	#fc8d62	0.6105556
## 3	o3-GPT-Image	134.48333	240	#fc8d62	0.5603472
## 4	o3-Pro	138.90833	180	#fc8d62	0.7717130
## 5	GPT-4.1	56.40714	120	#fc8d62	0.4700595
## 6	GPT-4.1-GPT-Image	41.00000	120	#fc8d62	0.3416667
## 7	ChatGPT-4o	48.98095	120	#fc8d62	0.4081746
## 8	o4-mini	63.00833	120	#fc8d62	0.5250694
## 9	Gemini-2.5	61.12500	120	#8da0cb	0.5093750
## 10	Gemini-2.0-Flash	41.10000	120	#8da0cb	0.3425000
## 11	Gemini-2.0-Flash-Images	20.53810	60	#8da0cb	0.3423016
## 12	Sonnet-4	54.65238	120	#e78ac3	0.4554365
## 13	Opus-4.1	44.46667	60	#e78ac3	0.7411111
## 14	GPT-5	91.95000	120	#fc8d62	0.7662500

```
cat("\n48 Novel Tasks Data:\n")
```

```
##
```

```
## 48 Novel Tasks Data:
```

```
print(novel_data)
```

##	model	score	max_score	color	proportion
## 1	Humans	3137.12024	5965	#66c2a5	0.5259212
## 2	o3	467.49048	720	#fc8d62	0.6492923
## 3	o3-GPT-Image	529.69881	960	#fc8d62	0.5517696
## 4	o3-Pro	460.71310	720	#fc8d62	0.6398793
## 5	GPT-4.1	198.45476	480	#fc8d62	0.4134474
## 6	GPT-4.1-GPT-Image	188.82738	480	#fc8d62	0.3933904
## 7	ChatGPT-4o	202.76786	480	#fc8d62	0.4224330

```
## 8          o4-mini 255.12262      480 #fc8d62 0.5315055
## 9          Gemini-2.5 215.94881      480 #8da0cb 0.4498934
## 10         Gemini-2.0-Flash 186.88214      480 #8da0cb 0.3893378
## 11 Gemini-2.0-Flash-Images 78.80714      240 #8da0cb 0.3283631
## 12          Sonnet-4 195.48810      480 #e78ac3 0.4072669
## 13          Opus-4.1 114.35238      240 #e78ac3 0.4764683
## 14          GPT-5 309.87262      480 #fc8d62 0.6455680
```

```
cat("\nCollapsed Data (Finke + 48 Novel Tasks):\n")
```

```
##
```

```
## Collapsed Data (Finke + 48 Novel Tasks):
```

```
print(collapsed_data)
```

```
##          model      score max_score  color proportion
## 1          Humans 4098.21667      7490 #66c2a5 0.5471584
## 2              o3  577.39048        900 #fc8d62 0.6415450
## 3      o3-GPT-Image 664.18214      1200 #fc8d62 0.5534851
## 4          o3-Pro 599.62143        900 #fc8d62 0.6662460
## 5          GPT-4.1 254.86190        600 #fc8d62 0.4247698
## 6      GPT-4.1-GPT-Image 229.82738        600 #fc8d62 0.3830456
## 7      ChatGPT-4o 251.74881        600 #fc8d62 0.4195813
## 8          o4-mini 318.13095        600 #fc8d62 0.5302183
## 9          Gemini-2.5 277.07381        600 #8da0cb 0.4617897
## 10         Gemini-2.0-Flash 227.98214        600 #8da0cb 0.3799702
## 11 Gemini-2.0-Flash-Images 99.34524        300 #8da0cb 0.3311508
## 12          Sonnet-4 250.14048        600 #e78ac3 0.4169008
## 13          Opus-4.1 158.81905        300 #e78ac3 0.5293968
## 14          GPT-5 401.82262        600 #fc8d62 0.6697044
```

```
# Display Original Finke data
```

```
cat("\n\nOriginal Finke Data:\n")
```

```
##
```

```
##
```

```
## Original Finke Data:
```

```
cat("Exp 2: ", original_finke_exp2_correct, "/", original_finke_exp2_total, " (", round(original_finke_
```

```
## Exp 2: 220/360 (0.611)
```

```
cat("Exp 3: ", original_finke_exp3_correct, "/", original_finke_exp3_total, " (", round(original_finke_
```

```
## Exp 3: 184/360 (0.511)
```

```
cat("Collapsed Original Finke: ", original_finke_correct, "/", original_finke_total, " (", round(origin
```

```
## Collapsed Original Finke: 404/720 (0.561)
```

```
# Display the reasoning variation data
```

```
cat("\n\nFinke et al. Tasks - Reasoning Variations Data:\n")
```

```
##
```

```
##
```

```
## Finke et al. Tasks - Reasoning Variations Data:
```

```
print(finke_reasoning_data)
```

```
##          model      score max_score  color proportion
```

```
## 1          Humans 961.09643      1525 #66c2a5 0.6302272
## 2          o3-High 109.90000      180 #980043 0.6105556
## 3          o3-Medium 34.41667      60 #dd1c77 0.5736111
## 4          o3-Low 37.38333      60 #df65b0 0.6230556
## 5          GPT-5-High 91.95000     120 #980043 0.7662500
## 6          o3-Pro 138.90833      180 #980043 0.7717130
## 7          GPT-5-Medium 38.00833    60 #dd1c77 0.6334722
## 8          GPT-5-Low 33.35833    60 #df65b0 0.5559722
## 9          GPT-5-Minimal 21.93452   60 #d7b5d8 0.3655754
## 10         o4-mini-High 63.00833    120 #980043 0.5250694
## 11         o4-mini-Medium 56.02500   120 #dd1c77 0.4668750
## 12         o3-GPT-Image-High 134.48333 240 #980043 0.5603472
## 13         o3-GPT-Image-Medium 30.33810 60 #dd1c77 0.5056349
```

```
cat("\n48 Novel Tasks - Reasoning Variations Data:\n")
```

```
##
```

```
## 48 Novel Tasks - Reasoning Variations Data:
```

```
print(novel_reasoning_data)
```

```
##          model      score max_score  color proportion
## 1          Humans 3137.1202      5965 #66c2a5 0.5259212
## 2          o3-High 467.4905       720 #980043 0.6492923
## 3          o3-Medium 134.8440      240 #dd1c77 0.5618502
## 4          o3-Low 124.4119      240 #df65b0 0.5183829
## 5          GPT-5-High 309.8726     480 #980043 0.6455680
## 6          o3-Pro 140.3917      240 #980043 0.5849653
## 7          GPT-5-Medium 460.7131    720 #dd1c77 0.6398793
## 8          GPT-5-Low 118.2940     240 #df65b0 0.4928919
## 9          GPT-5-Minimal 100.2702   240 #d7b5d8 0.4177927
## 10         o4-mini-High 255.1226    480 #980043 0.5315055
## 11         o4-mini-Medium 237.6810   480 #dd1c77 0.4951687
## 12         o3-GPT-Image-High 529.6988 960 #980043 0.5517696
## 13         o3-GPT-Image-Medium 134.2131 240 #dd1c77 0.5592212
```

```
cat("\nCollapsed Data (Finke + 48 Novel Tasks) - Reasoning Variations Data:\n")
```

```
##
```

```
## Collapsed Data (Finke + 48 Novel Tasks) - Reasoning Variations Data:
```

```
print(collapsed_reasoning_data)
```

```
##          model      score max_score  color proportion
## 1          Humans 4098.2167      7490 #66c2a5 0.5471584
## 2          o3-High 577.3905       900 #980043 0.6415450
## 3          o3-Medium 169.2607      300 #dd1c77 0.5642024
## 4          o3-Low 161.7952      300 #df65b0 0.5393175
## 5          GPT-5-High 401.8226     600 #980043 0.6697044
## 6          o3-Pro 599.6214       900 #980043 0.6662460
## 7          GPT-5-Medium 178.4000    300 #dd1c77 0.5946667
## 8          GPT-5-Low 151.6524     300 #df65b0 0.5055079
## 9          GPT-5-Minimal 122.2048   300 #d7b5d8 0.4073492
## 10         o4-mini-High 318.1310    600 #980043 0.5302183
## 11         o4-mini-Medium 293.7060   600 #dd1c77 0.4895099
## 12         o3-GPT-Image-High 664.1821 1200 #980043 0.5534851
## 13         o3-GPT-Image-Medium 164.5512 300 #dd1c77 0.5485040
```

Proportion Testing Function

```
# Function to perform proportion test and extract results
perform_prop_test <- function(model1_name, model1_correct, model1_total,
                              model2_name, model2_correct, model2_total) {

  # Perform the test
  test_result <- prop.test(x = c(model1_correct, model2_correct),
                           n = c(model1_total, model2_total),
                           alternative = "two.sided",
                           conf.level = 0.95,
                           correct = TRUE)

  # Calculate proportions
  prop1 <- model1_correct / model1_total
  prop2 <- model2_correct / model2_total
  diff <- prop1 - prop2

  # Return results as a list
  return(list(
    comparison = paste(model1_name, "vs", model2_name),
    model1 = model1_name,
    model2 = model2_name,
    prop1 = prop1,
    prop2 = prop2,
    diff = diff,
    chi_squared = test_result$statistic,
    df = test_result$parameter,
    p_value = test_result$p.value,
    ci_lower = test_result$conf.int[1],
    ci_upper = test_result$conf.int[2],
    significant = test_result$p.value < 0.05
  ))
}

# Function to test all combinations
test_all_combinations <- function(data, task_name) {
  results <- list()
  counter <- 1

  # Test all unique pairs
  for (i in 1:(nrow(data) - 1)) {
    for (j in (i + 1):nrow(data)) {
      results[[counter]] <- perform_prop_test(
        data$model[i], data$score[i], data$max_score[i],
        data$model[j], data$score[j], data$max_score[j]
      )
      counter <- counter + 1
    }
  }

  # Convert to data frame
  results_df <- do.call(rbind, lapply(results, as.data.frame))
  results_df$task <- task_name
}
```



```

    return(results_df)
}

```

Comparison: Current Human Finke vs Original Finke

```

##
##
## Comparison: Current Human Finke vs Original Finke (Collapsed Exp 2 + Exp 3)
## =====
## Current Human Finke: 961.0964/1525 (0.63)
## Original Finke: 404/720 (0.561)
## Difference: 0.069
## Chi-squared: 9.516
## P-value: 0.002037
## 95% CI: [ 0.024 , 0.114 ]
## Significant: YES (p < 0.05)
##
##
## Detailed Comparison: Current Humans vs Original Finke
## -----
## Proportions: 0.63 vs 0.561
## Difference: 0.069
## Chi-squared: 9.516
## Degrees of freedom: 1
## P-value: 0.002037
## 95% CI: [ 0.024 , 0.114 ]
## Significant: YES (p < 0.05)
##
##
## Summary Table - Human vs Original Finke:
##
##
## comparison                diff    p_value  significant
## -----
## Current Humans vs Original Finke  0.069    0.002    TRUE

```

Comparison: Current Human 48 vs Original Finke

```

##
##
## Comparison: Current Human 48-Item Task vs Original Finke (Collapsed Exp 2 + Exp 3)
## =====
## Current Human 48: 3137.12/5965 (0.526)

```

```

## Original Finke: 404/720 (0.561)
## Difference: -0.035
## Chi-squared: 3.054
## P-value: 0.08055
## 95% CI: [ -0.074 , 0.004 ]
## Significant: NO
##
##
## Detailed Comparison: Current Humans vs Original Finke
## -----
## Proportions: 0.526 vs 0.561
## Difference: -0.035
## Chi-squared: 3.054
## Degrees of freedom: 1
## P-value: 0.08055
## 95% CI: [ -0.074 , 0.004 ]
## Significant: NO
##
##
## Summary Table - Human vs Original Finke:
##
##
## comparison                diff    p_value  significant
## -----
## Current Humans vs Original Finke  -0.035    0.0805  FALSE

```

Comparison: Current Humans (collapsed) vs Original Finke

```

##
##
## Comparison: Current Human 48-Item Task vs Original Finke (Collapsed Exp 2 + Exp 3)
## =====
## Current Human Finke: 4098.217/7490 (0.547)
## Original Finke: 404/720 (0.561)
## Difference: -0.014
## Chi-squared: 0.462
## P-value: 0.4969
## 95% CI: [ -0.053 , 0.025 ]
## Significant: NO
##
##
## Detailed Comparison: Current Humans vs Original Finke

```

```
## -----
## Proportions: 0.547 vs 0.561
## Difference: -0.014
## Chi-squared: 0.462
## Degrees of freedom: 1
## P-value: 0.4969
## 95% CI: [ -0.053 , 0.025 ]
## Significant: NO
##
##
## Summary Table - Current Human (Collapsed) vs Original Finke:
##
##
## comparison diff p_value significant
## -----
## Current Humans (collapsed) vs Original Finke -0.014 0.4969 FALSE
```

Aphant vs Humans and Models - All Pairwise Comparisons

```
# Test all combinations for Aphant vs Humans and Models (results not included in paper)
aphant_results <- test_all_combinations(aphant_collapsed_data, "Aphant vs Humans and Models")
# Display results
cat("All Pairwise Comparisons for Aphant vs Humans and Models:\n")
```

```
## All Pairwise Comparisons for Aphant vs Humans and Models:
```

```
cat(paste(rep("=", 80), collapse = ""), "\n")
```

```
## =====
for (i in 1:nrow(aphant_results)) {
  cat("\n", aphant_results$comparison[i], "\n")
  cat(paste(rep("-", 40), collapse = ""), "\n")
  cat("Proportions: ", round(aphant_results$prop1[i], 3), " vs ",
      round(aphant_results$prop2[i], 3), "\n")
  cat("Difference: ", round(aphant_results$diff[i], 3), "\n")
  cat("Chi-squared: ", round(aphant_results$chi_squared[i], 3), "\n")
  cat("Degrees of freedom: ", round(aphant_results$df[i], 3), "\n")
  cat("P-value: ", format(aphant_results$p_value[i], scientific = FALSE, digits = 4), "\n")
  cat("95% CI: [", round(aphant_results$ci_lower[i], 3), ", ",
      round(aphant_results$ci_upper[i], 3), "]\n")
  cat("Significant: ", ifelse(aphant_results$significant[i], "YES (p < 0.05)", "NO"), "\n")
}
```

```
##
## Aphant vs Humans
## -----
## Proportions: 0.79 vs 0.547
## Difference: 0.243
## Chi-squared: 16.709
## Degrees of freedom: 1
```

```

## P-value: 0.00004357
## 95% CI: [ 0.143 , 0.342 ]
## Significant: YES (p < 0.05)
##
## Aphant vs o3
## -----
## Proportions: 0.79 vs 0.642
## Difference: 0.148
## Chi-squared: 6.086
## Degrees of freedom: 1
## P-value: 0.01363
## 95% CI: [ 0.044 , 0.253 ]
## Significant: YES (p < 0.05)
##
## Aphant vs o3-GPT-Image
## -----
## Proportions: 0.79 vs 0.553
## Difference: 0.236
## Chi-squared: 15.125
## Degrees of freedom: 1
## P-value: 0.0001006
## 95% CI: [ 0.133 , 0.34 ]
## Significant: YES (p < 0.05)
##
## Aphant vs o3-Pro
## -----
## Proportions: 0.79 vs 0.666
## Difference: 0.124
## Chi-squared: 4.284
## Degrees of freedom: 1
## P-value: 0.03848
## 95% CI: [ 0.019 , 0.228 ]
## Significant: YES (p < 0.05)
##
## Aphant vs GPT-4.1
## -----
## Proportions: 0.79 vs 0.425
## Difference: 0.365
## Chi-squared: 34.272
## Degrees of freedom: 1
## P-value: 0.000000004792
## 95% CI: [ 0.257 , 0.473 ]
## Significant: YES (p < 0.05)
##
## Aphant vs GPT-4.1-GPT-Image
## -----
## Proportions: 0.79 vs 0.383
## Difference: 0.407
## Chi-squared: 43.424
## Degrees of freedom: 1
## P-value: 0.0000000004407
## 95% CI: [ 0.299 , 0.514 ]
## Significant: YES (p < 0.05)
##

```

```

## Aphant vs ChatGPT-4o
## -----
## Proportions: 0.79 vs 0.42
## Difference: 0.37
## Chi-squared: 35.322
## Degrees of freedom: 1
## P-value: 0.000000002794
## 95% CI: [ 0.263 , 0.478 ]
## Significant: YES (p < 0.05)
##
## Aphant vs o4-mini
## -----
## Proportions: 0.79 vs 0.53
## Difference: 0.26
## Chi-squared: 17.2
## Degrees of freedom: 1
## P-value: 0.00003365
## 95% CI: [ 0.152 , 0.368 ]
## Significant: YES (p < 0.05)
##
## Aphant vs Gemini-2.5
## -----
## Proportions: 0.79 vs 0.462
## Difference: 0.328
## Chi-squared: 27.412
## Degrees of freedom: 1
## P-value: 0.0000001644
## 95% CI: [ 0.22 , 0.436 ]
## Significant: YES (p < 0.05)
##
## Aphant vs Gemini-2.0-Flash
## -----
## Proportions: 0.79 vs 0.38
## Difference: 0.41
## Chi-squared: 44.168
## Degrees of freedom: 1
## P-value: 0.0000000003014
## 95% CI: [ 0.302 , 0.517 ]
## Significant: YES (p < 0.05)
##
## Aphant vs Gemini-2.0-Flash-Images
## -----
## Proportions: 0.79 vs 0.331
## Difference: 0.459
## Chi-squared: 49.877
## Degrees of freedom: 1
## P-value: 0.00000000001637
## 95% CI: [ 0.344 , 0.574 ]
## Significant: YES (p < 0.05)
##
## Aphant vs Sonnet-4
## -----
## Proportions: 0.79 vs 0.417
## Difference: 0.373

```

```

## Chi-squared: 35.874
## Degrees of freedom: 1
## P-value: 0.000000002105
## 95% CI: [ 0.265 , 0.481 ]
## Significant: YES (p < 0.05)
##
## Aphant vs Opus-4.1
## -----
## Proportions: 0.79 vs 0.529
## Difference: 0.261
## Chi-squared: 15.679
## Degrees of freedom: 1
## P-value: 0.00007507
## 95% CI: [ 0.144 , 0.377 ]
## Significant: YES (p < 0.05)
##
## Aphant vs GPT-5
## -----
## Proportions: 0.79 vs 0.67
## Difference: 0.12
## Chi-squared: 3.911
## Degrees of freedom: 1
## P-value: 0.04796
## 95% CI: [ 0.013 , 0.227 ]
## Significant: YES (p < 0.05)
##
## Humans vs o3
## -----
## Proportions: 0.547 vs 0.642
## Difference: -0.094
## Chi-squared: 28.631
## Degrees of freedom: 1
## P-value: 0.00000008757
## 95% CI: [ -0.128 , -0.06 ]
## Significant: YES (p < 0.05)
##
## Humans vs o3-GPT-Image
## -----
## Proportions: 0.547 vs 0.553
## Difference: -0.006
## Chi-squared: 0.143
## Degrees of freedom: 1
## P-value: 0.7057
## 95% CI: [ -0.037 , 0.024 ]
## Significant: NO
##
## Humans vs o3-Pro
## -----
## Proportions: 0.547 vs 0.666
## Difference: -0.119
## Chi-squared: 45.76
## Degrees of freedom: 1
## P-value: 0.0000000001336
## 95% CI: [ -0.153 , -0.086 ]

```

```

## Significant: YES (p < 0.05)
##
## Humans vs GPT-4.1
## -----
## Proportions: 0.547 vs 0.425
## Difference: 0.122
## Chi-squared: 32.987
## Degrees of freedom: 1
## P-value: 0.000000009278
## 95% CI: [ 0.08 , 0.164 ]
## Significant: YES (p < 0.05)
##
## Humans vs GPT-4.1-GPT-Image
## -----
## Proportions: 0.547 vs 0.383
## Difference: 0.164
## Chi-squared: 59.482
## Degrees of freedom: 1
## P-value: 0.0000000000001234
## 95% CI: [ 0.123 , 0.206 ]
## Significant: YES (p < 0.05)
##
## Humans vs ChatGPT-4o
## -----
## Proportions: 0.547 vs 0.42
## Difference: 0.128
## Chi-squared: 35.86
## Degrees of freedom: 1
## P-value: 0.00000000212
## 95% CI: [ 0.086 , 0.17 ]
## Significant: YES (p < 0.05)
##
## Humans vs o4-mini
## -----
## Proportions: 0.547 vs 0.53
## Difference: 0.017
## Chi-squared: 0.577
## Degrees of freedom: 1
## P-value: 0.4477
## 95% CI: [ -0.025 , 0.059 ]
## Significant: NO
##
## Humans vs Gemini-2.5
## -----
## Proportions: 0.547 vs 0.462
## Difference: 0.085
## Chi-squared: 15.96
## Degrees of freedom: 1
## P-value: 0.00006468
## 95% CI: [ 0.043 , 0.128 ]
## Significant: YES (p < 0.05)
##
## Humans vs Gemini-2.0-Flash
## -----

```



```

## Proportions: 0.547 vs 0.38
## Difference: 0.167
## Chi-squared: 61.741
## Degrees of freedom: 1
## P-value: 0.000000000000003918
## 95% CI: [ 0.126 , 0.209 ]
## Significant: YES (p < 0.05)
##
## Humans vs Gemini-2.0-Flash-Images
## -----
## Proportions: 0.547 vs 0.331
## Difference: 0.216
## Chi-squared: 53.296
## Degrees of freedom: 1
## P-value: 0.00000000000002869
## 95% CI: [ 0.16 , 0.272 ]
## Significant: YES (p < 0.05)
##
## Humans vs Sonnet-4
## -----
## Proportions: 0.547 vs 0.417
## Difference: 0.13
## Chi-squared: 37.392
## Degrees of freedom: 1
## P-value: 0.0000000009662
## 95% CI: [ 0.088 , 0.172 ]
## Significant: YES (p < 0.05)
##
## Humans vs Opus-4.1
## -----
## Proportions: 0.547 vs 0.529
## Difference: 0.018
## Chi-squared: 0.299
## Degrees of freedom: 1
## P-value: 0.5845
## 95% CI: [ -0.042 , 0.077 ]
## Significant: NO
##
## Humans vs GPT-5
## -----
## Proportions: 0.547 vs 0.67
## Difference: -0.123
## Chi-squared: 33.302
## Degrees of freedom: 1
## P-value: 0.00000000789
## 95% CI: [ -0.163 , -0.082 ]
## Significant: YES (p < 0.05)
##
## o3 vs o3-GPT-Image
## -----
## Proportions: 0.642 vs 0.553
## Difference: 0.088
## Chi-squared: 16.139
## Degrees of freedom: 1

```

```

## P-value: 0.00005886
## 95% CI: [ 0.045 , 0.131 ]
## Significant: YES (p < 0.05)
##
## o3 vs o3-Pro
## -----
## Proportions: 0.642 vs 0.666
## Difference: -0.025
## Chi-squared: 1.106
## Degrees of freedom: 1
## P-value: 0.2928
## 95% CI: [ -0.07 , 0.02 ]
## Significant: NO
##
## o3 vs GPT-4.1
## -----
## Proportions: 0.642 vs 0.425
## Difference: 0.217
## Chi-squared: 67.617
## Degrees of freedom: 1
## P-value: 0.0000000000000001986
## 95% CI: [ 0.165 , 0.269 ]
## Significant: YES (p < 0.05)
##
## o3 vs GPT-4.1-GPT-Image
## -----
## Proportions: 0.642 vs 0.383
## Difference: 0.258
## Chi-squared: 95.75
## Degrees of freedom: 1
## P-value: 0.00000000000000000001304
## 95% CI: [ 0.207 , 0.31 ]
## Significant: YES (p < 0.05)
##
## o3 vs ChatGPT-4o
## -----
## Proportions: 0.642 vs 0.42
## Difference: 0.222
## Chi-squared: 70.849
## Degrees of freedom: 1
## P-value: 0.0000000000000000003855
## 95% CI: [ 0.17 , 0.274 ]
## Significant: YES (p < 0.05)
##
## o3 vs o4-mini
## -----
## Proportions: 0.642 vs 0.53
## Difference: 0.111
## Chi-squared: 18.085
## Degrees of freedom: 1
## P-value: 0.00002112
## 95% CI: [ 0.059 , 0.163 ]
## Significant: YES (p < 0.05)
##

```

```

## o3 vs Gemini-2.5
## -----
## Proportions: 0.642 vs 0.462
## Difference: 0.18
## Chi-squared: 46.719
## Degrees of freedom: 1
## P-value: 0.0000000000008192
## 95% CI: [ 0.128 , 0.232 ]
## Significant: YES (p < 0.05)
##
## o3 vs Gemini-2.0-Flash
## -----
## Proportions: 0.642 vs 0.38
## Difference: 0.262
## Chi-squared: 98.017
## Degrees of freedom: 1
## P-value: 0.000000000000000000004147
## 95% CI: [ 0.21 , 0.313 ]
## Significant: YES (p < 0.05)
##
## o3 vs Gemini-2.0-Flash-Images
## -----
## Proportions: 0.642 vs 0.331
## Difference: 0.31
## Chi-squared: 86.894
## Degrees of freedom: 1
## P-value: 0.00000000000000000001145
## 95% CI: [ 0.246 , 0.374 ]
## Significant: YES (p < 0.05)
##
## o3 vs Sonnet-4
## -----
## Proportions: 0.642 vs 0.417
## Difference: 0.225
## Chi-squared: 72.549
## Degrees of freedom: 1
## P-value: 0.000000000000000001629
## 95% CI: [ 0.173 , 0.276 ]
## Significant: YES (p < 0.05)
##
## o3 vs Opus-4.1
## -----
## Proportions: 0.642 vs 0.529
## Difference: 0.112
## Chi-squared: 11.466
## Degrees of freedom: 1
## P-value: 0.0007087
## 95% CI: [ 0.045 , 0.179 ]
## Significant: YES (p < 0.05)
##
## o3 vs GPT-5
## -----
## Proportions: 0.642 vs 0.67
## Difference: -0.028

```

```

## Chi-squared: 1.138
## Degrees of freedom: 1
## P-value: 0.286
## 95% CI: [ -0.079 , 0.022 ]
## Significant: NO
##
## o3-GPT-Image vs o3-Pro
## -----
## Proportions: 0.553 vs 0.666
## Difference: -0.113
## Chi-squared: 26.82
## Degrees of freedom: 1
## P-value: 0.0000002234
## 95% CI: [ -0.155 , -0.07 ]
## Significant: YES (p < 0.05)
##
## o3-GPT-Image vs GPT-4.1
## -----
## Proportions: 0.553 vs 0.425
## Difference: 0.129
## Chi-squared: 26.007
## Degrees of freedom: 1
## P-value: 0.0000003401
## 95% CI: [ 0.079 , 0.178 ]
## Significant: YES (p < 0.05)
##
## o3-GPT-Image vs GPT-4.1-GPT-Image
## -----
## Proportions: 0.553 vs 0.383
## Difference: 0.17
## Chi-squared: 45.802
## Degrees of freedom: 1
## P-value: 0.0000000001308
## 95% CI: [ 0.121 , 0.22 ]
## Significant: YES (p < 0.05)
##
## o3-GPT-Image vs ChatGPT-4o
## -----
## Proportions: 0.553 vs 0.42
## Difference: 0.134
## Chi-squared: 28.164
## Degrees of freedom: 1
## P-value: 0.0000001115
## 95% CI: [ 0.084 , 0.184 ]
## Significant: YES (p < 0.05)
##
## o3-GPT-Image vs o4-mini
## -----
## Proportions: 0.553 vs 0.53
## Difference: 0.023
## Chi-squared: 0.782
## Degrees of freedom: 1
## P-value: 0.3765
## 95% CI: [ -0.027 , 0.073 ]

```

```

## Significant: NO
##
## o3-GPT-Image vs Gemini-2.5
## -----
## Proportions: 0.553 vs 0.462
## Difference: 0.092
## Chi-squared: 13.116
## Degrees of freedom: 1
## P-value: 0.0002928
## 95% CI: [ 0.042 , 0.142 ]
## Significant: YES (p < 0.05)
##
## o3-GPT-Image vs Gemini-2.0-Flash
## -----
## Proportions: 0.553 vs 0.38
## Difference: 0.174
## Chi-squared: 47.484
## Degrees of freedom: 1
## P-value: 0.00000000005546
## 95% CI: [ 0.124 , 0.223 ]
## Significant: YES (p < 0.05)
##
## o3-GPT-Image vs Gemini-2.0-Flash-Images
## -----
## Proportions: 0.553 vs 0.331
## Difference: 0.222
## Chi-squared: 46.585
## Degrees of freedom: 1
## P-value: 0.00000000008772
## 95% CI: [ 0.16 , 0.285 ]
## Significant: YES (p < 0.05)
##
## o3-GPT-Image vs Sonnet-4
## -----
## Proportions: 0.553 vs 0.417
## Difference: 0.137
## Chi-squared: 29.312
## Degrees of freedom: 1
## P-value: 0.00000006161
## 95% CI: [ 0.087 , 0.186 ]
## Significant: YES (p < 0.05)
##
## o3-GPT-Image vs Opus-4.1
## -----
## Proportions: 0.553 vs 0.529
## Difference: 0.024
## Chi-squared: 0.469
## Degrees of freedom: 1
## P-value: 0.4933
## 95% CI: [ -0.041 , 0.089 ]
## Significant: NO
##
## o3-GPT-Image vs GPT-5
## -----

```

```

## Proportions: 0.553 vs 0.67
## Difference: -0.116
## Chi-squared: 21.894
## Degrees of freedom: 1
## P-value: 0.000002882
## 95% CI: [ -0.164 , -0.068 ]
## Significant: YES (p < 0.05)
##
## o3-Pro vs GPT-4.1
## -----
## Proportions: 0.666 vs 0.425
## Difference: 0.241
## Chi-squared: 84.647
## Degrees of freedom: 1
## P-value: 0.0000000000000000000003567
## 95% CI: [ 0.19 , 0.293 ]
## Significant: YES (p < 0.05)
##
## o3-Pro vs GPT-4.1-GPT-Image
## -----
## Proportions: 0.666 vs 0.383
## Difference: 0.283
## Chi-squared: 115.659
## Degrees of freedom: 1
## P-value: 0.000000000000000000000005644
## 95% CI: [ 0.232 , 0.334 ]
## Significant: YES (p < 0.05)
##
## o3-Pro vs ChatGPT-4o
## -----
## Proportions: 0.666 vs 0.42
## Difference: 0.247
## Chi-squared: 88.243
## Degrees of freedom: 1
## P-value: 0.00000000000000000000005789
## 95% CI: [ 0.195 , 0.298 ]
## Significant: YES (p < 0.05)
##
## o3-Pro vs o4-mini
## -----
## Proportions: 0.666 vs 0.53
## Difference: 0.136
## Chi-squared: 27.478
## Degrees of freedom: 1
## P-value: 0.0000001589
## 95% CI: [ 0.084 , 0.188 ]
## Significant: YES (p < 0.05)
##
## o3-Pro vs Gemini-2.5
## -----
## Proportions: 0.666 vs 0.462
## Difference: 0.204
## Chi-squared: 61.125
## Degrees of freedom: 1

```

[illegible]


```

## GPT-4.1 vs GPT-4.1-GPT-Image
## -----
## Proportions: 0.425 vs 0.383
## Difference: 0.042
## Chi-squared: 1.999
## Degrees of freedom: 1
## P-value: 0.1574
## 95% CI: [ -0.015 , 0.099 ]
## Significant: NO
##
## GPT-4.1 vs ChatGPT-4o
## -----
## Proportions: 0.425 vs 0.42
## Difference: 0.005
## Chi-squared: 0.015
## Degrees of freedom: 1
## P-value: 0.9017
## 95% CI: [ -0.052 , 0.063 ]
## Significant: NO
##
## GPT-4.1 vs o4-mini
## -----
## Proportions: 0.425 vs 0.53
## Difference: -0.105
## Chi-squared: 12.951
## Degrees of freedom: 1
## P-value: 0.0003197
## 95% CI: [ -0.163 , -0.048 ]
## Significant: YES (p < 0.05)
##
## GPT-4.1 vs Gemini-2.5
## -----
## Proportions: 0.425 vs 0.462
## Difference: -0.037
## Chi-squared: 1.519
## Degrees of freedom: 1
## P-value: 0.2177
## 95% CI: [ -0.095 , 0.021 ]
## Significant: NO
##
## GPT-4.1 vs Gemini-2.0-Flash
## -----
## Proportions: 0.425 vs 0.38
## Difference: 0.045
## Chi-squared: 2.321
## Degrees of freedom: 1
## P-value: 0.1276
## 95% CI: [ -0.012 , 0.102 ]
## Significant: NO
##
## GPT-4.1 vs Gemini-2.0-Flash-Images
## -----
## Proportions: 0.425 vs 0.331
## Difference: 0.094

```

```

## Chi-squared: 6.957
## Degrees of freedom: 1
## P-value: 0.008347
## 95% CI: [ 0.025 , 0.162 ]
## Significant: YES (p < 0.05)
##
## GPT-4.1 vs Sonnet-4
## -----
## Proportions: 0.425 vs 0.417
## Difference: 0.008
## Chi-squared: 0.047
## Degrees of freedom: 1
## P-value: 0.8277
## 95% CI: [ -0.05 , 0.065 ]
## Significant: NO
##
## GPT-4.1 vs Opus-4.1
## -----
## Proportions: 0.425 vs 0.529
## Difference: -0.105
## Chi-squared: 8.399
## Degrees of freedom: 1
## P-value: 0.003755
## 95% CI: [ -0.176 , -0.033 ]
## Significant: YES (p < 0.05)
##
## GPT-4.1 vs GPT-5
## -----
## Proportions: 0.425 vs 0.67
## Difference: -0.245
## Chi-squared: 71.655
## Degrees of freedom: 1
## P-value: 0.00000000000000002564
## 95% CI: [ -0.301 , -0.189 ]
## Significant: YES (p < 0.05)
##
## GPT-4.1-GPT-Image vs ChatGPT-4o
## -----
## Proportions: 0.383 vs 0.42
## Difference: -0.037
## Chi-squared: 1.518
## Degrees of freedom: 1
## P-value: 0.2179
## 95% CI: [ -0.094 , 0.021 ]
## Significant: NO
##
## GPT-4.1-GPT-Image vs o4-mini
## -----
## Proportions: 0.383 vs 0.53
## Difference: -0.147
## Chi-squared: 25.599
## Degrees of freedom: 1
## P-value: 0.0000004203
## 95% CI: [ -0.205 , -0.09 ]

```

```

## Significant: YES (p < 0.05)
##
## GPT-4.1-GPT-Image vs Gemini-2.5
## -----
## Proportions: 0.383 vs 0.462
## Difference: -0.079
## Chi-squared: 7.305
## Degrees of freedom: 1
## P-value: 0.006876
## 95% CI: [ -0.136 , -0.021 ]
## Significant: YES (p < 0.05)
##
## GPT-4.1-GPT-Image vs Gemini-2.0-Flash
## -----
## Proportions: 0.383 vs 0.38
## Difference: 0.003
## Chi-squared: 0.003
## Degrees of freedom: 1
## P-value: 0.9599
## 95% CI: [ -0.054 , 0.06 ]
## Significant: NO
##
## GPT-4.1-GPT-Image vs Gemini-2.0-Flash-Images
## -----
## Proportions: 0.383 vs 0.331
## Difference: 0.052
## Chi-squared: 2.104
## Degrees of freedom: 1
## P-value: 0.147
## 95% CI: [ -0.017 , 0.12 ]
## Significant: NO
##
## GPT-4.1-GPT-Image vs Sonnet-4
## -----
## Proportions: 0.383 vs 0.417
## Difference: -0.034
## Chi-squared: 1.295
## Degrees of freedom: 1
## P-value: 0.2551
## 95% CI: [ -0.091 , 0.023 ]
## Significant: NO
##
## GPT-4.1-GPT-Image vs Opus-4.1
## -----
## Proportions: 0.383 vs 0.529
## Difference: -0.146
## Chi-squared: 16.868
## Degrees of freedom: 1
## P-value: 0.00004007
## 95% CI: [ -0.217 , -0.075 ]
## Significant: YES (p < 0.05)
##
## GPT-4.1-GPT-Image vs GPT-5
## -----

```

```

## Proportions: 0.383 vs 0.67
## Difference: -0.287
## Chi-squared: 97.737
## Degrees of freedom: 1
## P-value: 0.00000000000000000000004779
## 95% CI: [ -0.342 , -0.231 ]
## Significant: YES (p < 0.05)
##
## ChatGPT-4o vs o4-mini
## -----
## Proportions: 0.42 vs 0.53
## Difference: -0.111
## Chi-squared: 14.285
## Degrees of freedom: 1
## P-value: 0.0001571
## 95% CI: [ -0.168 , -0.053 ]
## Significant: YES (p < 0.05)
##
## ChatGPT-4o vs Gemini-2.5
## -----
## Proportions: 0.42 vs 0.462
## Difference: -0.042
## Chi-squared: 2.001
## Degrees of freedom: 1
## P-value: 0.1572
## 95% CI: [ -0.1 , 0.016 ]
## Significant: NO
##
## ChatGPT-4o vs Gemini-2.0-Flash
## -----
## Proportions: 0.42 vs 0.38
## Difference: 0.04
## Chi-squared: 1.8
## Degrees of freedom: 1
## P-value: 0.1797
## 95% CI: [ -0.017 , 0.097 ]
## Significant: NO
##
## ChatGPT-4o vs Gemini-2.0-Flash-Images
## -----
## Proportions: 0.42 vs 0.331
## Difference: 0.088
## Chi-squared: 6.207
## Degrees of freedom: 1
## P-value: 0.01272
## 95% CI: [ 0.02 , 0.157 ]
## Significant: YES (p < 0.05)
##
## ChatGPT-4o vs Sonnet-4
## -----
## Proportions: 0.42 vs 0.417
## Difference: 0.003
## Chi-squared: 0.001
## Degrees of freedom: 1

```

```

## P-value: 0.9716
## 95% CI: [ -0.055 , 0.06 ]
## Significant: NO
##
## ChatGPT-4o vs Opus-4.1
## -----
## Proportions: 0.42 vs 0.529
## Difference: -0.11
## Chi-squared: 9.285
## Degrees of freedom: 1
## P-value: 0.002311
## 95% CI: [ -0.181 , -0.038 ]
## Significant: YES (p < 0.05)
##
## ChatGPT-4o vs GPT-5
## -----
## Proportions: 0.42 vs 0.67
## Difference: -0.25
## Chi-squared: 74.672
## Degrees of freedom: 1
## P-value: 0.00000000000000005558
## 95% CI: [ -0.306 , -0.194 ]
## Significant: YES (p < 0.05)
##
## o4-mini vs Gemini-2.5
## -----
## Proportions: 0.53 vs 0.462
## Difference: 0.068
## Chi-squared: 5.349
## Degrees of freedom: 1
## P-value: 0.02074
## 95% CI: [ 0.01 , 0.127 ]
## Significant: YES (p < 0.05)
##
## o4-mini vs Gemini-2.0-Flash
## -----
## Proportions: 0.53 vs 0.38
## Difference: 0.15
## Chi-squared: 26.707
## Degrees of freedom: 1
## P-value: 0.0000002367
## 95% CI: [ 0.093 , 0.208 ]
## Significant: YES (p < 0.05)
##
## o4-mini vs Gemini-2.0-Flash-Images
## -----
## Proportions: 0.53 vs 0.331
## Difference: 0.199
## Chi-squared: 31.073
## Degrees of freedom: 1
## P-value: 0.00000002485
## 95% CI: [ 0.13 , 0.268 ]
## Significant: YES (p < 0.05)
##

```

```

## o4-mini vs Sonnet-4
## -----
## Proportions: 0.53 vs 0.417
## Difference: 0.113
## Chi-squared: 15.001
## Degrees of freedom: 1
## P-value: 0.0001075
## 95% CI: [ 0.056 , 0.171 ]
## Significant: YES (p < 0.05)
##
## o4-mini vs Opus-4.1
## -----
## Proportions: 0.53 vs 0.529
## Difference: 0.001
## Chi-squared: 0
## Degrees of freedom: 1
## P-value: 1
## 95% CI: [ -0.069 , 0.071 ]
## Significant: NO
##
## o4-mini vs GPT-5
## -----
## Proportions: 0.53 vs 0.67
## Difference: -0.139
## Chi-squared: 23.742
## Degrees of freedom: 1
## P-value: 0.000001102
## 95% CI: [ -0.196 , -0.083 ]
## Significant: YES (p < 0.05)
##
## Gemini-2.5 vs Gemini-2.0-Flash
## -----
## Proportions: 0.462 vs 0.38
## Difference: 0.082
## Chi-squared: 7.907
## Degrees of freedom: 1
## P-value: 0.004923
## 95% CI: [ 0.024 , 0.139 ]
## Significant: YES (p < 0.05)
##
## Gemini-2.5 vs Gemini-2.0-Flash-Images
## -----
## Proportions: 0.462 vs 0.331
## Difference: 0.131
## Chi-squared: 13.497
## Degrees of freedom: 1
## P-value: 0.000239
## 95% CI: [ 0.062 , 0.2 ]
## Significant: YES (p < 0.05)
##
## Gemini-2.5 vs Sonnet-4
## -----
## Proportions: 0.462 vs 0.417
## Difference: 0.045

```

```

## Chi-squared: 2.275
## Degrees of freedom: 1
## P-value: 0.1315
## 95% CI: [ -0.013 , 0.103 ]
## Significant: NO
##
## Gemini-2.5 vs Opus-4.1
## -----
## Proportions: 0.462 vs 0.529
## Difference: -0.068
## Chi-squared: 3.394
## Degrees of freedom: 1
## P-value: 0.06541
## 95% CI: [ -0.139 , 0.004 ]
## Significant: NO
##
## Gemini-2.5 vs GPT-5
## -----
## Proportions: 0.462 vs 0.67
## Difference: -0.208
## Chi-squared: 51.944
## Degrees of freedom: 1
## P-value: 0.0000000000005711
## 95% CI: [ -0.264 , -0.151 ]
## Significant: YES (p < 0.05)
##
## Gemini-2.0-Flash vs Gemini-2.0-Flash-Images
## -----
## Proportions: 0.38 vs 0.331
## Difference: 0.049
## Chi-squared: 1.854
## Degrees of freedom: 1
## P-value: 0.1733
## 95% CI: [ -0.02 , 0.117 ]
## Significant: NO
##
## Gemini-2.0-Flash vs Sonnet-4
## -----
## Proportions: 0.38 vs 0.417
## Difference: -0.037
## Chi-squared: 1.556
## Degrees of freedom: 1
## P-value: 0.2122
## 95% CI: [ -0.094 , 0.02 ]
## Significant: NO
##
## Gemini-2.0-Flash vs Opus-4.1
## -----
## Proportions: 0.38 vs 0.529
## Difference: -0.149
## Chi-squared: 17.617
## Degrees of freedom: 1
## P-value: 0.00002701
## 95% CI: [ -0.22 , -0.078 ]

```


[illegible]

```
## Proportions: 0.417 vs 0.67
## Difference: -0.253
## Chi-squared: 76.256
## Degrees of freedom: 1
## P-value: 0.000000000000000002492
## 95% CI: [ -0.309 , -0.197 ]
## Significant: YES (p < 0.05)
```

```
##
## Opus-4.1 vs GPT-5
## -----
## Proportions: 0.529 vs 0.67
## Difference: -0.14
## Chi-squared: 16.17
## Degrees of freedom: 1
## P-value: 0.0000579
## 95% CI: [ -0.211 , -0.07 ]
## Significant: YES (p < 0.05)
```

```
# Summary table
```

```
aphant_summary <- aphant_results %>%
  select(comparison, diff, chi_squared, p_value, significant) %>%
  mutate(diff = round(diff, 3),
         p_value = round(p_value, 4))
cat("\n\nSummary Table - Aphant vs Humans and Models:\n")
```

```
##
##
## Summary Table - Aphant vs Humans and Models:
```

```
print(kable(aphant_summary, format = "simple"))
```

```
##
##
## comparison diff chi_squared p_value signi.
## -----
## X-squared Aphant vs Humans 0.243 16.7091541 0.0000 TRUE
## X-squared1 Aphant vs o3 0.148 6.0857862 0.0136 TRUE
## X-squared2 Aphant vs o3-GPT-Image 0.236 15.1251694 0.0001 TRUE
## X-squared3 Aphant vs o3-Pro 0.124 4.2836818 0.0385 TRUE
## X-squared4 Aphant vs GPT-4.1 0.365 34.2720790 0.0000 TRUE
## X-squared5 Aphant vs GPT-4.1-GPT-Image 0.407 43.4242037 0.0000 TRUE
## X-squared6 Aphant vs ChatGPT-4o 0.370 35.3221245 0.0000 TRUE
## X-squared7 Aphant vs o4-mini 0.260 17.1995499 0.0000 TRUE
## X-squared8 Aphant vs Gemini-2.5 0.328 27.4120781 0.0000 TRUE
## X-squared9 Aphant vs Gemini-2.0-Flash 0.410 44.1676918 0.0000 TRUE
## X-squared10 Aphant vs Gemini-2.0-Flash-Images 0.459 49.8768035 0.0000 TRUE
## X-squared11 Aphant vs Sonnet-4 0.373 35.8738163 0.0000 TRUE
## X-squared12 Aphant vs Opus-4.1 0.261 15.6786368 0.0001 TRUE
## X-squared13 Aphant vs GPT-5 0.120 3.9113231 0.0480 TRUE
## X-squared14 Humans vs o3 -0.094 28.6308876 0.0000 TRUE
## X-squared15 Humans vs o3-GPT-Image -0.006 0.1425741 0.7057 FALSE
## X-squared16 Humans vs o3-Pro -0.119 45.7603911 0.0000 TRUE
## X-squared17 Humans vs GPT-4.1 0.122 32.9868982 0.0000 TRUE
## X-squared18 Humans vs GPT-4.1-GPT-Image 0.164 59.4818080 0.0000 TRUE
## X-squared19 Humans vs ChatGPT-4o 0.128 35.8604451 0.0000 TRUE
```

## X-squared20	Humans vs o4-mini	0.017	0.5765459	0.4477	FALSE
## X-squared21	Humans vs Gemini-2.5	0.085	15.9603007	0.0001	TRUE
## X-squared22	Humans vs Gemini-2.0-Flash	0.167	61.7405958	0.0000	TRUE
## X-squared23	Humans vs Gemini-2.0-Flash-Images	0.216	53.2959199	0.0000	TRUE
## X-squared24	Humans vs Sonnet-4	0.130	37.3919075	0.0000	TRUE
## X-squared25	Humans vs Opus-4.1	0.018	0.2989942	0.5845	FALSE
## X-squared26	Humans vs GPT-5	-0.123	33.3019857	0.0000	TRUE
## X-squared27	o3 vs o3-GPT-Image	0.088	16.1391378	0.0001	TRUE
## X-squared28	o3 vs o3-Pro	-0.025	1.1064986	0.2928	FALSE
## X-squared29	o3 vs GPT-4.1	0.217	67.6166340	0.0000	TRUE
## X-squared30	o3 vs GPT-4.1-GPT-Image	0.258	95.7496135	0.0000	TRUE
## X-squared31	o3 vs ChatGPT-4o	0.222	70.8494853	0.0000	TRUE
## X-squared32	o3 vs o4-mini	0.111	18.0851641	0.0000	TRUE
## X-squared33	o3 vs Gemini-2.5	0.180	46.7193652	0.0000	TRUE
## X-squared34	o3 vs Gemini-2.0-Flash	0.262	98.0174945	0.0000	TRUE
## X-squared35	o3 vs Gemini-2.0-Flash-Images	0.310	86.8942530	0.0000	TRUE
## X-squared36	o3 vs Sonnet-4	0.225	72.5490940	0.0000	TRUE
## X-squared37	o3 vs Opus-4.1	0.112	11.4662661	0.0007	TRUE
## X-squared38	o3 vs GPT-5	-0.028	1.1383107	0.2860	FALSE
## X-squared39	o3-GPT-Image vs o3-Pro	-0.113	26.8195138	0.0000	TRUE
## X-squared40	o3-GPT-Image vs GPT-4.1	0.129	26.0074801	0.0000	TRUE
## X-squared41	o3-GPT-Image vs GPT-4.1-GPT-Image	0.170	45.8021597	0.0000	TRUE
## X-squared42	o3-GPT-Image vs ChatGPT-4o	0.134	28.1640608	0.0000	TRUE
## X-squared43	o3-GPT-Image vs o4-mini	0.023	0.7821301	0.3765	FALSE
## X-squared44	o3-GPT-Image vs Gemini-2.5	0.092	13.1161642	0.0003	TRUE
## X-squared45	o3-GPT-Image vs Gemini-2.0-Flash	0.174	47.4839020	0.0000	TRUE
## X-squared46	o3-GPT-Image vs Gemini-2.0-Flash-Images	0.222	46.5852344	0.0000	TRUE
## X-squared47	o3-GPT-Image vs Sonnet-4	0.137	29.3120309	0.0000	TRUE
## X-squared48	o3-GPT-Image vs Opus-4.1	0.024	0.4692957	0.4933	FALSE
## X-squared49	o3-GPT-Image vs GPT-5	-0.116	21.8935396	0.0000	TRUE
## X-squared50	o3-Pro vs GPT-4.1	0.241	84.6471507	0.0000	TRUE
## X-squared51	o3-Pro vs GPT-4.1-GPT-Image	0.283	115.6594014	0.0000	TRUE
## X-squared52	o3-Pro vs ChatGPT-4o	0.247	88.2427557	0.0000	TRUE
## X-squared53	o3-Pro vs o4-mini	0.136	27.4784870	0.0000	TRUE
## X-squared54	o3-Pro vs Gemini-2.5	0.204	61.1246804	0.0000	TRUE
## X-squared55	o3-Pro vs Gemini-2.0-Flash	0.286	118.1359936	0.0000	TRUE
## X-squared56	o3-Pro vs Gemini-2.0-Flash-Images	0.335	102.5130386	0.0000	TRUE
## X-squared57	o3-Pro vs Sonnet-4	0.249	90.1292627	0.0000	TRUE
## X-squared58	o3-Pro vs Opus-4.1	0.137	17.5347059	0.0000	TRUE
## X-squared59	o3-Pro vs GPT-5	-0.003	0.0069479	0.9336	FALSE
## X-squared60	GPT-4.1 vs GPT-4.1-GPT-Image	0.042	1.9993745	0.1574	FALSE
## X-squared61	GPT-4.1 vs ChatGPT-4o	0.005	0.0152534	0.9017	FALSE
## X-squared62	GPT-4.1 vs o4-mini	-0.105	12.9510207	0.0003	TRUE
## X-squared63	GPT-4.1 vs Gemini-2.5	-0.037	1.5193687	0.2177	FALSE
## X-squared64	GPT-4.1 vs Gemini-2.0-Flash	0.045	2.3210330	0.1276	FALSE
## X-squared65	GPT-4.1 vs Gemini-2.0-Flash-Images	0.094	6.9574196	0.0083	TRUE
## X-squared66	GPT-4.1 vs Sonnet-4	0.008	0.0473504	0.8277	FALSE
## X-squared67	GPT-4.1 vs Opus-4.1	-0.105	8.3986450	0.0038	TRUE
## X-squared68	GPT-4.1 vs GPT-5	-0.245	71.6546450	0.0000	TRUE
## X-squared69	GPT-4.1-GPT-Image vs ChatGPT-4o	-0.037	1.5181623	0.2179	FALSE
## X-squared70	GPT-4.1-GPT-Image vs o4-mini	-0.147	25.5989635	0.0000	TRUE
## X-squared71	GPT-4.1-GPT-Image vs Gemini-2.5	-0.079	7.3049825	0.0069	TRUE
## X-squared72	GPT-4.1-GPT-Image vs Gemini-2.0-Flash	0.003	0.0025231	0.9599	FALSE
## X-squared73	GPT-4.1-GPT-Image vs Gemini-2.0-Flash-Images	0.052	2.1035348	0.1470	FALSE

## X-squared74	GPT-4.1-GPT-Image vs Sonnet-4	-0.034	1.2951527	0.2551	FALSE
## X-squared75	GPT-4.1-GPT-Image vs Opus-4.1	-0.146	16.8680920	0.0000	TRUE
## X-squared76	GPT-4.1-GPT-Image vs GPT-5	-0.287	97.7365295	0.0000	TRUE
## X-squared77	ChatGPT-4o vs o4-mini	-0.111	14.2854157	0.0002	TRUE
## X-squared78	ChatGPT-4o vs Gemini-2.5	-0.042	2.0005049	0.1572	FALSE
## X-squared79	ChatGPT-4o vs Gemini-2.0-Flash	0.040	1.8000628	0.1797	FALSE
## X-squared80	ChatGPT-4o vs Gemini-2.0-Flash-Images	0.088	6.2071015	0.0127	TRUE
## X-squared81	ChatGPT-4o vs Sonnet-4	0.003	0.0012675	0.9716	FALSE
## X-squared82	ChatGPT-4o vs Opus-4.1	-0.110	9.2845807	0.0023	TRUE
## X-squared83	ChatGPT-4o vs GPT-5	-0.250	74.6719492	0.0000	TRUE
## X-squared84	o4-mini vs Gemini-2.5	0.068	5.3489240	0.0207	TRUE
## X-squared85	o4-mini vs Gemini-2.0-Flash	0.150	26.7071233	0.0000	TRUE
## X-squared86	o4-mini vs Gemini-2.0-Flash-Images	0.199	31.0733308	0.0000	TRUE
## X-squared87	o4-mini vs Sonnet-4	0.113	15.0010285	0.0001	TRUE
## X-squared88	o4-mini vs Opus-4.1	0.001	0.0000000	1.0000	FALSE
## X-squared89	o4-mini vs GPT-5	-0.139	23.7419837	0.0000	TRUE
## X-squared90	Gemini-2.5 vs Gemini-2.0-Flash	0.082	7.9073611	0.0049	TRUE
## X-squared91	Gemini-2.5 vs Gemini-2.0-Flash-Images	0.131	13.4965103	0.0002	TRUE
## X-squared92	Gemini-2.5 vs Sonnet-4	0.045	2.2752755	0.1315	FALSE
## X-squared93	Gemini-2.5 vs Opus-4.1	-0.068	3.3944881	0.0654	FALSE
## X-squared94	Gemini-2.5 vs GPT-5	-0.208	51.9440409	0.0000	TRUE
## X-squared95	Gemini-2.0-Flash vs Gemini-2.0-Flash-Images	0.049	1.8541845	0.1733	FALSE
## X-squared96	Gemini-2.0-Flash vs Sonnet-4	-0.037	1.5564724	0.2122	FALSE
## X-squared97	Gemini-2.0-Flash vs Opus-4.1	-0.149	17.6174219	0.0000	TRUE
## X-squared98	Gemini-2.0-Flash vs GPT-5	-0.290	99.8257607	0.0000	TRUE
## X-squared99	Gemini-2.0-Flash-Images vs Sonnet-4	-0.086	5.8355995	0.0157	TRUE
## X-squared100	Gemini-2.0-Flash-Images vs Opus-4.1	-0.198	23.2466529	0.0000	TRUE
## X-squared101	Gemini-2.0-Flash-Images vs GPT-5	-0.339	91.5289929	0.0000	TRUE
## X-squared102	Sonnet-4 vs Opus-4.1	-0.112	9.7604857	0.0018	TRUE
## X-squared103	Sonnet-4 vs GPT-5	-0.253	76.2556458	0.0000	TRUE
## X-squared104	Opus-4.1 vs GPT-5	-0.140	16.1702630	0.0001	TRUE

Single Context vs Multiple Context - All Pairwise Comparisons

All Pairwise Comparisons for Single-Context vs Multiple-Context:

=====

##

o3-SC vs o3-MC

Proportions: 0.636 vs 0.622

Difference: 0.014

Chi-squared: 0.106

Degrees of freedom: 1

P-value: 0.7443

95% CI: [-0.056 , 0.083]

Significant: NO

##

o3-SC vs o3-Pro-SC

Proportions: 0.636 vs 0.667

Difference: -0.032

Chi-squared: 0.524

Degrees of freedom: 1

```

## P-value: 0.469
## 95% CI: [ -0.111 , 0.048 ]
## Significant: NO
##
## o3-SC vs o3-Pro-MC
## -----
## Proportions: 0.636 vs 0.66
## Difference: -0.024
## Chi-squared: 0.417
## Degrees of freedom: 1
## P-value: 0.5183
## 95% CI: [ -0.093 , 0.045 ]
## Significant: NO
##
## o3-SC vs o4-mini-SC
## -----
## Proportions: 0.636 vs 0.487
## Difference: 0.149
## Chi-squared: 12.868
## Degrees of freedom: 1
## P-value: 0.0003342
## 95% CI: [ 0.067 , 0.231 ]
## Significant: YES (p < 0.05)
##
## o3-SC vs o4-mini-MC
## -----
## Proportions: 0.636 vs 0.573
## Difference: 0.063
## Chi-squared: 2.216
## Degrees of freedom: 1
## P-value: 0.1366
## 95% CI: [ -0.019 , 0.144 ]
## Significant: NO
##
## o3-SC vs Sonnet-4-SC
## -----
## Proportions: 0.636 vs 0.428
## Difference: 0.208
## Chi-squared: 25.307
## Degrees of freedom: 1
## P-value: 0.000000489
## 95% CI: [ 0.127 , 0.29 ]
## Significant: YES (p < 0.05)
##
## o3-SC vs Sonnet-4-MC
## -----
## Proportions: 0.636 vs 0.406
## Difference: 0.23
## Chi-squared: 30.82
## Degrees of freedom: 1
## P-value: 0.00000002831
## 95% CI: [ 0.149 , 0.311 ]
## Significant: YES (p < 0.05)
##

```

```

## o3-SC vs Gemini-2.0-Flash-SC
## -----
## Proportions: 0.636 vs 0.387
## Difference: 0.249
## Chi-squared: 36.123
## Degrees of freedom: 1
## P-value: 0.000000001852
## 95% CI: [ 0.168 , 0.329 ]
## Significant: YES (p < 0.05)
##
## o3-SC vs Gemini-2.0-Flash-MC
## -----
## Proportions: 0.636 vs 0.373
## Difference: 0.263
## Chi-squared: 40.549
## Degrees of freedom: 1
## P-value: 0.0000000001917
## 95% CI: [ 0.183 , 0.344 ]
## Significant: YES (p < 0.05)
##
## o3-SC vs Gemini-2.5-Pro-SC
## -----
## Proportions: 0.636 vs 0.467
## Difference: 0.169
## Chi-squared: 16.577
## Degrees of freedom: 1
## P-value: 0.00004672
## 95% CI: [ 0.087 , 0.25 ]
## Significant: YES (p < 0.05)
##
## o3-SC vs Gemini-2.5-Pro-MC
## -----
## Proportions: 0.636 vs 0.456
## Difference: 0.18
## Chi-squared: 18.807
## Degrees of freedom: 1
## P-value: 0.00001446
## 95% CI: [ 0.098 , 0.261 ]
## Significant: YES (p < 0.05)
##
## o3-SC vs ChatGPT-4o-SC
## -----
## Proportions: 0.636 vs 0.398
## Difference: 0.238
## Chi-squared: 33.06
## Degrees of freedom: 1
## P-value: 0.000000008935
## 95% CI: [ 0.157 , 0.319 ]
## Significant: YES (p < 0.05)
##
## o3-SC vs ChatGPT-4o-MC
## -----
## Proportions: 0.636 vs 0.441
## Difference: 0.195

```

```

## Chi-squared: 22.12
## Degrees of freedom: 1
## P-value: 0.000002561
## 95% CI: [ 0.113 , 0.276 ]
## Significant: YES (p < 0.05)
##
## o3-SC vs GPT-4.1-SC
## -----
## Proportions: 0.636 vs 0.441
## Difference: 0.195
## Chi-squared: 22.068
## Degrees of freedom: 1
## P-value: 0.000002632
## 95% CI: [ 0.113 , 0.276 ]
## Significant: YES (p < 0.05)
##
## o3-SC vs GPT-4.1-MC
## -----
## Proportions: 0.636 vs 0.408
## Difference: 0.228
## Chi-squared: 30.286
## Degrees of freedom: 1
## P-value: 0.00000003728
## 95% CI: [ 0.147 , 0.309 ]
## Significant: YES (p < 0.05)
##
## o3-SC vs GPT-4.1-GPT-Image-SC
## -----
## Proportions: 0.636 vs 0.386
## Difference: 0.25
## Chi-squared: 36.467
## Degrees of freedom: 1
## P-value: 0.000000001553
## 95% CI: [ 0.169 , 0.331 ]
## Significant: YES (p < 0.05)
##
## o3-SC vs GPT-4.1-GPT-Image-MC
## -----
## Proportions: 0.636 vs 0.38
## Difference: 0.256
## Chi-squared: 38.304
## Degrees of freedom: 1
## P-value: 0.0000000006053
## 95% CI: [ 0.175 , 0.337 ]
## Significant: YES (p < 0.05)
##
## o3-MC vs o3-Pro-SC
## -----
## Proportions: 0.622 vs 0.667
## Difference: -0.045
## Chi-squared: 1.575
## Degrees of freedom: 1
## P-value: 0.2095
## 95% CI: [ -0.114 , 0.023 ]

```

```

## Significant: NO
##
## o3-MC vs o3-Pro-MC
## -----
## Proportions: 0.622 vs 0.66
## Difference: -0.038
## Chi-squared: 1.713
## Degrees of freedom: 1
## P-value: 0.1906
## 95% CI: [ -0.094 , 0.018 ]
## Significant: NO
##
## o3-MC vs o4-mini-SC
## -----
## Proportions: 0.622 vs 0.487
## Difference: 0.135
## Chi-squared: 14.391
## Degrees of freedom: 1
## P-value: 0.0001485
## 95% CI: [ 0.064 , 0.206 ]
## Significant: YES (p < 0.05)
##
## o3-MC vs o4-mini-MC
## -----
## Proportions: 0.622 vs 0.573
## Difference: 0.049
## Chi-squared: 1.819
## Degrees of freedom: 1
## P-value: 0.1774
## 95% CI: [ -0.021 , 0.12 ]
## Significant: NO
##
## o3-MC vs Sonnet-4-SC
## -----
## Proportions: 0.622 vs 0.428
## Difference: 0.195
## Chi-squared: 29.926
## Degrees of freedom: 1
## P-value: 0.00000004488
## 95% CI: [ 0.124 , 0.265 ]
## Significant: YES (p < 0.05)
##
## o3-MC vs Sonnet-4-MC
## -----
## Proportions: 0.622 vs 0.406
## Difference: 0.216
## Chi-squared: 36.878
## Degrees of freedom: 1
## P-value: 0.000000001258
## 95% CI: [ 0.146 , 0.286 ]
## Significant: YES (p < 0.05)
##
## o3-MC vs Gemini-2.0-Flash-SC
## -----

```



```

## Proportions: 0.622 vs 0.387
## Difference: 0.235
## Chi-squared: 43.574
## Degrees of freedom: 1
## P-value: 0.00000000004083
## 95% CI: [ 0.165 , 0.305 ]
## Significant: YES (p < 0.05)
##
## o3-MC vs Gemini-2.0-Flash-MC
## -----
## Proportions: 0.622 vs 0.373
## Difference: 0.25
## Chi-squared: 49.16
## Degrees of freedom: 1
## P-value: 0.00000000002359
## 95% CI: [ 0.18 , 0.319 ]
## Significant: YES (p < 0.05)
##
## o3-MC vs Gemini-2.5-Pro-SC
## -----
## Proportions: 0.622 vs 0.467
## Difference: 0.155
## Chi-squared: 18.985
## Degrees of freedom: 1
## P-value: 0.00001317
## 95% CI: [ 0.084 , 0.226 ]
## Significant: YES (p < 0.05)
##
## o3-MC vs Gemini-2.5-Pro-MC
## -----
## Proportions: 0.622 vs 0.456
## Difference: 0.166
## Chi-squared: 21.767
## Degrees of freedom: 1
## P-value: 0.000003078
## 95% CI: [ 0.095 , 0.237 ]
## Significant: YES (p < 0.05)
##
## o3-MC vs ChatGPT-4o-SC
## -----
## Proportions: 0.622 vs 0.398
## Difference: 0.224
## Chi-squared: 39.706
## Degrees of freedom: 1
## P-value: 0.0000000002952
## 95% CI: [ 0.154 , 0.294 ]
## Significant: YES (p < 0.05)
##
## o3-MC vs ChatGPT-4o-MC
## -----
## Proportions: 0.622 vs 0.441
## Difference: 0.181
## Chi-squared: 25.919
## Degrees of freedom: 1

```

```

## P-value: 0.000000356
## 95% CI: [ 0.11 , 0.252 ]
## Significant: YES (p < 0.05)
##
## o3-MC vs GPT-4.1-SC
## -----
## Proportions: 0.622 vs 0.441
## Difference: 0.181
## Chi-squared: 25.854
## Degrees of freedom: 1
## P-value: 0.0000003683
## 95% CI: [ 0.11 , 0.252 ]
## Significant: YES (p < 0.05)
##
## o3-MC vs GPT-4.1-MC
## -----
## Proportions: 0.622 vs 0.408
## Difference: 0.214
## Chi-squared: 36.205
## Degrees of freedom: 1
## P-value: 0.000000001776
## 95% CI: [ 0.144 , 0.284 ]
## Significant: YES (p < 0.05)
##
## o3-MC vs GPT-4.1-GPT-Image-SC
## -----
## Proportions: 0.622 vs 0.386
## Difference: 0.236
## Chi-squared: 44.007
## Degrees of freedom: 1
## P-value: 0.00000000003271
## 95% CI: [ 0.166 , 0.306 ]
## Significant: YES (p < 0.05)
##
## o3-MC vs GPT-4.1-GPT-Image-MC
## -----
## Proportions: 0.622 vs 0.38
## Difference: 0.242
## Chi-squared: 46.327
## Degrees of freedom: 1
## P-value: 0.00000000001001
## 95% CI: [ 0.173 , 0.312 ]
## Significant: YES (p < 0.05)
##
## o3-Pro-SC vs o3-Pro-MC
## -----
## Proportions: 0.667 vs 0.66
## Difference: 0.007
## Chi-squared: 0.02
## Degrees of freedom: 1
## P-value: 0.887
## 95% CI: [ -0.061 , 0.075 ]
## Significant: NO
##

```

```

## o3-Pro-SC vs o4-mini-SC
## -----
## Proportions: 0.667 vs 0.487
## Difference: 0.18
## Chi-squared: 19.223
## Degrees of freedom: 1
## P-value: 0.00001163
## 95% CI: [ 0.099 , 0.261 ]
## Significant: YES (p < 0.05)
##
## o3-Pro-SC vs o4-mini-MC
## -----
## Proportions: 0.667 vs 0.573
## Difference: 0.094
## Chi-squared: 5.266
## Degrees of freedom: 1
## P-value: 0.02174
## 95% CI: [ 0.014 , 0.175 ]
## Significant: YES (p < 0.05)
##
## o3-Pro-SC vs Sonnet-4-SC
## -----
## Proportions: 0.667 vs 0.428
## Difference: 0.24
## Chi-squared: 33.854
## Degrees of freedom: 1
## P-value: 0.00000000594
## 95% CI: [ 0.159 , 0.32 ]
## Significant: YES (p < 0.05)
##
## o3-Pro-SC vs Sonnet-4-MC
## -----
## Proportions: 0.667 vs 0.406
## Difference: 0.261
## Chi-squared: 40.139
## Degrees of freedom: 1
## P-value: 0.0000000002366
## 95% CI: [ 0.181 , 0.342 ]
## Significant: YES (p < 0.05)
##
## o3-Pro-SC vs Gemini-2.0-Flash-SC
## -----
## Proportions: 0.667 vs 0.387
## Difference: 0.28
## Chi-squared: 46.111
## Degrees of freedom: 1
## P-value: 0.0000000001117
## 95% CI: [ 0.2 , 0.36 ]
## Significant: YES (p < 0.05)
##
## o3-Pro-SC vs Gemini-2.0-Flash-MC
## -----
## Proportions: 0.667 vs 0.373
## Difference: 0.295

```

```

## Chi-squared: 51.051
## Degrees of freedom: 1
## P-value: 0.0000000000008998
## 95% CI: [ 0.215 , 0.375 ]
## Significant: YES (p < 0.05)
##
## o3-Pro-SC vs Gemini-2.5-Pro-SC
## -----
## Proportions: 0.667 vs 0.467
## Difference: 0.2
## Chi-squared: 23.676
## Degrees of freedom: 1
## P-value: 0.00000114
## 95% CI: [ 0.119 , 0.281 ]
## Significant: YES (p < 0.05)
##
## o3-Pro-SC vs Gemini-2.5-Pro-MC
## -----
## Proportions: 0.667 vs 0.456
## Difference: 0.211
## Chi-squared: 26.31
## Degrees of freedom: 1
## P-value: 0.0000002908
## 95% CI: [ 0.13 , 0.292 ]
## Significant: YES (p < 0.05)
##
## o3-Pro-SC vs ChatGPT-4o-SC
## -----
## Proportions: 0.667 vs 0.398
## Difference: 0.269
## Chi-squared: 42.669
## Degrees of freedom: 1
## P-value: 0.00000000006482
## 95% CI: [ 0.189 , 0.35 ]
## Significant: YES (p < 0.05)
##
## o3-Pro-SC vs ChatGPT-4o-MC
## -----
## Proportions: 0.667 vs 0.441
## Difference: 0.226
## Chi-squared: 30.177
## Degrees of freedom: 1
## P-value: 0.00000003943
## 95% CI: [ 0.145 , 0.307 ]
## Significant: YES (p < 0.05)
##
## o3-Pro-SC vs GPT-4.1-SC
## -----
## Proportions: 0.667 vs 0.441
## Difference: 0.226
## Chi-squared: 30.117
## Degrees of freedom: 1
## P-value: 0.00000004068
## 95% CI: [ 0.145 , 0.307 ]

```

```

## Significant: YES (p < 0.05)
##
## o3-Pro-SC vs GPT-4.1-MC
## -----
## Proportions: 0.667 vs 0.408
## Difference: 0.259
## Chi-squared: 39.534
## Degrees of freedom: 1
## P-value: 0.0000000003224
## 95% CI: [ 0.179 , 0.34 ]
## Significant: YES (p < 0.05)
##
## o3-Pro-SC vs GPT-4.1-GPT-Image-SC
## -----
## Proportions: 0.667 vs 0.386
## Difference: 0.281
## Chi-squared: 46.496
## Degrees of freedom: 1
## P-value: 0.00000000009181
## 95% CI: [ 0.201 , 0.361 ]
## Significant: YES (p < 0.05)
##
## o3-Pro-SC vs GPT-4.1-GPT-Image-MC
## -----
## Proportions: 0.667 vs 0.38
## Difference: 0.287
## Chi-squared: 48.55
## Degrees of freedom: 1
## P-value: 0.0000000000322
## 95% CI: [ 0.208 , 0.367 ]
## Significant: YES (p < 0.05)
##
## o3-Pro-MC vs o4-mini-SC
## -----
## Proportions: 0.66 vs 0.487
## Difference: 0.173
## Chi-squared: 24.255
## Degrees of freedom: 1
## P-value: 0.000000844
## 95% CI: [ 0.102 , 0.244 ]
## Significant: YES (p < 0.05)
##
## o3-Pro-MC vs o4-mini-MC
## -----
## Proportions: 0.66 vs 0.573
## Difference: 0.087
## Chi-squared: 6.137
## Degrees of freedom: 1
## P-value: 0.01324
## 95% CI: [ 0.017 , 0.157 ]
## Significant: YES (p < 0.05)
##
## o3-Pro-MC vs Sonnet-4-SC
## -----

```

```

## Proportions: 0.66 vs 0.428
## Difference: 0.233
## Chi-squared: 43.526
## Degrees of freedom: 1
## P-value: 0.00000000004184
## 95% CI: [ 0.162 , 0.303 ]
## Significant: YES (p < 0.05)
##
## o3-Pro-MC vs Sonnet-4-MC
## -----
## Proportions: 0.66 vs 0.406
## Difference: 0.254
## Chi-squared: 51.794
## Degrees of freedom: 1
## P-value: 0.000000000006163
## 95% CI: [ 0.184 , 0.324 ]
## Significant: YES (p < 0.05)
##
## o3-Pro-MC vs Gemini-2.0-Flash-SC
## -----
## Proportions: 0.66 vs 0.387
## Difference: 0.273
## Chi-squared: 59.631
## Degrees of freedom: 1
## P-value: 0.0000000000001144
## 95% CI: [ 0.203 , 0.342 ]
## Significant: YES (p < 0.05)
##
## o3-Pro-MC vs Gemini-2.0-Flash-MC
## -----
## Proportions: 0.66 vs 0.373
## Difference: 0.288
## Chi-squared: 66.094
## Degrees of freedom: 1
## P-value: 0.00000000000004299
## 95% CI: [ 0.218 , 0.357 ]
## Significant: YES (p < 0.05)
##
## o3-Pro-MC vs Gemini-2.5-Pro-SC
## -----
## Proportions: 0.66 vs 0.467
## Difference: 0.193
## Chi-squared: 30.114
## Degrees of freedom: 1
## P-value: 0.00000004073
## 95% CI: [ 0.122 , 0.263 ]
## Significant: YES (p < 0.05)
##
## o3-Pro-MC vs Gemini-2.5-Pro-MC
## -----
## Proportions: 0.66 vs 0.456
## Difference: 0.204
## Chi-squared: 33.585
## Degrees of freedom: 1

```

```

## P-value: 0.000000006822
## 95% CI: [ 0.133 , 0.274 ]
## Significant: YES (p < 0.05)
##
## o3-Pro-MC vs ChatGPT-4o-SC
## -----
## Proportions: 0.66 vs 0.398
## Difference: 0.262
## Chi-squared: 55.118
## Degrees of freedom: 1
## P-value: 0.0000000000001135
## 95% CI: [ 0.193 , 0.332 ]
## Significant: YES (p < 0.05)
##
## o3-Pro-MC vs ChatGPT-4o-MC
## -----
## Proportions: 0.66 vs 0.441
## Difference: 0.219
## Chi-squared: 38.682
## Degrees of freedom: 1
## P-value: 0.0000000004988
## 95% CI: [ 0.149 , 0.289 ]
## Significant: YES (p < 0.05)
##
## o3-Pro-MC vs GPT-4.1-SC
## -----
## Proportions: 0.66 vs 0.441
## Difference: 0.219
## Chi-squared: 38.602
## Degrees of freedom: 1
## P-value: 0.0000000005197
## 95% CI: [ 0.149 , 0.289 ]
## Significant: YES (p < 0.05)
##
## o3-Pro-MC vs GPT-4.1-MC
## -----
## Proportions: 0.66 vs 0.408
## Difference: 0.252
## Chi-squared: 51
## Degrees of freedom: 1
## P-value: 0.0000000000009238
## 95% CI: [ 0.182 , 0.322 ]
## Significant: YES (p < 0.05)
##
## o3-Pro-MC vs GPT-4.1-GPT-Image-SC
## -----
## Proportions: 0.66 vs 0.386
## Difference: 0.274
## Chi-squared: 60.135
## Degrees of freedom: 1
## P-value: 0.00000000000008855
## 95% CI: [ 0.205 , 0.343 ]
## Significant: YES (p < 0.05)
##

```

```

## o3-Pro-MC vs GPT-4.1-GPT-Image-MC
## -----
## Proportions: 0.66 vs 0.38
## Difference: 0.28
## Chi-squared: 62.824
## Degrees of freedom: 1
## P-value: 0.00000000000000226
## 95% CI: [ 0.211 , 0.349 ]
## Significant: YES (p < 0.05)
##
## o4-mini-SC vs o4-mini-MC
## -----
## Proportions: 0.487 vs 0.573
## Difference: -0.086
## Chi-squared: 4.106
## Degrees of freedom: 1
## P-value: 0.04274
## 95% CI: [ -0.169 , -0.003 ]
## Significant: YES (p < 0.05)
##
## o4-mini-SC vs Sonnet-4-SC
## -----
## Proportions: 0.487 vs 0.428
## Difference: 0.06
## Chi-squared: 1.915
## Degrees of freedom: 1
## P-value: 0.1664
## 95% CI: [ -0.023 , 0.143 ]
## Significant: NO
##
## o4-mini-SC vs Sonnet-4-MC
## -----
## Proportions: 0.487 vs 0.406
## Difference: 0.081
## Chi-squared: 3.671
## Degrees of freedom: 1
## P-value: 0.05537
## 95% CI: [ -0.002 , 0.164 ]
## Significant: NO
##
## o4-mini-SC vs Gemini-2.0-Flash-SC
## -----
## Proportions: 0.487 vs 0.387
## Difference: 0.1
## Chi-squared: 5.693
## Degrees of freedom: 1
## P-value: 0.01704
## 95% CI: [ 0.018 , 0.182 ]
## Significant: YES (p < 0.05)
##
## o4-mini-SC vs Gemini-2.0-Flash-MC
## -----
## Proportions: 0.487 vs 0.373
## Difference: 0.115

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## Chi-squared: 7.58
## Degrees of freedom: 1
## P-value: 0.005902
## 95% CI: [ 0.033 , 0.197 ]
## Significant: YES (p < 0.05)
##
## o4-mini-SC vs Gemini-2.5-Pro-SC
## -----
## Proportions: 0.487 vs 0.467
## Difference: 0.02
## Chi-squared: 0.167
## Degrees of freedom: 1
## P-value: 0.6829
## 95% CI: [ -0.063 , 0.103 ]
## Significant: NO
##
## o4-mini-SC vs Gemini-2.5-Pro-MC
## -----
## Proportions: 0.487 vs 0.456
## Difference: 0.031
## Chi-squared: 0.459
## Degrees of freedom: 1
## P-value: 0.498
## 95% CI: [ -0.052 , 0.114 ]
## Significant: NO
##
## o4-mini-SC vs ChatGPT-4o-SC
## -----
## Proportions: 0.487 vs 0.398
## Difference: 0.089
## Chi-squared: 4.49
## Degrees of freedom: 1
## P-value: 0.0341
## 95% CI: [ 0.007 , 0.172 ]
## Significant: YES (p < 0.05)
##
## o4-mini-SC vs ChatGPT-4o-MC
## -----
## Proportions: 0.487 vs 0.441
## Difference: 0.046
## Chi-squared: 1.103
## Degrees of freedom: 1
## P-value: 0.2936
## 95% CI: [ -0.037 , 0.129 ]
## Significant: NO
##
## o4-mini-SC vs GPT-4.1-SC
## -----
## Proportions: 0.487 vs 0.441
## Difference: 0.046
## Chi-squared: 1.091
## Degrees of freedom: 1
## P-value: 0.2962
## 95% CI: [ -0.037 , 0.129 ]

```

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## Significant: NO
##
## o4-mini-SC vs GPT-4.1-MC
## -----
## Proportions: 0.487 vs 0.408
## Difference: 0.079
## Chi-squared: 3.484
## Degrees of freedom: 1
## P-value: 0.06196
## 95% CI: [ -0.004 , 0.162 ]
## Significant: NO
##
## o4-mini-SC vs GPT-4.1-GPT-Image-SC
## -----
## Proportions: 0.487 vs 0.386
## Difference: 0.101
## Chi-squared: 5.833
## Degrees of freedom: 1
## P-value: 0.01573
## 95% CI: [ 0.019 , 0.183 ]
## Significant: YES (p < 0.05)
##
## o4-mini-SC vs GPT-4.1-GPT-Image-MC
## -----
## Proportions: 0.487 vs 0.38
## Difference: 0.107
## Chi-squared: 6.602
## Degrees of freedom: 1
## P-value: 0.01019
## 95% CI: [ 0.025 , 0.189 ]
## Significant: YES (p < 0.05)
##
## o4-mini-MC vs Sonnet-4-SC
## -----
## Proportions: 0.573 vs 0.428
## Difference: 0.146
## Chi-squared: 12.132
## Degrees of freedom: 1
## P-value: 0.0004958
## 95% CI: [ 0.063 , 0.228 ]
## Significant: YES (p < 0.05)
##
## o4-mini-MC vs Sonnet-4-MC
## -----
## Proportions: 0.573 vs 0.406
## Difference: 0.167
## Chi-squared: 16.081
## Degrees of freedom: 1
## P-value: 0.00006068
## 95% CI: [ 0.085 , 0.249 ]
## Significant: YES (p < 0.05)
##
## o4-mini-MC vs Gemini-2.0-Flash-SC
## -----

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## Proportions: 0.573 vs 0.387
## Difference: 0.186
## Chi-squared: 20.024
## Degrees of freedom: 1
## P-value: 0.000007649
## 95% CI: [ 0.104 , 0.268 ]
## Significant: YES (p < 0.05)
##
## o4-mini-MC vs Gemini-2.0-Flash-MC
## -----
## Proportions: 0.573 vs 0.373
## Difference: 0.201
## Chi-squared: 23.4
## Degrees of freedom: 1
## P-value: 0.000001316
## 95% CI: [ 0.119 , 0.282 ]
## Significant: YES (p < 0.05)
##
## o4-mini-MC vs Gemini-2.5-Pro-SC
## -----
## Proportions: 0.573 vs 0.467
## Difference: 0.106
## Chi-squared: 6.322
## Degrees of freedom: 1
## P-value: 0.01192
## 95% CI: [ 0.023 , 0.189 ]
## Significant: YES (p < 0.05)
##
## o4-mini-MC vs Gemini-2.5-Pro-MC
## -----
## Proportions: 0.573 vs 0.456
## Difference: 0.117
## Chi-squared: 7.74
## Degrees of freedom: 1
## P-value: 0.005401
## 95% CI: [ 0.034 , 0.2 ]
## Significant: YES (p < 0.05)
##
## o4-mini-MC vs ChatGPT-4o-SC
## -----
## Proportions: 0.573 vs 0.398
## Difference: 0.175
## Chi-squared: 17.732
## Degrees of freedom: 1
## P-value: 0.00002544
## 95% CI: [ 0.093 , 0.257 ]
## Significant: YES (p < 0.05)
##
## o4-mini-MC vs ChatGPT-4o-MC
## -----
## Proportions: 0.573 vs 0.441
## Difference: 0.132
## Chi-squared: 9.936
## Degrees of freedom: 1

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## P-value: 0.00162
## 95% CI: [ 0.049 , 0.215 ]
## Significant: YES (p < 0.05)
##
## o4-mini-MC vs GPT-4.1-SC
## -----
## Proportions: 0.573 vs 0.441
## Difference: 0.132
## Chi-squared: 9.901
## Degrees of freedom: 1
## P-value: 0.001652
## 95% CI: [ 0.049 , 0.214 ]
## Significant: YES (p < 0.05)
##
## o4-mini-MC vs GPT-4.1-MC
## -----
## Proportions: 0.573 vs 0.408
## Difference: 0.165
## Chi-squared: 15.692
## Degrees of freedom: 1
## P-value: 0.00007455
## 95% CI: [ 0.083 , 0.247 ]
## Significant: YES (p < 0.05)
##
## o4-mini-MC vs GPT-4.1-GPT-Image-SC
## -----
## Proportions: 0.573 vs 0.386
## Difference: 0.187
## Chi-squared: 20.283
## Degrees of freedom: 1
## P-value: 0.000006678
## 95% CI: [ 0.105 , 0.269 ]
## Significant: YES (p < 0.05)
##
## o4-mini-MC vs GPT-4.1-GPT-Image-MC
## -----
## Proportions: 0.573 vs 0.38
## Difference: 0.193
## Chi-squared: 21.679
## Degrees of freedom: 1
## P-value: 0.000003224
## 95% CI: [ 0.111 , 0.275 ]
## Significant: YES (p < 0.05)
##
## Sonnet-4-SC vs Sonnet-4-MC
## -----
## Proportions: 0.428 vs 0.406
## Difference: 0.021
## Chi-squared: 0.203
## Degrees of freedom: 1
## P-value: 0.6521
## 95% CI: [ -0.061 , 0.104 ]
## Significant: NO
##

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## Sonnet-4-SC vs Gemini-2.0-Flash-SC
## -----
## Proportions: 0.428 vs 0.387
## Difference: 0.04
## Chi-squared: 0.851
## Degrees of freedom: 1
## P-value: 0.3562
## 95% CI: [ -0.042 , 0.122 ]
## Significant: NO
##
## Sonnet-4-SC vs Gemini-2.0-Flash-MC
## -----
## Proportions: 0.428 vs 0.373
## Difference: 0.055
## Chi-squared: 1.668
## Degrees of freedom: 1
## P-value: 0.1965
## 95% CI: [ -0.027 , 0.137 ]
## Significant: NO
##
## Sonnet-4-SC vs Gemini-2.5-Pro-SC
## -----
## Proportions: 0.428 vs 0.467
## Difference: -0.04
## Chi-squared: 0.799
## Degrees of freedom: 1
## P-value: 0.3713
## 95% CI: [ -0.122 , 0.043 ]
## Significant: NO
##
## Sonnet-4-SC vs Gemini-2.5-Pro-MC
## -----
## Proportions: 0.428 vs 0.456
## Difference: -0.029
## Chi-squared: 0.39
## Degrees of freedom: 1
## P-value: 0.5321
## 95% CI: [ -0.111 , 0.054 ]
## Significant: NO
##
## Sonnet-4-SC vs ChatGPT-4o-SC
## -----
## Proportions: 0.428 vs 0.398
## Difference: 0.03
## Chi-squared: 0.428
## Degrees of freedom: 1
## P-value: 0.5128
## 95% CI: [ -0.052 , 0.112 ]
## Significant: NO
##
## Sonnet-4-SC vs ChatGPT-4o-MC
## -----
## Proportions: 0.428 vs 0.441
## Difference: -0.014

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## Chi-squared: 0.063
## Degrees of freedom: 1
## P-value: 0.8013
## 95% CI: [ -0.096 , 0.069 ]
## Significant: NO
##
## Sonnet-4-SC vs GPT-4.1-SC
## -----
## Proportions: 0.428 vs 0.441
## Difference: -0.014
## Chi-squared: 0.066
## Degrees of freedom: 1
## P-value: 0.7969
## 95% CI: [ -0.096 , 0.069 ]
## Significant: NO
##
## Sonnet-4-SC vs GPT-4.1-MC
## -----
## Proportions: 0.428 vs 0.408
## Difference: 0.019
## Chi-squared: 0.161
## Degrees of freedom: 1
## P-value: 0.6882
## 95% CI: [ -0.063 , 0.102 ]
## Significant: NO
##
## Sonnet-4-SC vs GPT-4.1-GPT-Image-SC
## -----
## Proportions: 0.428 vs 0.386
## Difference: 0.042
## Chi-squared: 0.906
## Degrees of freedom: 1
## P-value: 0.3411
## 95% CI: [ -0.04 , 0.123 ]
## Significant: NO
##
## Sonnet-4-SC vs GPT-4.1-GPT-Image-MC
## -----
## Proportions: 0.428 vs 0.38
## Difference: 0.048
## Chi-squared: 1.225
## Degrees of freedom: 1
## P-value: 0.2683
## 95% CI: [ -0.034 , 0.129 ]
## Significant: NO
##
## Sonnet-4-MC vs Gemini-2.0-Flash-SC
## -----
## Proportions: 0.406 vs 0.387
## Difference: 0.019
## Chi-squared: 0.151
## Degrees of freedom: 1
## P-value: 0.6975
## 95% CI: [ -0.063 , 0.1 ]

```

```

## Significant: NO
##
## Sonnet-4-MC vs Gemini-2.0-Flash-MC
## -----
## Proportions: 0.406 vs 0.373
## Difference: 0.034
## Chi-squared: 0.575
## Degrees of freedom: 1
## P-value: 0.4484
## 95% CI: [ -0.048 , 0.115 ]
## Significant: NO
##
## Sonnet-4-MC vs Gemini-2.5-Pro-SC
## -----
## Proportions: 0.406 vs 0.467
## Difference: -0.061
## Chi-squared: 2.036
## Degrees of freedom: 1
## P-value: 0.1537
## 95% CI: [ -0.144 , 0.021 ]
## Significant: NO
##
## Sonnet-4-MC vs Gemini-2.5-Pro-MC
## -----
## Proportions: 0.406 vs 0.456
## Difference: -0.05
## Chi-squared: 1.34
## Degrees of freedom: 1
## P-value: 0.2469
## 95% CI: [ -0.133 , 0.032 ]
## Significant: NO
##
## Sonnet-4-MC vs ChatGPT-4o-SC
## -----
## Proportions: 0.406 vs 0.398
## Difference: 0.008
## Chi-squared: 0.015
## Degrees of freedom: 1
## P-value: 0.9041
## 95% CI: [ -0.074 , 0.09 ]
## Significant: NO
##
## Sonnet-4-MC vs ChatGPT-4o-MC
## -----
## Proportions: 0.406 vs 0.441
## Difference: -0.035
## Chi-squared: 0.616
## Degrees of freedom: 1
## P-value: 0.4325
## 95% CI: [ -0.117 , 0.047 ]
## Significant: NO
##
## Sonnet-4-MC vs GPT-4.1-SC
## -----

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## Proportions: 0.406 vs 0.441
## Difference: -0.035
## Chi-squared: 0.625
## Degrees of freedom: 1
## P-value: 0.4291
## 95% CI: [ -0.118 , 0.047 ]
## Significant: NO
##
## Sonnet-4-MC vs GPT-4.1-MC
## -----
## Proportions: 0.406 vs 0.408
## Difference: -0.002
## Chi-squared: 0
## Degrees of freedom: 1
## P-value: 1
## 95% CI: [ -0.083 , 0.079 ]
## Significant: NO
##
## Sonnet-4-MC vs GPT-4.1-GPT-Image-SC
## -----
## Proportions: 0.406 vs 0.386
## Difference: 0.02
## Chi-squared: 0.175
## Degrees of freedom: 1
## P-value: 0.6758
## 95% CI: [ -0.062 , 0.102 ]
## Significant: NO
##
## Sonnet-4-MC vs GPT-4.1-GPT-Image-MC
## -----
## Proportions: 0.406 vs 0.38
## Difference: 0.026
## Chi-squared: 0.329
## Degrees of freedom: 1
## P-value: 0.5665
## 95% CI: [ -0.055 , 0.108 ]
## Significant: NO
##
## Gemini-2.0-Flash-SC vs Gemini-2.0-Flash-MC
## -----
## Proportions: 0.387 vs 0.373
## Difference: 0.015
## Chi-squared: 0.082
## Degrees of freedom: 1
## P-value: 0.7751
## 95% CI: [ -0.066 , 0.096 ]
## Significant: NO
##
## Gemini-2.0-Flash-SC vs Gemini-2.5-Pro-SC
## -----
## Proportions: 0.387 vs 0.467
## Difference: -0.08
## Chi-squared: 3.6
## Degrees of freedom: 1

```



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## P-value: 0.05777
## 95% CI: [ -0.162 , 0.002 ]
## Significant: NO
##
## Gemini-2.0-Flash-SC vs Gemini-2.5-Pro-MC
## -----
## Proportions: 0.387 vs 0.456
## Difference: -0.069
## Chi-squared: 2.653
## Degrees of freedom: 1
## P-value: 0.1033
## 95% CI: [ -0.151 , 0.013 ]
## Significant: NO
##
## Gemini-2.0-Flash-SC vs ChatGPT-4o-SC
## -----
## Proportions: 0.387 vs 0.398
## Difference: -0.011
## Chi-squared: 0.034
## Degrees of freedom: 1
## P-value: 0.8534
## 95% CI: [ -0.092 , 0.071 ]
## Significant: NO
##
## Gemini-2.0-Flash-SC vs ChatGPT-4o-MC
## -----
## Proportions: 0.387 vs 0.441
## Difference: -0.054
## Chi-squared: 1.579
## Degrees of freedom: 1
## P-value: 0.209
## 95% CI: [ -0.136 , 0.028 ]
## Significant: NO
##
## Gemini-2.0-Flash-SC vs GPT-4.1-SC
## -----
## Proportions: 0.387 vs 0.441
## Difference: -0.054
## Chi-squared: 1.593
## Degrees of freedom: 1
## P-value: 0.2069
## 95% CI: [ -0.136 , 0.028 ]
## Significant: NO
##
## Gemini-2.0-Flash-SC vs GPT-4.1-MC
## -----
## Proportions: 0.387 vs 0.408
## Difference: -0.021
## Chi-squared: 0.192
## Degrees of freedom: 1
## P-value: 0.6612
## 95% CI: [ -0.102 , 0.061 ]
## Significant: NO
##

```

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## Gemini-2.0-Flash-SC vs GPT-4.1-GPT-Image-SC
## -----
## Proportions: 0.387 vs 0.386
## Difference: 0.001
## Chi-squared: 0
## Degrees of freedom: 1
## P-value: 1
## 95% CI: [ -0.078 , 0.08 ]
## Significant: NO
##
## Gemini-2.0-Flash-SC vs GPT-4.1-GPT-Image-MC
## -----
## Proportions: 0.387 vs 0.38
## Difference: 0.007
## Chi-squared: 0.01
## Degrees of freedom: 1
## P-value: 0.9198
## 95% CI: [ -0.074 , 0.088 ]
## Significant: NO
##
## Gemini-2.0-Flash-MC vs Gemini-2.5-Pro-SC
## -----
## Proportions: 0.373 vs 0.467
## Difference: -0.095
## Chi-squared: 5.132
## Degrees of freedom: 1
## P-value: 0.02349
## 95% CI: [ -0.177 , -0.013 ]
## Significant: YES (p < 0.05)
##
## Gemini-2.0-Flash-MC vs Gemini-2.5-Pro-MC
## -----
## Proportions: 0.373 vs 0.456
## Difference: -0.084
## Chi-squared: 3.989
## Degrees of freedom: 1
## P-value: 0.0458
## 95% CI: [ -0.166 , -0.002 ]
## Significant: YES (p < 0.05)
##
## Gemini-2.0-Flash-MC vs ChatGPT-4o-SC
## -----
## Proportions: 0.373 vs 0.398
## Difference: -0.025
## Chi-squared: 0.307
## Degrees of freedom: 1
## P-value: 0.5794
## 95% CI: [ -0.107 , 0.056 ]
## Significant: NO
##
## Gemini-2.0-Flash-MC vs ChatGPT-4o-MC
## -----
## Proportions: 0.373 vs 0.441
## Difference: -0.069

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## Chi-squared: 2.641
## Degrees of freedom: 1
## P-value: 0.1041
## 95% CI: [ -0.15 , 0.013 ]
## Significant: NO
##
## Gemini-2.0-Flash-MC vs GPT-4.1-SC
## -----
## Proportions: 0.373 vs 0.441
## Difference: -0.069
## Chi-squared: 2.66
## Degrees of freedom: 1
## P-value: 0.1029
## 95% CI: [ -0.151 , 0.013 ]
## Significant: NO
##
## Gemini-2.0-Flash-MC vs GPT-4.1-MC
## -----
## Proportions: 0.373 vs 0.408
## Difference: -0.036
## Chi-squared: 0.652
## Degrees of freedom: 1
## P-value: 0.4193
## 95% CI: [ -0.117 , 0.046 ]
## Significant: NO
##
## Gemini-2.0-Flash-MC vs GPT-4.1-GPT-Image-SC
## -----
## Proportions: 0.373 vs 0.386
## Difference: -0.013
## Chi-squared: 0.066
## Degrees of freedom: 1
## P-value: 0.7978
## 95% CI: [ -0.094 , 0.067 ]
## Significant: NO
##
## Gemini-2.0-Flash-MC vs GPT-4.1-GPT-Image-MC
## -----
## Proportions: 0.373 vs 0.38
## Difference: -0.007
## Chi-squared: 0.01
## Degrees of freedom: 1
## P-value: 0.9197
## 95% CI: [ -0.088 , 0.074 ]
## Significant: NO
##
## Gemini-2.5-Pro-SC vs Gemini-2.5-Pro-MC
## -----
## Proportions: 0.467 vs 0.456
## Difference: 0.011
## Chi-squared: 0.035
## Degrees of freedom: 1
## P-value: 0.8514
## 95% CI: [ -0.072 , 0.094 ]

```

```

## Significant: NO
##
## Gemini-2.5-Pro-SC vs ChatGPT-4o-SC
## -----
## Proportions: 0.467 vs 0.398
## Difference: 0.069
## Chi-squared: 2.657
## Degrees of freedom: 1
## P-value: 0.1031
## 95% CI: [ -0.013 , 0.152 ]
## Significant: NO
##
## Gemini-2.5-Pro-SC vs ChatGPT-4o-MC
## -----
## Proportions: 0.467 vs 0.441
## Difference: 0.026
## Chi-squared: 0.314
## Degrees of freedom: 1
## P-value: 0.5753
## 95% CI: [ -0.057 , 0.109 ]
## Significant: NO
##
## Gemini-2.5-Pro-SC vs GPT-4.1-SC
## -----
## Proportions: 0.467 vs 0.441
## Difference: 0.026
## Chi-squared: 0.307
## Degrees of freedom: 1
## P-value: 0.5792
## 95% CI: [ -0.057 , 0.109 ]
## Significant: NO
##
## Gemini-2.5-Pro-SC vs GPT-4.1-MC
## -----
## Proportions: 0.467 vs 0.408
## Difference: 0.059
## Chi-squared: 1.897
## Degrees of freedom: 1
## P-value: 0.1684
## 95% CI: [ -0.023 , 0.142 ]
## Significant: NO
##
## Gemini-2.5-Pro-SC vs GPT-4.1-GPT-Image-SC
## -----
## Proportions: 0.467 vs 0.386
## Difference: 0.081
## Chi-squared: 3.712
## Degrees of freedom: 1
## P-value: 0.05401
## 95% CI: [ -0.001 , 0.163 ]
## Significant: NO
##
## Gemini-2.5-Pro-SC vs GPT-4.1-GPT-Image-MC
## -----

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## Proportions: 0.467 vs 0.38
## Difference: 0.087
## Chi-squared: 4.332
## Degrees of freedom: 1
## P-value: 0.0374
## 95% CI: [ 0.005 , 0.169 ]
## Significant: YES (p < 0.05)
##
## Gemini-2.5-Pro-MC vs ChatGPT-4o-SC
## -----
## Proportions: 0.456 vs 0.398
## Difference: 0.058
## Chi-squared: 1.853
## Degrees of freedom: 1
## P-value: 0.1735
## 95% CI: [ -0.024 , 0.141 ]
## Significant: NO
##
## Gemini-2.5-Pro-MC vs ChatGPT-4o-MC
## -----
## Proportions: 0.456 vs 0.441
## Difference: 0.015
## Chi-squared: 0.085
## Degrees of freedom: 1
## P-value: 0.7711
## 95% CI: [ -0.068 , 0.098 ]
## Significant: NO
##
## Gemini-2.5-Pro-MC vs GPT-4.1-SC
## -----
## Proportions: 0.456 vs 0.441
## Difference: 0.015
## Chi-squared: 0.081
## Degrees of freedom: 1
## P-value: 0.7755
## 95% CI: [ -0.068 , 0.098 ]
## Significant: NO
##
## Gemini-2.5-Pro-MC vs GPT-4.1-MC
## -----
## Proportions: 0.456 vs 0.408
## Difference: 0.048
## Chi-squared: 1.228
## Degrees of freedom: 1
## P-value: 0.2677
## 95% CI: [ -0.034 , 0.131 ]
## Significant: NO
##
## Gemini-2.5-Pro-MC vs GPT-4.1-GPT-Image-SC
## -----
## Proportions: 0.456 vs 0.386
## Difference: 0.07
## Chi-squared: 2.75
## Degrees of freedom: 1

```

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## P-value: 0.09728
## 95% CI: [ -0.012 , 0.152 ]
## Significant: NO
##
## Gemini-2.5-Pro-MC vs GPT-4.1-GPT-Image-MC
## -----
## Proportions: 0.456 vs 0.38
## Difference: 0.076
## Chi-squared: 3.287
## Degrees of freedom: 1
## P-value: 0.06985
## 95% CI: [ -0.006 , 0.158 ]
## Significant: NO
##
## ChatGPT-4o-SC vs ChatGPT-4o-MC
## -----
## Proportions: 0.398 vs 0.441
## Difference: -0.043
## Chi-squared: 0.977
## Degrees of freedom: 1
## P-value: 0.3229
## 95% CI: [ -0.125 , 0.039 ]
## Significant: NO
##
## ChatGPT-4o-SC vs GPT-4.1-SC
## -----
## Proportions: 0.398 vs 0.441
## Difference: -0.043
## Chi-squared: 0.988
## Degrees of freedom: 1
## P-value: 0.3201
## 95% CI: [ -0.126 , 0.039 ]
## Significant: NO
##
## ChatGPT-4o-SC vs GPT-4.1-MC
## -----
## Proportions: 0.398 vs 0.408
## Difference: -0.01
## Chi-squared: 0.029
## Degrees of freedom: 1
## P-value: 0.8649
## 95% CI: [ -0.092 , 0.072 ]
## Significant: NO
##
## ChatGPT-4o-SC vs GPT-4.1-GPT-Image-SC
## -----
## Proportions: 0.398 vs 0.386
## Difference: 0.012
## Chi-squared: 0.046
## Degrees of freedom: 1
## P-value: 0.8304
## 95% CI: [ -0.07 , 0.093 ]
## Significant: NO
##

```

```

## ChatGPT-4o-SC vs GPT-4.1-GPT-Image-MC
## -----
## Proportions: 0.398 vs 0.38
## Difference: 0.018
## Chi-squared: 0.136
## Degrees of freedom: 1
## P-value: 0.7119
## 95% CI: [ -0.063 , 0.099 ]
## Significant: NO
##
## ChatGPT-4o-MC vs GPT-4.1-SC
## -----
## Proportions: 0.441 vs 0.441
## Difference: 0
## Chi-squared: 0
## Degrees of freedom: 1
## P-value: 1
## 95% CI: [ -0.08 , 0.079 ]
## Significant: NO
##
## ChatGPT-4o-MC vs GPT-4.1-MC
## -----
## Proportions: 0.441 vs 0.408
## Difference: 0.033
## Chi-squared: 0.541
## Degrees of freedom: 1
## P-value: 0.4621
## 95% CI: [ -0.049 , 0.115 ]
## Significant: NO
##
## ChatGPT-4o-MC vs GPT-4.1-GPT-Image-SC
## -----
## Proportions: 0.441 vs 0.386
## Difference: 0.055
## Chi-squared: 1.653
## Degrees of freedom: 1
## P-value: 0.1985
## 95% CI: [ -0.027 , 0.137 ]
## Significant: NO
##
## ChatGPT-4o-MC vs GPT-4.1-GPT-Image-MC
## -----
## Proportions: 0.441 vs 0.38
## Difference: 0.061
## Chi-squared: 2.075
## Degrees of freedom: 1
## P-value: 0.1497
## 95% CI: [ -0.021 , 0.143 ]
## Significant: NO
##
## GPT-4.1-SC vs GPT-4.1-MC
## -----
## Proportions: 0.441 vs 0.408
## Difference: 0.033

```

```

## Chi-squared: 0.549
## Degrees of freedom: 1
## P-value: 0.4586
## 95% CI: [ -0.049 , 0.116 ]
## Significant: NO
##
## GPT-4.1-SC vs GPT-4.1-GPT-Image-SC
## -----
## Proportions: 0.441 vs 0.386
## Difference: 0.055
## Chi-squared: 1.668
## Degrees of freedom: 1
## P-value: 0.1966
## 95% CI: [ -0.027 , 0.137 ]
## Significant: NO
##
## GPT-4.1-SC vs GPT-4.1-GPT-Image-MC
## -----
## Proportions: 0.441 vs 0.38
## Difference: 0.061
## Chi-squared: 2.092
## Degrees of freedom: 1
## P-value: 0.1481
## 95% CI: [ -0.02 , 0.143 ]
## Significant: NO
##
## GPT-4.1-MC vs GPT-4.1-GPT-Image-SC
## -----
## Proportions: 0.408 vs 0.386
## Difference: 0.022
## Chi-squared: 0.219
## Degrees of freedom: 1
## P-value: 0.64
## 95% CI: [ -0.06 , 0.104 ]
## Significant: NO
##
## GPT-4.1-MC vs GPT-4.1-GPT-Image-MC
## -----
## Proportions: 0.408 vs 0.38
## Difference: 0.028
## Chi-squared: 0.388
## Degrees of freedom: 1
## P-value: 0.5334
## 95% CI: [ -0.053 , 0.11 ]
## Significant: NO
##
## GPT-4.1-GPT-Image-SC vs GPT-4.1-GPT-Image-MC
## -----
## Proportions: 0.386 vs 0.38
## Difference: 0.006
## Chi-squared: 0.005
## Degrees of freedom: 1
## P-value: 0.9432
## 95% CI: [ -0.075 , 0.087 ]

```


Significant: NO

##

##

Summary Table - Single-Context vs Multiple-Context:

##

##

##	comparison	diff	chi_squared	p_value	signi.
##	-----	-----	-----	-----	-----
## X-squared	o3-SC vs o3-MC	0.014	0.1064260	0.7443	FALSE
## X-squared1	o3-SC vs o3-Pro-SC	-0.032	0.5244141	0.4690	FALSE
## X-squared2	o3-SC vs o3-Pro-MC	-0.024	0.4171953	0.5183	FALSE
## X-squared3	o3-SC vs o4-mini-SC	0.149	12.8683810	0.0003	TRUE
## X-squared4	o3-SC vs o4-mini-MC	0.063	2.2159433	0.1366	FALSE
## X-squared5	o3-SC vs Sonnet-4-SC	0.208	25.3065478	0.0000	TRUE
## X-squared6	o3-SC vs Sonnet-4-MC	0.230	30.8197762	0.0000	TRUE
## X-squared7	o3-SC vs Gemini-2.0-Flash-SC	0.249	36.1232148	0.0000	TRUE
## X-squared8	o3-SC vs Gemini-2.0-Flash-MC	0.263	40.5493640	0.0000	TRUE
## X-squared9	o3-SC vs Gemini-2.5-Pro-SC	0.169	16.5768348	0.0000	TRUE
## X-squared10	o3-SC vs Gemini-2.5-Pro-MC	0.180	18.8068512	0.0000	TRUE
## X-squared11	o3-SC vs ChatGPT-4o-SC	0.238	33.0601386	0.0000	TRUE
## X-squared12	o3-SC vs ChatGPT-4o-MC	0.195	22.1202375	0.0000	TRUE
## X-squared13	o3-SC vs GPT-4.1-SC	0.195	22.0678694	0.0000	TRUE
## X-squared14	o3-SC vs GPT-4.1-MC	0.228	30.2861685	0.0000	TRUE
## X-squared15	o3-SC vs GPT-4.1-GPT-Image-SC	0.250	36.4668794	0.0000	TRUE
## X-squared16	o3-SC vs GPT-4.1-GPT-Image-MC	0.256	38.3043217	0.0000	TRUE
## X-squared17	o3-MC vs o3-Pro-SC	-0.045	1.5747438	0.2095	FALSE
## X-squared18	o3-MC vs o3-Pro-MC	-0.038	1.7130313	0.1906	FALSE
## X-squared19	o3-MC vs o4-mini-SC	0.135	14.3908156	0.0001	TRUE
## X-squared20	o3-MC vs o4-mini-MC	0.049	1.8192544	0.1774	FALSE
## X-squared21	o3-MC vs Sonnet-4-SC	0.195	29.9264284	0.0000	TRUE
## X-squared22	o3-MC vs Sonnet-4-MC	0.216	36.8780816	0.0000	TRUE
## X-squared23	o3-MC vs Gemini-2.0-Flash-SC	0.235	43.5735443	0.0000	TRUE
## X-squared24	o3-MC vs Gemini-2.0-Flash-MC	0.250	49.1598340	0.0000	TRUE
## X-squared25	o3-MC vs Gemini-2.5-Pro-SC	0.155	18.9850421	0.0000	TRUE
## X-squared26	o3-MC vs Gemini-2.5-Pro-MC	0.166	21.7672906	0.0000	TRUE
## X-squared27	o3-MC vs ChatGPT-4o-SC	0.224	39.7062102	0.0000	TRUE
## X-squared28	o3-MC vs ChatGPT-4o-MC	0.181	25.9194238	0.0000	TRUE
## X-squared29	o3-MC vs GPT-4.1-SC	0.181	25.8536662	0.0000	TRUE
## X-squared30	o3-MC vs GPT-4.1-MC	0.214	36.2046458	0.0000	TRUE
## X-squared31	o3-MC vs GPT-4.1-GPT-Image-SC	0.236	44.0074173	0.0000	TRUE
## X-squared32	o3-MC vs GPT-4.1-GPT-Image-MC	0.242	46.3268747	0.0000	TRUE
## X-squared33	o3-Pro-SC vs o3-Pro-MC	0.007	0.0201847	0.8870	FALSE
## X-squared34	o3-Pro-SC vs o4-mini-SC	0.180	19.2229175	0.0000	TRUE
## X-squared35	o3-Pro-SC vs o4-mini-MC	0.094	5.2661001	0.0217	TRUE
## X-squared36	o3-Pro-SC vs Sonnet-4-SC	0.240	33.8541333	0.0000	TRUE
## X-squared37	o3-Pro-SC vs Sonnet-4-MC	0.261	40.1386029	0.0000	TRUE
## X-squared38	o3-Pro-SC vs Gemini-2.0-Flash-SC	0.280	46.1109296	0.0000	TRUE
## X-squared39	o3-Pro-SC vs Gemini-2.0-Flash-MC	0.295	51.0514768	0.0000	TRUE
## X-squared40	o3-Pro-SC vs Gemini-2.5-Pro-SC	0.200	23.6756299	0.0000	TRUE
## X-squared41	o3-Pro-SC vs Gemini-2.5-Pro-MC	0.211	26.3098049	0.0000	TRUE
## X-squared42	o3-Pro-SC vs ChatGPT-4o-SC	0.269	42.6692467	0.0000	TRUE
## X-squared43	o3-Pro-SC vs ChatGPT-4o-MC	0.226	30.1773792	0.0000	TRUE
## X-squared44	o3-Pro-SC vs GPT-4.1-SC	0.226	30.1166275	0.0000	TRUE

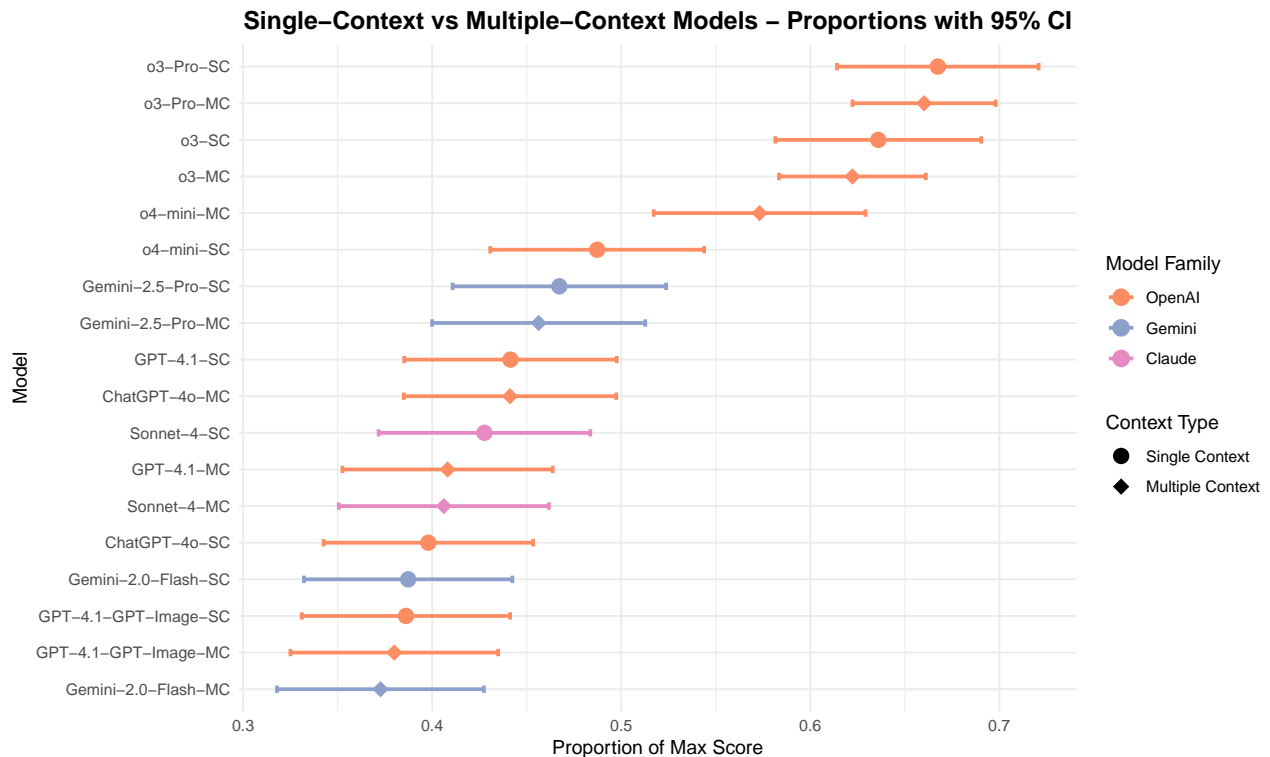
## X-squared45	o3-Pro-SC vs GPT-4.1-MC	0.259	39.5340433	0.0000	TRUE
## X-squared46	o3-Pro-SC vs GPT-4.1-GPT-Image-SC	0.281	46.4958563	0.0000	TRUE
## X-squared47	o3-Pro-SC vs GPT-4.1-GPT-Image-MC	0.287	48.5500288	0.0000	TRUE
## X-squared48	o3-Pro-MC vs o4-mini-SC	0.173	24.2547825	0.0000	TRUE
## X-squared49	o3-Pro-MC vs o4-mini-MC	0.087	6.1367646	0.0132	TRUE
## X-squared50	o3-Pro-MC vs Sonnet-4-SC	0.233	43.5260055	0.0000	TRUE
## X-squared51	o3-Pro-MC vs Sonnet-4-MC	0.254	51.7942706	0.0000	TRUE
## X-squared52	o3-Pro-MC vs Gemini-2.0-Flash-SC	0.273	59.6311060	0.0000	TRUE
## X-squared53	o3-Pro-MC vs Gemini-2.0-Flash-MC	0.288	66.0942845	0.0000	TRUE
## X-squared54	o3-Pro-MC vs Gemini-2.5-Pro-SC	0.193	30.1141832	0.0000	TRUE
## X-squared55	o3-Pro-MC vs Gemini-2.5-Pro-MC	0.204	33.5848305	0.0000	TRUE
## X-squared56	o3-Pro-MC vs ChatGPT-4o-SC	0.262	55.1178401	0.0000	TRUE
## X-squared57	o3-Pro-MC vs ChatGPT-4o-MC	0.219	38.6819968	0.0000	TRUE
## X-squared58	o3-Pro-MC vs GPT-4.1-SC	0.219	38.6019359	0.0000	TRUE
## X-squared59	o3-Pro-MC vs GPT-4.1-MC	0.252	50.9997192	0.0000	TRUE
## X-squared60	o3-Pro-MC vs GPT-4.1-GPT-Image-SC	0.274	60.1353518	0.0000	TRUE
## X-squared61	o3-Pro-MC vs GPT-4.1-GPT-Image-MC	0.280	62.8243540	0.0000	TRUE
## X-squared62	o4-mini-SC vs o4-mini-MC	-0.086	4.1058213	0.0427	TRUE
## X-squared63	o4-mini-SC vs Sonnet-4-SC	0.060	1.9149825	0.1664	FALSE
## X-squared64	o4-mini-SC vs Sonnet-4-MC	0.081	3.6709551	0.0554	FALSE
## X-squared65	o4-mini-SC vs Gemini-2.0-Flash-SC	0.100	5.6925532	0.0170	TRUE
## X-squared66	o4-mini-SC vs Gemini-2.0-Flash-MC	0.115	7.5799978	0.0059	TRUE
## X-squared67	o4-mini-SC vs Gemini-2.5-Pro-SC	0.020	0.1669324	0.6829	FALSE
## X-squared68	o4-mini-SC vs Gemini-2.5-Pro-MC	0.031	0.4592808	0.4980	FALSE
## X-squared69	o4-mini-SC vs ChatGPT-4o-SC	0.089	4.4897434	0.0341	TRUE
## X-squared70	o4-mini-SC vs ChatGPT-4o-MC	0.046	1.1032067	0.2936	FALSE
## X-squared71	o4-mini-SC vs GPT-4.1-SC	0.046	1.0913292	0.2962	FALSE
## X-squared72	o4-mini-SC vs GPT-4.1-MC	0.079	3.4841966	0.0620	FALSE
## X-squared73	o4-mini-SC vs GPT-4.1-GPT-Image-SC	0.101	5.8330562	0.0157	TRUE
## X-squared74	o4-mini-SC vs GPT-4.1-GPT-Image-MC	0.107	6.6020180	0.0102	TRUE
## X-squared75	o4-mini-MC vs Sonnet-4-SC	0.146	12.1315640	0.0005	TRUE
## X-squared76	o4-mini-MC vs Sonnet-4-MC	0.167	16.0812760	0.0001	TRUE
## X-squared77	o4-mini-MC vs Gemini-2.0-Flash-SC	0.186	20.0237337	0.0000	TRUE
## X-squared78	o4-mini-MC vs Gemini-2.0-Flash-MC	0.201	23.4000962	0.0000	TRUE
## X-squared79	o4-mini-MC vs Gemini-2.5-Pro-SC	0.106	6.3223902	0.0119	TRUE
## X-squared80	o4-mini-MC vs Gemini-2.5-Pro-MC	0.117	7.7398604	0.0054	TRUE
## X-squared81	o4-mini-MC vs ChatGPT-4o-SC	0.175	17.7315722	0.0000	TRUE
## X-squared82	o4-mini-MC vs ChatGPT-4o-MC	0.132	9.9363335	0.0016	TRUE
## X-squared83	o4-mini-MC vs GPT-4.1-SC	0.132	9.9008851	0.0017	TRUE
## X-squared84	o4-mini-MC vs GPT-4.1-MC	0.165	15.6917631	0.0001	TRUE
## X-squared85	o4-mini-MC vs GPT-4.1-GPT-Image-SC	0.187	20.2832914	0.0000	TRUE
## X-squared86	o4-mini-MC vs GPT-4.1-GPT-Image-MC	0.193	21.6786709	0.0000	TRUE
## X-squared87	Sonnet-4-SC vs Sonnet-4-MC	0.021	0.2032859	0.6521	FALSE
## X-squared88	Sonnet-4-SC vs Gemini-2.0-Flash-SC	0.040	0.8510755	0.3562	FALSE
## X-squared89	Sonnet-4-SC vs Gemini-2.0-Flash-MC	0.055	1.6682043	0.1965	FALSE
## X-squared90	Sonnet-4-SC vs Gemini-2.5-Pro-SC	-0.040	0.7991629	0.3713	FALSE
## X-squared91	Sonnet-4-SC vs Gemini-2.5-Pro-MC	-0.029	0.3903232	0.5321	FALSE
## X-squared92	Sonnet-4-SC vs ChatGPT-4o-SC	0.030	0.4283362	0.5128	FALSE
## X-squared93	Sonnet-4-SC vs ChatGPT-4o-MC	-0.014	0.0633493	0.8013	FALSE
## X-squared94	Sonnet-4-SC vs GPT-4.1-SC	-0.014	0.0662403	0.7969	FALSE
## X-squared95	Sonnet-4-SC vs GPT-4.1-MC	0.019	0.1610833	0.6882	FALSE
## X-squared96	Sonnet-4-SC vs GPT-4.1-GPT-Image-SC	0.042	0.9061713	0.3411	FALSE
## X-squared97	Sonnet-4-SC vs GPT-4.1-GPT-Image-MC	0.048	1.2252528	0.2683	FALSE
## X-squared98	Sonnet-4-MC vs Gemini-2.0-Flash-SC	0.019	0.1511137	0.6975	FALSE

## X-squared99	Sonnet-4-MC vs Gemini-2.0-Flash-MC	0.034	0.5747113	0.4484	FALSE
## X-squared100	Sonnet-4-MC vs Gemini-2.5-Pro-SC	-0.061	2.0355735	0.1537	FALSE
## X-squared101	Sonnet-4-MC vs Gemini-2.5-Pro-MC	-0.050	1.3404799	0.2469	FALSE
## X-squared102	Sonnet-4-MC vs ChatGPT-4o-SC	0.008	0.0145279	0.9041	FALSE
## X-squared103	Sonnet-4-MC vs ChatGPT-4o-MC	-0.035	0.6161811	0.4325	FALSE
## X-squared104	Sonnet-4-MC vs GPT-4.1-SC	-0.035	0.6251246	0.4291	FALSE
## X-squared105	Sonnet-4-MC vs GPT-4.1-MC	-0.002	0.0000000	1.0000	FALSE
## X-squared106	Sonnet-4-MC vs GPT-4.1-GPT-Image-SC	0.020	0.1748460	0.6758	FALSE
## X-squared107	Sonnet-4-MC vs GPT-4.1-GPT-Image-MC	0.026	0.3286100	0.5665	FALSE
## X-squared108	Gemini-2.0-Flash-SC vs Gemini-2.0-Flash-MC	0.015	0.0816078	0.7751	FALSE
## X-squared109	Gemini-2.0-Flash-SC vs Gemini-2.5-Pro-SC	-0.080	3.6002593	0.0578	FALSE
## X-squared110	Gemini-2.0-Flash-SC vs Gemini-2.5-Pro-MC	-0.069	2.6530962	0.1033	FALSE
## X-squared111	Gemini-2.0-Flash-SC vs ChatGPT-4o-SC	-0.011	0.0341562	0.8534	FALSE
## X-squared112	Gemini-2.0-Flash-SC vs ChatGPT-4o-MC	-0.054	1.5785238	0.2090	FALSE
## X-squared113	Gemini-2.0-Flash-SC vs GPT-4.1-SC	-0.054	1.5928066	0.2069	FALSE
## X-squared114	Gemini-2.0-Flash-SC vs GPT-4.1-MC	-0.021	0.1921225	0.6612	FALSE
## X-squared115	Gemini-2.0-Flash-SC vs GPT-4.1-GPT-Image-SC	0.001	0.0000000	1.0000	FALSE
## X-squared116	Gemini-2.0-Flash-SC vs GPT-4.1-GPT-Image-MC	0.007	0.0101498	0.9198	FALSE
## X-squared117	Gemini-2.0-Flash-MC vs Gemini-2.5-Pro-SC	-0.095	5.1322474	0.0235	TRUE
## X-squared118	Gemini-2.0-Flash-MC vs Gemini-2.5-Pro-MC	-0.084	3.9887672	0.0458	TRUE
## X-squared119	Gemini-2.0-Flash-MC vs ChatGPT-4o-SC	-0.025	0.3071885	0.5794	FALSE
## X-squared120	Gemini-2.0-Flash-MC vs ChatGPT-4o-MC	-0.069	2.6411322	0.1041	FALSE
## X-squared121	Gemini-2.0-Flash-MC vs GPT-4.1-SC	-0.069	2.6595797	0.1029	FALSE
## X-squared122	Gemini-2.0-Flash-MC vs GPT-4.1-MC	-0.036	0.6523157	0.4193	FALSE
## X-squared123	Gemini-2.0-Flash-MC vs GPT-4.1-GPT-Image-SC	-0.013	0.0656431	0.7978	FALSE
## X-squared124	Gemini-2.0-Flash-MC vs GPT-4.1-GPT-Image-MC	-0.007	0.0101651	0.9197	FALSE
## X-squared125	Gemini-2.5-Pro-SC vs Gemini-2.5-Pro-MC	0.011	0.0351076	0.8514	FALSE
## X-squared126	Gemini-2.5-Pro-SC vs ChatGPT-4o-SC	0.069	2.6568007	0.1031	FALSE
## X-squared127	Gemini-2.5-Pro-SC vs ChatGPT-4o-MC	0.026	0.3138191	0.5753	FALSE
## X-squared128	Gemini-2.5-Pro-SC vs GPT-4.1-SC	0.026	0.3074950	0.5792	FALSE
## X-squared129	Gemini-2.5-Pro-SC vs GPT-4.1-MC	0.059	1.8969356	0.1684	FALSE
## X-squared130	Gemini-2.5-Pro-SC vs GPT-4.1-GPT-Image-SC	0.081	3.7123815	0.0540	FALSE
## X-squared131	Gemini-2.5-Pro-SC vs GPT-4.1-GPT-Image-MC	0.087	4.3318957	0.0374	TRUE
## X-squared132	Gemini-2.5-Pro-MC vs ChatGPT-4o-SC	0.058	1.8527550	0.1735	FALSE
## X-squared133	Gemini-2.5-Pro-MC vs ChatGPT-4o-MC	0.015	0.0846247	0.7711	FALSE
## X-squared134	Gemini-2.5-Pro-MC vs GPT-4.1-SC	0.015	0.0813555	0.7755	FALSE
## X-squared135	Gemini-2.5-Pro-MC vs GPT-4.1-MC	0.048	1.2283709	0.2677	FALSE
## X-squared136	Gemini-2.5-Pro-MC vs GPT-4.1-GPT-Image-SC	0.070	2.7495509	0.0973	FALSE
## X-squared137	Gemini-2.5-Pro-MC vs GPT-4.1-GPT-Image-MC	0.076	3.2865429	0.0698	FALSE
## X-squared138	ChatGPT-4o-SC vs ChatGPT-4o-MC	-0.043	0.9771033	0.3229	FALSE
## X-squared139	ChatGPT-4o-SC vs GPT-4.1-SC	-0.043	0.9883535	0.3201	FALSE
## X-squared140	ChatGPT-4o-SC vs GPT-4.1-MC	-0.010	0.0289418	0.8649	FALSE
## X-squared141	ChatGPT-4o-SC vs GPT-4.1-GPT-Image-SC	0.012	0.0458944	0.8304	FALSE
## X-squared142	ChatGPT-4o-SC vs GPT-4.1-GPT-Image-MC	0.018	0.1364216	0.7119	FALSE
## X-squared143	ChatGPT-4o-MC vs GPT-4.1-SC	0.000	0.0000000	1.0000	FALSE
## X-squared144	ChatGPT-4o-MC vs GPT-4.1-MC	0.033	0.5409148	0.4621	FALSE
## X-squared145	ChatGPT-4o-MC vs GPT-4.1-GPT-Image-SC	0.055	1.6531946	0.1985	FALSE
## X-squared146	ChatGPT-4o-MC vs GPT-4.1-GPT-Image-MC	0.061	2.0754248	0.1497	FALSE
## X-squared147	GPT-4.1-SC vs GPT-4.1-MC	0.033	0.5492969	0.4586	FALSE
## X-squared148	GPT-4.1-SC vs GPT-4.1-GPT-Image-SC	0.055	1.6678095	0.1966	FALSE
## X-squared149	GPT-4.1-SC vs GPT-4.1-GPT-Image-MC	0.061	2.0917899	0.1481	FALSE
## X-squared150	GPT-4.1-MC vs GPT-4.1-GPT-Image-SC	0.022	0.2187704	0.6400	FALSE
## X-squared151	GPT-4.1-MC vs GPT-4.1-GPT-Image-MC	0.028	0.3879056	0.5334	FALSE
## X-squared152	GPT-4.1-GPT-Image-SC vs GPT-4.1-GPT-Image-MC	0.006	0.0050812	0.9432	FALSE

Visualization of Single vs Multiple Context

```
# Plot for Single-Context vs Multiple-Context
sc_mc_plot <- ggplot(sc_mc_data, aes(x = reorder(model, proportion), y = proportion, color = model)) +
  geom_point(size = 4, aes(color = as.factor(color), shape = as.factor(shape))) +
  geom_errorbar(aes(ymin = proportion - 1.96 * sqrt(proportion * (1 - proportion) / max_score),
    ymax = proportion + 1.96 * sqrt(proportion * (1 - proportion) / max_score),
    color = color),
    width = 0.2, size = 1) +
  coord_flip() +
  theme_minimal() +
  labs(title = "Single-Context vs Multiple-Context Models - Proportions with 95% CI",
    x = "Model",
    y = "Proportion of Max Score") +
  theme(plot.title = element_text(hjust = 0.5, size = 14, face = "bold")) +
  scale_color_manual(
    values = c("#fc8d62", "#8da0cb", "#e78ac3"),
    name = "Model Family",
    breaks = c("#fc8d62", "#8da0cb", "#e78ac3"),
    labels = c("OpenAI", "Gemini", "Claude")
  ) +
  scale_shape_manual(
    values = c(16, 18),
    name = "Context Type",
    breaks = c(16, 18),
    labels = c("Single Context", "Multiple Context")
  )
)

print(sc_mc_plot)
```



Finke et al. Tasks - All Pairwise Comparisons

```
# Test all combinations for Finke tasks
finke_results <- test_all_combinations(finke_data, "Finke")

# Display results
cat("All Pairwise Comparisons for Finke et al. Tasks:\n")

## All Pairwise Comparisons for Finke et al. Tasks:
cat(paste(rep("=", 80), collapse = ""), "\n")

## =====
for (i in 1:nrow(finke_results)) {
  cat("\n", finke_results$comparison[i], "\n")
  cat(paste(rep("-", 40), collapse = ""), "\n")
  cat("Proportions: ", round(finke_results$prop1[i], 3), " vs ",
      round(finke_results$prop2[i], 3), "\n")
  cat("Difference: ", round(finke_results$diff[i], 3), "\n")
  cat("Chi-squared: ", round(finke_results$chi_squared[i], 3), "\n")
  cat("Degrees of freedom: ", round(finke_results$df[i], 3), "\n")
  cat("P-value: ", format(finke_results$p_value[i], scientific = FALSE, digits = 4), "\n")
  cat("95% CI: [", round(finke_results$ci_lower[i], 3), ", ",
      round(finke_results$ci_upper[i], 3), "]\n")
  cat("Significant: ", ifelse(finke_results$significant[i], "YES (p < 0.05)", "NO"), "\n")
}

##
## Humans vs o3
## -----
## Proportions: 0.63 vs 0.611
## Difference: 0.02
## Chi-squared: 0.189
## Degrees of freedom: 1
## P-value: 0.6636
## 95% CI: [ -0.059 , 0.098 ]
## Significant: NO
##
## Humans vs o3-GPT-Image
## -----
## Proportions: 0.63 vs 0.56
## Difference: 0.07
## Chi-squared: 4.009
## Degrees of freedom: 1
## P-value: 0.04525
## 95% CI: [ 0 , 0.14 ]
## Significant: YES (p < 0.05)
##
## Humans vs o3-Pro
## -----
## Proportions: 0.63 vs 0.772
## Difference: -0.141
## Chi-squared: 13.467
## Degrees of freedom: 1
## P-value: 0.0002428
```

```

## 95% CI: [ -0.211 , -0.072 ]
## Significant: YES (p < 0.05)
##
## Humans vs GPT-4.1
## -----
## Proportions: 0.63 vs 0.47
## Difference: 0.16
## Chi-squared: 11.426
## Degrees of freedom: 1
## P-value: 0.0007242
## 95% CI: [ 0.063 , 0.257 ]
## Significant: YES (p < 0.05)
##
## Humans vs GPT-4.1-GPT-Image
## -----
## Proportions: 0.63 vs 0.342
## Difference: 0.289
## Chi-squared: 37.705
## Degrees of freedom: 1
## P-value: 0.0000000008229
## 95% CI: [ 0.196 , 0.381 ]
## Significant: YES (p < 0.05)
##
## Humans vs ChatGPT-4o
## -----
## Proportions: 0.63 vs 0.408
## Difference: 0.222
## Chi-squared: 22.217
## Degrees of freedom: 1
## P-value: 0.000002435
## 95% CI: [ 0.126 , 0.318 ]
## Significant: YES (p < 0.05)
##
## Humans vs o4-mini
## -----
## Proportions: 0.63 vs 0.525
## Difference: 0.105
## Chi-squared: 4.797
## Degrees of freedom: 1
## P-value: 0.0285
## 95% CI: [ 0.008 , 0.202 ]
## Significant: YES (p < 0.05)
##
## Humans vs Gemini-2.5
## -----
## Proportions: 0.63 vs 0.509
## Difference: 0.121
## Chi-squared: 6.402
## Degrees of freedom: 1
## P-value: 0.0114
## 95% CI: [ 0.024 , 0.218 ]
## Significant: YES (p < 0.05)
##
## Humans vs Gemini-2.0-Flash

```

```

## -----
## Proportions: 0.63 vs 0.343
## Difference: 0.288
## Chi-squared: 37.486
## Degrees of freedom: 1
## P-value: 0.0000000009206
## 95% CI: [ 0.195 , 0.381 ]
## Significant: YES (p < 0.05)
##
## Humans vs Gemini-2.0-Flash-Images
## -----
## Proportions: 0.63 vs 0.342
## Difference: 0.288
## Chi-squared: 19.096
## Degrees of freedom: 1
## P-value: 0.00001243
## 95% CI: [ 0.157 , 0.419 ]
## Significant: YES (p < 0.05)
##
## Humans vs Sonnet-4
## -----
## Proportions: 0.63 vs 0.455
## Difference: 0.175
## Chi-squared: 13.659
## Degrees of freedom: 1
## P-value: 0.0002192
## 95% CI: [ 0.078 , 0.272 ]
## Significant: YES (p < 0.05)
##
## Humans vs Opus-4.1
## -----
## Proportions: 0.63 vs 0.741
## Difference: -0.111
## Chi-squared: 2.601
## Degrees of freedom: 1
## P-value: 0.1068
## 95% CI: [ -0.233 , 0.011 ]
## Significant: NO
##
## Humans vs GPT-5
## -----
## Proportions: 0.63 vs 0.766
## Difference: -0.136
## Chi-squared: 8.354
## Degrees of freedom: 1
## P-value: 0.003847
## 95% CI: [ -0.22 , -0.052 ]
## Significant: YES (p < 0.05)
##
## o3 vs o3-GPT-Image
## -----
## Proportions: 0.611 vs 0.56
## Difference: 0.05
## Chi-squared: 0.869

```

```

## Degrees of freedom: 1
## P-value: 0.3511
## 95% CI: [ -0.05 , 0.15 ]
## Significant: NO
##
## o3 vs o3-Pro
## -----
## Proportions: 0.611 vs 0.772
## Difference: -0.161
## Chi-squared: 10.208
## Degrees of freedom: 1
## P-value: 0.001398
## 95% CI: [ -0.261 , -0.062 ]
## Significant: YES (p < 0.05)
##
## o3 vs GPT-4.1
## -----
## Proportions: 0.611 vs 0.47
## Difference: 0.14
## Chi-squared: 5.198
## Degrees of freedom: 1
## P-value: 0.02261
## 95% CI: [ 0.019 , 0.262 ]
## Significant: YES (p < 0.05)
##
## o3 vs GPT-4.1-GPT-Image
## -----
## Proportions: 0.611 vs 0.342
## Difference: 0.269
## Chi-squared: 19.762
## Degrees of freedom: 1
## P-value: 0.000008772
## 95% CI: [ 0.151 , 0.387 ]
## Significant: YES (p < 0.05)
##
## o3 vs ChatGPT-4o
## -----
## Proportions: 0.611 vs 0.408
## Difference: 0.202
## Chi-squared: 11.039
## Degrees of freedom: 1
## P-value: 0.0008922
## 95% CI: [ 0.082 , 0.322 ]
## Significant: YES (p < 0.05)
##
## o3 vs o4-mini
## -----
## Proportions: 0.611 vs 0.525
## Difference: 0.085
## Chi-squared: 1.819
## Degrees of freedom: 1
## P-value: 0.1774
## 95% CI: [ -0.036 , 0.207 ]
## Significant: NO

```



```

##
## o3 vs Gemini-2.5
## -----
## Proportions: 0.611 vs 0.509
## Difference: 0.101
## Chi-squared: 2.609
## Degrees of freedom: 1
## P-value: 0.1063
## 95% CI: [ -0.02 , 0.222 ]
## Significant: NO
##
## o3 vs Gemini-2.0-Flash
## -----
## Proportions: 0.611 vs 0.343
## Difference: 0.268
## Chi-squared: 19.636
## Degrees of freedom: 1
## P-value: 0.000009367
## 95% CI: [ 0.15 , 0.386 ]
## Significant: YES (p < 0.05)
##
## o3 vs Gemini-2.0-Flash-Images
## -----
## Proportions: 0.611 vs 0.342
## Difference: 0.268
## Chi-squared: 11.993
## Degrees of freedom: 1
## P-value: 0.0005341
## 95% CI: [ 0.118 , 0.419 ]
## Significant: YES (p < 0.05)
##
## o3 vs Sonnet-4
## -----
## Proportions: 0.611 vs 0.455
## Difference: 0.155
## Chi-squared: 6.383
## Degrees of freedom: 1
## P-value: 0.01152
## 95% CI: [ 0.034 , 0.276 ]
## Significant: YES (p < 0.05)
##
## o3 vs Opus-4.1
## -----
## Proportions: 0.611 vs 0.741
## Difference: -0.131
## Chi-squared: 2.798
## Degrees of freedom: 1
## P-value: 0.09441
## 95% CI: [ -0.273 , 0.012 ]
## Significant: NO
##
## o3 vs GPT-5
## -----
## Proportions: 0.611 vs 0.766

```

```

## Difference: -0.156
## Chi-squared: 7.237
## Degrees of freedom: 1
## P-value: 0.007141
## 95% CI: [ -0.267 , -0.045 ]
## Significant: YES (p < 0.05)
##
## o3-GPT-Image vs o3-Pro
## -----
## Proportions: 0.56 vs 0.772
## Difference: -0.211
## Chi-squared: 19.304
## Degrees of freedom: 1
## P-value: 0.00001115
## 95% CI: [ -0.304 , -0.119 ]
## Significant: YES (p < 0.05)
##
## o3-GPT-Image vs GPT-4.1
## -----
## Proportions: 0.56 vs 0.47
## Difference: 0.09
## Chi-squared: 2.268
## Degrees of freedom: 1
## P-value: 0.132
## 95% CI: [ -0.025 , 0.206 ]
## Significant: NO
##
## o3-GPT-Image vs GPT-4.1-GPT-Image
## -----
## Proportions: 0.56 vs 0.342
## Difference: 0.219
## Chi-squared: 14.45
## Degrees of freedom: 1
## P-value: 0.000144
## 95% CI: [ 0.107 , 0.33 ]
## Significant: YES (p < 0.05)
##
## o3-GPT-Image vs ChatGPT-4o
## -----
## Proportions: 0.56 vs 0.408
## Difference: 0.152
## Chi-squared: 6.816
## Degrees of freedom: 1
## P-value: 0.009032
## 95% CI: [ 0.038 , 0.266 ]
## Significant: YES (p < 0.05)
##
## o3-GPT-Image vs o4-mini
## -----
## Proportions: 0.56 vs 0.525
## Difference: 0.035
## Chi-squared: 0.272
## Degrees of freedom: 1
## P-value: 0.6019

```

```

## 95% CI: [ -0.08 ,  0.151 ]
## Significant: NO
##
## o3-GPT-Image vs Gemini-2.5
## -----
## Proportions:  0.56  vs  0.509
## Difference:   0.051
## Chi-squared:  0.645
## Degrees of freedom:  1
## P-value:     0.422
## 95% CI: [ -0.065 ,  0.167 ]
## Significant: NO
##
## o3-GPT-Image vs Gemini-2.0-Flash
## -----
## Proportions:  0.56  vs  0.343
## Difference:   0.218
## Chi-squared:  14.336
## Degrees of freedom:  1
## P-value:     0.0001529
## 95% CI: [ 0.106 ,  0.33 ]
## Significant: YES (p < 0.05)
##
## o3-GPT-Image vs Gemini-2.0-Flash-Images
## -----
## Proportions:  0.56  vs  0.342
## Difference:   0.218
## Chi-squared:  8.286
## Degrees of freedom:  1
## P-value:     0.003994
## 95% CI: [ 0.072 ,  0.364 ]
## Significant: YES (p < 0.05)
##
## o3-GPT-Image vs Sonnet-4
## -----
## Proportions:  0.56  vs  0.455
## Difference:   0.105
## Chi-squared:  3.123
## Degrees of freedom:  1
## P-value:     0.0772
## 95% CI: [ -0.01 ,  0.22 ]
## Significant: NO
##
## o3-GPT-Image vs Opus-4.1
## -----
## Proportions:  0.56  vs  0.741
## Difference:   -0.181
## Chi-squared:  5.787
## Degrees of freedom:  1
## P-value:     0.01614
## 95% CI: [ -0.319 , -0.043 ]
## Significant: YES (p < 0.05)
##
## o3-GPT-Image vs GPT-5

```

```

## -----
## Proportions: 0.56 vs 0.766
## Difference: -0.206
## Chi-squared: 13.665
## Degrees of freedom: 1
## P-value: 0.0002185
## 95% CI: [ -0.311 , -0.101 ]
## Significant: YES (p < 0.05)
##
## o3-Pro vs GPT-4.1
## -----
## Proportions: 0.772 vs 0.47
## Difference: 0.302
## Chi-squared: 27.526
## Degrees of freedom: 1
## P-value: 0.000000155
## 95% CI: [ 0.186 , 0.417 ]
## Significant: YES (p < 0.05)
##
## o3-Pro vs GPT-4.1-GPT-Image
## -----
## Proportions: 0.772 vs 0.342
## Difference: 0.43
## Chi-squared: 53.691
## Degrees of freedom: 1
## P-value: 0.0000000000002346
## 95% CI: [ 0.318 , 0.542 ]
## Significant: YES (p < 0.05)
##
## o3-Pro vs ChatGPT-4o
## -----
## Proportions: 0.772 vs 0.408
## Difference: 0.364
## Chi-squared: 39.118
## Degrees of freedom: 1
## P-value: 0.000000000399
## 95% CI: [ 0.249 , 0.478 ]
## Significant: YES (p < 0.05)
##
## o3-Pro vs o4-mini
## -----
## Proportions: 0.772 vs 0.525
## Difference: 0.247
## Chi-squared: 18.799
## Degrees of freedom: 1
## P-value: 0.00001452
## 95% CI: [ 0.131 , 0.362 ]
## Significant: YES (p < 0.05)
##
## o3-Pro vs Gemini-2.5
## -----
## Proportions: 0.772 vs 0.509
## Difference: 0.262
## Chi-squared: 21.137

```

```

## Degrees of freedom: 1
## P-value: 0.000004277
## 95% CI: [ 0.147 , 0.378 ]
## Significant: YES (p < 0.05)
##
## o3-Pro vs Gemini-2.0-Flash
## -----
## Proportions: 0.772 vs 0.343
## Difference: 0.429
## Chi-squared: 53.494
## Degrees of freedom: 1
## P-value: 0.0000000000002593
## 95% CI: [ 0.318 , 0.541 ]
## Significant: YES (p < 0.05)
##
## o3-Pro vs Gemini-2.0-Flash-Images
## -----
## Proportions: 0.772 vs 0.342
## Difference: 0.429
## Chi-squared: 35.311
## Degrees of freedom: 1
## P-value: 0.00000000281
## 95% CI: [ 0.283 , 0.575 ]
## Significant: YES (p < 0.05)
##
## o3-Pro vs Sonnet-4
## -----
## Proportions: 0.772 vs 0.455
## Difference: 0.316
## Chi-squared: 30.096
## Degrees of freedom: 1
## P-value: 0.00000004112
## 95% CI: [ 0.201 , 0.431 ]
## Significant: YES (p < 0.05)
##
## o3-Pro vs Opus-4.1
## -----
## Proportions: 0.772 vs 0.741
## Difference: 0.031
## Chi-squared: 0.095
## Degrees of freedom: 1
## P-value: 0.7581
## 95% CI: [ -0.107 , 0.168 ]
## Significant: NO
##
## o3-Pro vs GPT-5
## -----
## Proportions: 0.772 vs 0.766
## Difference: 0.005
## Chi-squared: 0
## Degrees of freedom: 1
## P-value: 1
## 95% CI: [ -0.097 , 0.108 ]
## Significant: NO

```

```

##
## GPT-4.1 vs GPT-4.1-GPT-Image
## -----
## Proportions: 0.47 vs 0.342
## Difference: 0.128
## Chi-squared: 3.587
## Degrees of freedom: 1
## P-value: 0.05825
## 95% CI: [ -0.003 , 0.26 ]
## Significant: NO
##
## GPT-4.1 vs ChatGPT-4o
## -----
## Proportions: 0.47 vs 0.408
## Difference: 0.062
## Chi-squared: 0.699
## Degrees of freedom: 1
## P-value: 0.4032
## 95% CI: [ -0.072 , 0.196 ]
## Significant: NO
##
## GPT-4.1 vs o4-mini
## -----
## Proportions: 0.47 vs 0.525
## Difference: -0.055
## Chi-squared: 0.523
## Degrees of freedom: 1
## P-value: 0.4696
## 95% CI: [ -0.19 , 0.08 ]
## Significant: NO
##
## GPT-4.1 vs Gemini-2.5
## -----
## Proportions: 0.47 vs 0.509
## Difference: -0.039
## Chi-squared: 0.23
## Degrees of freedom: 1
## P-value: 0.6312
## 95% CI: [ -0.174 , 0.095 ]
## Significant: NO
##
## GPT-4.1 vs Gemini-2.0-Flash
## -----
## Proportions: 0.47 vs 0.343
## Difference: 0.128
## Chi-squared: 3.536
## Degrees of freedom: 1
## P-value: 0.06006
## 95% CI: [ -0.004 , 0.259 ]
## Significant: NO
##
## GPT-4.1 vs Gemini-2.0-Flash-Images
## -----
## Proportions: 0.47 vs 0.342

```

```

## Difference: 0.128
## Chi-squared: 2.171
## Degrees of freedom: 1
## P-value: 0.1406
## 95% CI: [ -0.034 , 0.29 ]
## Significant: NO
##
## GPT-4.1 vs Sonnet-4
## -----
## Proportions: 0.47 vs 0.455
## Difference: 0.015
## Chi-squared: 0.01
## Degrees of freedom: 1
## P-value: 0.9222
## 95% CI: [ -0.12 , 0.149 ]
## Significant: NO
##
## GPT-4.1 vs Opus-4.1
## -----
## Proportions: 0.47 vs 0.741
## Difference: -0.271
## Chi-squared: 10.854
## Degrees of freedom: 1
## P-value: 0.0009857
## 95% CI: [ -0.426 , -0.116 ]
## Significant: YES (p < 0.05)
##
## GPT-4.1 vs GPT-5
## -----
## Proportions: 0.47 vs 0.766
## Difference: -0.296
## Chi-squared: 21.063
## Degrees of freedom: 1
## P-value: 0.000004444
## 95% CI: [ -0.422 , -0.171 ]
## Significant: YES (p < 0.05)
##
## GPT-4.1-GPT-Image vs ChatGPT-4o
## -----
## Proportions: 0.342 vs 0.408
## Difference: -0.067
## Chi-squared: 0.866
## Degrees of freedom: 1
## P-value: 0.3519
## 95% CI: [ -0.197 , 0.064 ]
## Significant: NO
##
## GPT-4.1-GPT-Image vs o4-mini
## -----
## Proportions: 0.342 vs 0.525
## Difference: -0.183
## Chi-squared: 7.489
## Degrees of freedom: 1
## P-value: 0.006208

```

```

## 95% CI: [ -0.315 , -0.052 ]
## Significant: YES (p < 0.05)
##
## GPT-4.1-GPT-Image vs Gemini-2.5
## -----
## Proportions: 0.342 vs 0.509
## Difference: -0.168
## Chi-squared: 6.234
## Degrees of freedom: 1
## P-value: 0.01253
## 95% CI: [ -0.299 , -0.036 ]
## Significant: YES (p < 0.05)
##
## GPT-4.1-GPT-Image vs Gemini-2.0-Flash
## -----
## Proportions: 0.342 vs 0.343
## Difference: -0.001
## Chi-squared: 0
## Degrees of freedom: 1
## P-value: 1
## 95% CI: [ -0.122 , 0.12 ]
## Significant: NO
##
## GPT-4.1-GPT-Image vs Gemini-2.0-Flash-Images
## -----
## Proportions: 0.342 vs 0.342
## Difference: -0.001
## Chi-squared: 0
## Degrees of freedom: 1
## P-value: 1
## 95% CI: [ -0.148 , 0.147 ]
## Significant: NO
##
## GPT-4.1-GPT-Image vs Sonnet-4
## -----
## Proportions: 0.342 vs 0.455
## Difference: -0.114
## Chi-squared: 2.783
## Degrees of freedom: 1
## P-value: 0.09529
## 95% CI: [ -0.245 , 0.018 ]
## Significant: NO
##
## GPT-4.1-GPT-Image vs Opus-4.1
## -----
## Proportions: 0.342 vs 0.741
## Difference: -0.399
## Chi-squared: 24.017
## Degrees of freedom: 1
## P-value: 0.0000009548
## 95% CI: [ -0.552 , -0.247 ]
## Significant: YES (p < 0.05)
##
## GPT-4.1-GPT-Image vs GPT-5

```



```

## -----
## Proportions: 0.342 vs 0.766
## Difference: -0.425
## Chi-squared: 42.073
## Degrees of freedom: 1
## P-value: 0.00000000008791
## 95% CI: [ -0.547 , -0.303 ]
## Significant: YES (p < 0.05)
##
## ChatGPT-4o vs o4-mini
## -----
## Proportions: 0.408 vs 0.525
## Difference: -0.117
## Chi-squared: 2.841
## Degrees of freedom: 1
## P-value: 0.09188
## 95% CI: [ -0.251 , 0.017 ]
## Significant: NO
##
## ChatGPT-4o vs Gemini-2.5
## -----
## Proportions: 0.408 vs 0.509
## Difference: -0.101
## Chi-squared: 2.084
## Degrees of freedom: 1
## P-value: 0.1488
## 95% CI: [ -0.235 , 0.033 ]
## Significant: NO
##
## ChatGPT-4o vs Gemini-2.0-Flash
## -----
## Proportions: 0.408 vs 0.343
## Difference: 0.066
## Chi-squared: 0.841
## Degrees of freedom: 1
## P-value: 0.359
## 95% CI: [ -0.065 , 0.196 ]
## Significant: NO
##
## ChatGPT-4o vs Gemini-2.0-Flash-Images
## -----
## Proportions: 0.408 vs 0.342
## Difference: 0.066
## Chi-squared: 0.481
## Degrees of freedom: 1
## P-value: 0.4881
## 95% CI: [ -0.095 , 0.227 ]
## Significant: NO
##
## ChatGPT-4o vs Sonnet-4
## -----
## Proportions: 0.408 vs 0.455
## Difference: -0.047
## Chi-squared: 0.371

```

```

## Degrees of freedom: 1
## P-value: 0.5427
## 95% CI: [ -0.181 , 0.086 ]
## Significant: NO
##
## ChatGPT-4o vs Opus-4.1
## -----
## Proportions: 0.408 vs 0.741
## Difference: -0.333
## Chi-squared: 16.453
## Degrees of freedom: 1
## P-value: 0.00004987
## 95% CI: [ -0.487 , -0.179 ]
## Significant: YES (p < 0.05)
##
## ChatGPT-4o vs GPT-5
## -----
## Proportions: 0.408 vs 0.766
## Difference: -0.358
## Chi-squared: 30.278
## Degrees of freedom: 1
## P-value: 0.00000003744
## 95% CI: [ -0.482 , -0.234 ]
## Significant: YES (p < 0.05)
##
## o4-mini vs Gemini-2.5
## -----
## Proportions: 0.525 vs 0.509
## Difference: 0.016
## Chi-squared: 0.013
## Degrees of freedom: 1
## P-value: 0.9092
## 95% CI: [ -0.119 , 0.15 ]
## Significant: NO
##
## o4-mini vs Gemini-2.0-Flash
## -----
## Proportions: 0.525 vs 0.343
## Difference: 0.183
## Chi-squared: 7.416
## Degrees of freedom: 1
## P-value: 0.006465
## 95% CI: [ 0.051 , 0.314 ]
## Significant: YES (p < 0.05)
##
## o4-mini vs Gemini-2.0-Flash-Images
## -----
## Proportions: 0.525 vs 0.342
## Difference: 0.183
## Chi-squared: 4.663
## Degrees of freedom: 1
## P-value: 0.03083
## 95% CI: [ 0.021 , 0.345 ]
## Significant: YES (p < 0.05)

```

```

##
## o4-mini vs Sonnet-4
## -----
## Proportions: 0.525 vs 0.455
## Difference: 0.07
## Chi-squared: 0.902
## Degrees of freedom: 1
## P-value: 0.3422
## 95% CI: [ -0.065 , 0.204 ]
## Significant: NO
##
## o4-mini vs Opus-4.1
## -----
## Proportions: 0.525 vs 0.741
## Difference: -0.216
## Chi-squared: 6.888
## Degrees of freedom: 1
## P-value: 0.008676
## 95% CI: [ -0.371 , -0.061 ]
## Significant: YES (p < 0.05)
##
## o4-mini vs GPT-5
## -----
## Proportions: 0.525 vs 0.766
## Difference: -0.241
## Chi-squared: 14.219
## Degrees of freedom: 1
## P-value: 0.0001627
## 95% CI: [ -0.367 , -0.116 ]
## Significant: YES (p < 0.05)
##
## Gemini-2.5 vs Gemini-2.0-Flash
## -----
## Proportions: 0.509 vs 0.343
## Difference: 0.167
## Chi-squared: 6.168
## Degrees of freedom: 1
## P-value: 0.01301
## 95% CI: [ 0.035 , 0.299 ]
## Significant: YES (p < 0.05)
##
## Gemini-2.5 vs Gemini-2.0-Flash-Images
## -----
## Proportions: 0.509 vs 0.342
## Difference: 0.167
## Chi-squared: 3.856
## Degrees of freedom: 1
## P-value: 0.04957
## 95% CI: [ 0.005 , 0.329 ]
## Significant: YES (p < 0.05)
##
## Gemini-2.5 vs Sonnet-4
## -----
## Proportions: 0.509 vs 0.455

```

```

## Difference: 0.054
## Chi-squared: 0.5
## Degrees of freedom: 1
## P-value: 0.4796
## 95% CI: [ -0.081 , 0.189 ]
## Significant: NO
##
## Gemini-2.5 vs Opus-4.1
## -----
## Proportions: 0.509 vs 0.741
## Difference: -0.232
## Chi-squared: 7.928
## Degrees of freedom: 1
## P-value: 0.004867
## 95% CI: [ -0.387 , -0.077 ]
## Significant: YES (p < 0.05)
##
## Gemini-2.5 vs GPT-5
## -----
## Proportions: 0.509 vs 0.766
## Difference: -0.257
## Chi-squared: 16.044
## Degrees of freedom: 1
## P-value: 0.00006187
## 95% CI: [ -0.382 , -0.131 ]
## Significant: YES (p < 0.05)
##
## Gemini-2.0-Flash vs Gemini-2.0-Flash-Images
## -----
## Proportions: 0.343 vs 0.342
## Difference: 0
## Chi-squared: 0
## Degrees of freedom: 1
## P-value: 1
## 95% CI: [ -0.147 , 0.147 ]
## Significant: NO
##
## Gemini-2.0-Flash vs Sonnet-4
## -----
## Proportions: 0.343 vs 0.455
## Difference: -0.113
## Chi-squared: 2.738
## Degrees of freedom: 1
## P-value: 0.098
## 95% CI: [ -0.244 , 0.018 ]
## Significant: NO
##
## Gemini-2.0-Flash vs Opus-4.1
## -----
## Proportions: 0.343 vs 0.741
## Difference: -0.399
## Chi-squared: 23.911
## Degrees of freedom: 1
## P-value: 0.000001009

```

```

## 95% CI: [ -0.551 , -0.246 ]
## Significant: YES (p < 0.05)
##
## Gemini-2.0-Flash vs GPT-5
## -----
## Proportions: 0.343 vs 0.766
## Difference: -0.424
## Chi-squared: 41.913
## Degrees of freedom: 1
## P-value: 0.0000000009544
## 95% CI: [ -0.546 , -0.302 ]
## Significant: YES (p < 0.05)
##
## Gemini-2.0-Flash-Images vs Sonnet-4
## -----
## Proportions: 0.342 vs 0.455
## Difference: -0.113
## Chi-squared: 1.665
## Degrees of freedom: 1
## P-value: 0.1969
## 95% CI: [ -0.275 , 0.049 ]
## Significant: NO
##
## Gemini-2.0-Flash-Images vs Opus-4.1
## -----
## Proportions: 0.342 vs 0.741
## Difference: -0.399
## Chi-squared: 17.647
## Degrees of freedom: 1
## P-value: 0.0000266
## 95% CI: [ -0.579 , -0.219 ]
## Significant: YES (p < 0.05)
##
## Gemini-2.0-Flash-Images vs GPT-5
## -----
## Proportions: 0.342 vs 0.766
## Difference: -0.424
## Chi-squared: 28.89
## Degrees of freedom: 1
## P-value: 0.000000766
## 95% CI: [ -0.578 , -0.27 ]
## Significant: YES (p < 0.05)
##
## Sonnet-4 vs Opus-4.1
## -----
## Proportions: 0.455 vs 0.741
## Difference: -0.286
## Chi-squared: 12.064
## Degrees of freedom: 1
## P-value: 0.0005141
## 95% CI: [ -0.44 , -0.131 ]
## Significant: YES (p < 0.05)
##
## Sonnet-4 vs GPT-5

```

```
## -----
## Proportions: 0.455 vs 0.766
## Difference: -0.311
## Chi-squared: 23.094
## Degrees of freedom: 1
## P-value: 0.000001543
## 95% CI: [ -0.436 , -0.186 ]
## Significant: YES (p < 0.05)
##
```

```
## Opus-4.1 vs GPT-5
## -----
## Proportions: 0.741 vs 0.766
## Difference: -0.025
## Chi-squared: 0.035
## Degrees of freedom: 1
## P-value: 0.852
## 95% CI: [ -0.172 , 0.122 ]
## Significant: NO
```

```
# Summary table
finke_summary <- finke_results %>%
  select(comparison, diff, chi_squared, p_value, significant) %>%
  mutate(diff = round(diff, 3),
         p_value = round(p_value, 4))

cat("\n\nSummary Table - Finke Tasks:\n")
```

```
##
##
## Summary Table - Finke Tasks:
print(kable(finke_summary, format = "simple"))
```

```
##
##
## comparison diff chi_squared p_value signif
## -----
## X-squared Humans vs o3 0.020 0.1891561 0.6636 FALSE
## X-squared1 Humans vs o3-GPT-Image 0.070 4.0094812 0.0452 TRUE
## X-squared2 Humans vs o3-Pro -0.141 13.4669053 0.0002 TRUE
## X-squared3 Humans vs GPT-4.1 0.160 11.4260726 0.0007 TRUE
## X-squared4 Humans vs GPT-4.1-GPT-Image 0.289 37.7050952 0.0000 TRUE
## X-squared5 Humans vs ChatGPT-4o 0.222 22.2173252 0.0000 TRUE
## X-squared6 Humans vs o4-mini 0.105 4.7972861 0.0285 TRUE
## X-squared7 Humans vs Gemini-2.5 0.121 6.4021831 0.0114 TRUE
## X-squared8 Humans vs Gemini-2.0-Flash 0.288 37.4862876 0.0000 TRUE
## X-squared9 Humans vs Gemini-2.0-Flash-Images 0.288 19.0963849 0.0000 TRUE
## X-squared10 Humans vs Sonnet-4 0.175 13.6589132 0.0002 TRUE
## X-squared11 Humans vs Opus-4.1 -0.111 2.6009376 0.1068 FALSE
## X-squared12 Humans vs GPT-5 -0.136 8.3544955 0.0038 TRUE
## X-squared13 o3 vs o3-GPT-Image 0.050 0.8693549 0.3511 FALSE
## X-squared14 o3 vs o3-Pro -0.161 10.2079814 0.0014 TRUE
## X-squared15 o3 vs GPT-4.1 0.140 5.1982122 0.0226 TRUE
## X-squared16 o3 vs GPT-4.1-GPT-Image 0.269 19.7618003 0.0000 TRUE
## X-squared17 o3 vs ChatGPT-4o 0.202 11.0389794 0.0009 TRUE
```

## X-squared18	o3 vs o4-mini	0.085	1.8190399	0.1774	FALSE
## X-squared19	o3 vs Gemini-2.5	0.101	2.6088228	0.1063	FALSE
## X-squared20	o3 vs Gemini-2.0-Flash	0.268	19.6364283	0.0000	TRUE
## X-squared21	o3 vs Gemini-2.0-Flash-Images	0.268	11.9927811	0.0005	TRUE
## X-squared22	o3 vs Sonnet-4	0.155	6.3833257	0.0115	TRUE
## X-squared23	o3 vs Opus-4.1	-0.131	2.7975028	0.0944	FALSE
## X-squared24	o3 vs GPT-5	-0.156	7.2371887	0.0071	TRUE
## X-squared25	o3-GPT-Image vs o3-Pro	-0.211	19.3040615	0.0000	TRUE
## X-squared26	o3-GPT-Image vs GPT-4.1	0.090	2.2682502	0.1320	FALSE
## X-squared27	o3-GPT-Image vs GPT-4.1-GPT-Image	0.219	14.4496552	0.0001	TRUE
## X-squared28	o3-GPT-Image vs ChatGPT-4o	0.152	6.8164163	0.0090	TRUE
## X-squared29	o3-GPT-Image vs o4-mini	0.035	0.2722063	0.6019	FALSE
## X-squared30	o3-GPT-Image vs Gemini-2.5	0.051	0.6448736	0.4220	FALSE
## X-squared31	o3-GPT-Image vs Gemini-2.0-Flash	0.218	14.3361143	0.0002	TRUE
## X-squared32	o3-GPT-Image vs Gemini-2.0-Flash-Images	0.218	8.2863655	0.0040	TRUE
## X-squared33	o3-GPT-Image vs Sonnet-4	0.105	3.1229042	0.0772	FALSE
## X-squared34	o3-GPT-Image vs Opus-4.1	-0.181	5.7870517	0.0161	TRUE
## X-squared35	o3-GPT-Image vs GPT-5	-0.206	13.6649251	0.0002	TRUE
## X-squared36	o3-Pro vs GPT-4.1	0.302	27.5259711	0.0000	TRUE
## X-squared37	o3-Pro vs GPT-4.1-GPT-Image	0.430	53.6909027	0.0000	TRUE
## X-squared38	o3-Pro vs ChatGPT-4o	0.364	39.1177375	0.0000	TRUE
## X-squared39	o3-Pro vs o4-mini	0.247	18.7992418	0.0000	TRUE
## X-squared40	o3-Pro vs Gemini-2.5	0.262	21.1366991	0.0000	TRUE
## X-squared41	o3-Pro vs Gemini-2.0-Flash	0.429	53.4944490	0.0000	TRUE
## X-squared42	o3-Pro vs Gemini-2.0-Flash-Images	0.429	35.3111352	0.0000	TRUE
## X-squared43	o3-Pro vs Sonnet-4	0.316	30.0957775	0.0000	TRUE
## X-squared44	o3-Pro vs Opus-4.1	0.031	0.0948295	0.7581	FALSE
## X-squared45	o3-Pro vs GPT-5	0.005	0.0000000	1.0000	FALSE
## X-squared46	GPT-4.1 vs GPT-4.1-GPT-Image	0.128	3.5865624	0.0582	FALSE
## X-squared47	GPT-4.1 vs ChatGPT-4o	0.062	0.6986238	0.4032	FALSE
## X-squared48	GPT-4.1 vs o4-mini	-0.055	0.5229013	0.4696	FALSE
## X-squared49	GPT-4.1 vs Gemini-2.5	-0.039	0.2304718	0.6312	FALSE
## X-squared50	GPT-4.1 vs Gemini-2.0-Flash	0.128	3.5357988	0.0601	FALSE
## X-squared51	GPT-4.1 vs Gemini-2.0-Flash-Images	0.128	2.1711852	0.1406	FALSE
## X-squared52	GPT-4.1 vs Sonnet-4	0.015	0.0095474	0.9222	FALSE
## X-squared53	GPT-4.1 vs Opus-4.1	-0.271	10.8542730	0.0010	TRUE
## X-squared54	GPT-4.1 vs GPT-5	-0.296	21.0630216	0.0000	TRUE
## X-squared55	GPT-4.1-GPT-Image vs ChatGPT-4o	-0.067	0.8664502	0.3519	FALSE
## X-squared56	GPT-4.1-GPT-Image vs o4-mini	-0.183	7.4888306	0.0062	TRUE
## X-squared57	GPT-4.1-GPT-Image vs Gemini-2.5	-0.168	6.2344269	0.0125	TRUE
## X-squared58	GPT-4.1-GPT-Image vs Gemini-2.0-Flash	-0.001	0.0000000	1.0000	FALSE
## X-squared59	GPT-4.1-GPT-Image vs Gemini-2.0-Flash-Images	-0.001	0.0000000	1.0000	FALSE
## X-squared60	GPT-4.1-GPT-Image vs Sonnet-4	-0.114	2.7825972	0.0953	FALSE
## X-squared61	GPT-4.1-GPT-Image vs Opus-4.1	-0.399	24.0170961	0.0000	TRUE
## X-squared62	GPT-4.1-GPT-Image vs GPT-5	-0.425	42.0733617	0.0000	TRUE
## X-squared63	ChatGPT-4o vs o4-mini	-0.117	2.8412057	0.0919	FALSE
## X-squared64	ChatGPT-4o vs Gemini-2.5	-0.101	2.0839971	0.1488	FALSE
## X-squared65	ChatGPT-4o vs Gemini-2.0-Flash	0.066	0.8414311	0.3590	FALSE
## X-squared66	ChatGPT-4o vs Gemini-2.0-Flash-Images	0.066	0.4806813	0.4881	FALSE
## X-squared67	ChatGPT-4o vs Sonnet-4	-0.047	0.3705979	0.5427	FALSE
## X-squared68	ChatGPT-4o vs Opus-4.1	-0.333	16.4528721	0.0000	TRUE
## X-squared69	ChatGPT-4o vs GPT-5	-0.358	30.2778543	0.0000	TRUE
## X-squared70	o4-mini vs Gemini-2.5	0.016	0.0130201	0.9092	FALSE
## X-squared71	o4-mini vs Gemini-2.0-Flash	0.183	7.4160347	0.0065	TRUE

## X-squared72	o4-mini vs Gemini-2.0-Flash-Images	0.183	4.6625568	0.0308	TRUE
## X-squared73	o4-mini vs Sonnet-4	0.070	0.9021768	0.3422	FALSE
## X-squared74	o4-mini vs Opus-4.1	-0.216	6.8883699	0.0087	TRUE
## X-squared75	o4-mini vs GPT-5	-0.241	14.2190034	0.0002	TRUE
## X-squared76	Gemini-2.5 vs Gemini-2.0-Flash	0.167	6.1678391	0.0130	TRUE
## X-squared77	Gemini-2.5 vs Gemini-2.0-Flash-Images	0.167	3.8559573	0.0496	TRUE
## X-squared78	Gemini-2.5 vs Sonnet-4	0.054	0.4997782	0.4796	FALSE
## X-squared79	Gemini-2.5 vs Opus-4.1	-0.232	7.9282614	0.0049	TRUE
## X-squared80	Gemini-2.5 vs GPT-5	-0.257	16.0443888	0.0001	TRUE
## X-squared81	Gemini-2.0-Flash vs Gemini-2.0-Flash-Images	0.000	0.0000000	1.0000	FALSE
## X-squared82	Gemini-2.0-Flash vs Sonnet-4	-0.113	2.7378221	0.0980	FALSE
## X-squared83	Gemini-2.0-Flash vs Opus-4.1	-0.399	23.9111061	0.0000	TRUE
## X-squared84	Gemini-2.0-Flash vs GPT-5	-0.424	41.9127251	0.0000	TRUE
## X-squared85	Gemini-2.0-Flash-Images vs Sonnet-4	-0.113	1.6654778	0.1969	FALSE
## X-squared86	Gemini-2.0-Flash-Images vs Opus-4.1	-0.399	17.6467601	0.0000	TRUE
## X-squared87	Gemini-2.0-Flash-Images vs GPT-5	-0.424	28.8900877	0.0000	TRUE
## X-squared88	Sonnet-4 vs Opus-4.1	-0.286	12.0637483	0.0005	TRUE
## X-squared89	Sonnet-4 vs GPT-5	-0.311	23.0935495	0.0000	TRUE
## X-squared90	Opus-4.1 vs GPT-5	-0.025	0.0348205	0.8520	FALSE

48 Novel Tasks - All Pairwise Comparisons

```
# Test all combinations for 48 Novel tasks
novel_48_results <- test_all_combinations(novel_data, "48 Novel")

# Display results
cat("All Pairwise Comparisons for 48 Novel Tasks:\n")

## All Pairwise Comparisons for 48 Novel Tasks:
cat(paste(rep("=", 80), collapse = ""), "\n")

## =====

for (i in 1:nrow(novel_48_results)) {
  cat("\n", novel_48_results$comparison[i], "\n")
  cat(paste(rep("-", 40), collapse = ""), "\n")
  cat("Proportions: ", round(novel_48_results$prop1[i], 3), " vs ",
      round(novel_48_results$prop2[i], 3), "\n")
  cat("Difference: ", round(novel_48_results$diff[i], 3), "\n")
  cat("Chi-squared: ", round(novel_48_results$chi_squared[i], 3), "\n")
  cat("Degrees of freedom: ", round(novel_48_results$df[i], 3), "\n")
  cat("P-value: ", format(novel_48_results$p_value[i], scientific = FALSE, digits = 4), "\n")
  cat("95% CI: [", round(novel_48_results$ci_lower[i], 3), ", ",
      round(novel_48_results$ci_upper[i], 3), "]\n")
  cat("Significant: ", ifelse(novel_48_results$significant[i], "YES (p < 0.05)", "NO"), "\n")
}

##
## Humans vs o3
## -----
## Proportions: 0.526 vs 0.649
## Difference: -0.123
## Chi-squared: 38.861
## Degrees of freedom: 1
```



```

## P-value: 0.0000000004552
## 95% CI: [ -0.161 , -0.086 ]
## Significant: YES (p < 0.05)
##
## Humans vs o3-GPT-Image
## -----
## Proportions: 0.526 vs 0.552
## Difference: -0.026
## Chi-squared: 2.115
## Degrees of freedom: 1
## P-value: 0.1458
## 95% CI: [ -0.06 , 0.009 ]
## Significant: NO
##
## Humans vs o3-Pro
## -----
## Proportions: 0.526 vs 0.64
## Difference: -0.114
## Chi-squared: 33.112
## Degrees of freedom: 1
## P-value: 0.000000008702
## 95% CI: [ -0.152 , -0.076 ]
## Significant: YES (p < 0.05)
##
## Humans vs GPT-4.1
## -----
## Proportions: 0.526 vs 0.413
## Difference: 0.112
## Chi-squared: 22.059
## Degrees of freedom: 1
## P-value: 0.000002644
## 95% CI: [ 0.066 , 0.159 ]
## Significant: YES (p < 0.05)
##
## Humans vs GPT-4.1-GPT-Image
## -----
## Proportions: 0.526 vs 0.393
## Difference: 0.133
## Chi-squared: 30.716
## Degrees of freedom: 1
## P-value: 0.00000002987
## 95% CI: [ 0.086 , 0.179 ]
## Significant: YES (p < 0.05)
##
## Humans vs ChatGPT-4o
## -----
## Proportions: 0.526 vs 0.422
## Difference: 0.103
## Chi-squared: 18.644
## Degrees of freedom: 1
## P-value: 0.00001575
## 95% CI: [ 0.056 , 0.151 ]
## Significant: YES (p < 0.05)
##

```

```

## Humans vs o4-mini
## -----
## Proportions: 0.526 vs 0.532
## Difference: -0.006
## Chi-squared: 0.035
## Degrees of freedom: 1
## P-value: 0.8507
## 95% CI: [ -0.053 , 0.042 ]
## Significant: NO
##
## Humans vs Gemini-2.5
## -----
## Proportions: 0.526 vs 0.45
## Difference: 0.076
## Chi-squared: 9.986
## Degrees of freedom: 1
## P-value: 0.001577
## 95% CI: [ 0.029 , 0.123 ]
## Significant: YES (p < 0.05)
##
## Humans vs Gemini-2.0-Flash
## -----
## Proportions: 0.526 vs 0.389
## Difference: 0.137
## Chi-squared: 32.638
## Degrees of freedom: 1
## P-value: 0.0000000111
## 95% CI: [ 0.09 , 0.183 ]
## Significant: YES (p < 0.05)
##
## Humans vs Gemini-2.0-Flash-Images
## -----
## Proportions: 0.526 vs 0.328
## Difference: 0.198
## Chi-squared: 35.28
## Degrees of freedom: 1
## P-value: 0.000000002855
## 95% CI: [ 0.135 , 0.26 ]
## Significant: YES (p < 0.05)
##
## Humans vs Sonnet-4
## -----
## Proportions: 0.526 vs 0.407
## Difference: 0.119
## Chi-squared: 24.575
## Degrees of freedom: 1
## P-value: 0.0000007149
## 95% CI: [ 0.072 , 0.166 ]
## Significant: YES (p < 0.05)
##
## Humans vs Opus-4.1
## -----
## Proportions: 0.526 vs 0.476
## Difference: 0.049

```

```

## Chi-squared: 2.068
## Degrees of freedom: 1
## P-value: 0.1504
## 95% CI: [ -0.017 , 0.116 ]
## Significant: NO
##
## Humans vs GPT-5
## -----
## Proportions: 0.526 vs 0.646
## Difference: -0.12
## Chi-squared: 25.084
## Degrees of freedom: 1
## P-value: 0.0000005489
## 95% CI: [ -0.165 , -0.074 ]
## Significant: YES (p < 0.05)
##
## o3 vs o3-GPT-Image
## -----
## Proportions: 0.649 vs 0.552
## Difference: 0.098
## Chi-squared: 15.818
## Degrees of freedom: 1
## P-value: 0.00006973
## 95% CI: [ 0.049 , 0.146 ]
## Significant: YES (p < 0.05)
##
## o3 vs o3-Pro
## -----
## Proportions: 0.649 vs 0.64
## Difference: 0.009
## Chi-squared: 0.101
## Degrees of freedom: 1
## P-value: 0.7504
## 95% CI: [ -0.041 , 0.06 ]
## Significant: NO
##
## o3 vs GPT-4.1
## -----
## Proportions: 0.649 vs 0.413
## Difference: 0.236
## Chi-squared: 63.91
## Degrees of freedom: 1
## P-value: 0.0000000000000001303
## 95% CI: [ 0.178 , 0.294 ]
## Significant: YES (p < 0.05)
##
## o3 vs GPT-4.1-GPT-Image
## -----
## Proportions: 0.649 vs 0.393
## Difference: 0.256
## Chi-squared: 75.081
## Degrees of freedom: 1
## P-value: 0.00000000000000004518
## 95% CI: [ 0.198 , 0.314 ]

```

```

## Significant: YES (p < 0.05)
##
## o3 vs ChatGPT-4o
## -----
## Proportions: 0.649 vs 0.422
## Difference: 0.227
## Chi-squared: 59.196
## Degrees of freedom: 1
## P-value: 0.00000000000001428
## 95% CI: [ 0.169 , 0.285 ]
## Significant: YES (p < 0.05)
##
## o3 vs o4-mini
## -----
## Proportions: 0.649 vs 0.532
## Difference: 0.118
## Chi-squared: 16.191
## Degrees of freedom: 1
## P-value: 0.00005726
## 95% CI: [ 0.059 , 0.176 ]
## Significant: YES (p < 0.05)
##
## o3 vs Gemini-2.5
## -----
## Proportions: 0.649 vs 0.45
## Difference: 0.199
## Chi-squared: 45.897
## Degrees of freedom: 1
## P-value: 0.00000000001246
## 95% CI: [ 0.141 , 0.258 ]
## Significant: YES (p < 0.05)
##
## o3 vs Gemini-2.0-Flash
## -----
## Proportions: 0.649 vs 0.389
## Difference: 0.26
## Chi-squared: 77.448
## Degrees of freedom: 1
## P-value: 0.0000000000000001363
## 95% CI: [ 0.202 , 0.318 ]
## Significant: YES (p < 0.05)
##
## o3 vs Gemini-2.0-Flash-Images
## -----
## Proportions: 0.649 vs 0.328
## Difference: 0.321
## Chi-squared: 74.296
## Degrees of freedom: 1
## P-value: 0.0000000000000006724
## 95% CI: [ 0.249 , 0.393 ]
## Significant: YES (p < 0.05)
##
## o3 vs Sonnet-4
## -----

```

```

## Proportions: 0.649 vs 0.407
## Difference: 0.242
## Chi-squared: 67.256
## Degrees of freedom: 1
## P-value: 0.0000000000000002384
## 95% CI: [ 0.184 , 0.3 ]
## Significant: YES (p < 0.05)
##
## o3 vs Opus-4.1
## -----
## Proportions: 0.649 vs 0.476
## Difference: 0.173
## Chi-squared: 21.801
## Degrees of freedom: 1
## P-value: 0.000003025
## 95% CI: [ 0.098 , 0.248 ]
## Significant: YES (p < 0.05)
##
## o3 vs GPT-5
## -----
## Proportions: 0.649 vs 0.646
## Difference: 0.004
## Chi-squared: 0.005
## Degrees of freedom: 1
## P-value: 0.9437
## 95% CI: [ -0.053 , 0.061 ]
## Significant: NO
##
## o3-GPT-Image vs o3-Pro
## -----
## Proportions: 0.552 vs 0.64
## Difference: -0.088
## Chi-squared: 12.838
## Degrees of freedom: 1
## P-value: 0.0003397
## 95% CI: [ -0.136 , -0.04 ]
## Significant: YES (p < 0.05)
##
## o3-GPT-Image vs GPT-4.1
## -----
## Proportions: 0.552 vs 0.413
## Difference: 0.138
## Chi-squared: 23.943
## Degrees of freedom: 1
## P-value: 0.0000009922
## 95% CI: [ 0.083 , 0.194 ]
## Significant: YES (p < 0.05)
##
## o3-GPT-Image vs GPT-4.1-GPT-Image
## -----
## Proportions: 0.552 vs 0.393
## Difference: 0.158
## Chi-squared: 31.477
## Degrees of freedom: 1

```

```

## P-value: 0.00000002018
## 95% CI: [ 0.103 , 0.214 ]
## Significant: YES (p < 0.05)
##
## o3-GPT-Image vs ChatGPT-4o
## -----
## Proportions: 0.552 vs 0.422
## Difference: 0.129
## Chi-squared: 20.904
## Degrees of freedom: 1
## P-value: 0.000004829
## 95% CI: [ 0.074 , 0.185 ]
## Significant: YES (p < 0.05)
##
## o3-GPT-Image vs o4-mini
## -----
## Proportions: 0.552 vs 0.532
## Difference: 0.02
## Chi-squared: 0.451
## Degrees of freedom: 1
## P-value: 0.5017
## 95% CI: [ -0.036 , 0.076 ]
## Significant: NO
##
## o3-GPT-Image vs Gemini-2.5
## -----
## Proportions: 0.552 vs 0.45
## Difference: 0.102
## Chi-squared: 12.897
## Degrees of freedom: 1
## P-value: 0.0003291
## 95% CI: [ 0.046 , 0.158 ]
## Significant: YES (p < 0.05)
##
## o3-GPT-Image vs Gemini-2.0-Flash
## -----
## Proportions: 0.552 vs 0.389
## Difference: 0.162
## Chi-squared: 33.126
## Degrees of freedom: 1
## P-value: 0.000000008639
## 95% CI: [ 0.107 , 0.218 ]
## Significant: YES (p < 0.05)
##
## o3-GPT-Image vs Gemini-2.0-Flash-Images
## -----
## Proportions: 0.552 vs 0.328
## Difference: 0.223
## Chi-squared: 37.45
## Degrees of freedom: 1
## P-value: 0.0000000009377
## 95% CI: [ 0.154 , 0.293 ]
## Significant: YES (p < 0.05)
##

```

```

## o3-GPT-Image vs Sonnet-4
## -----
## Proportions: 0.552 vs 0.407
## Difference: 0.145
## Chi-squared: 26.154
## Degrees of freedom: 1
## P-value: 0.0000003152
## 95% CI: [ 0.089 , 0.2 ]
## Significant: YES (p < 0.05)
##
## o3-GPT-Image vs Opus-4.1
## -----
## Proportions: 0.552 vs 0.476
## Difference: 0.075
## Chi-squared: 4.081
## Degrees of freedom: 1
## P-value: 0.04337
## 95% CI: [ 0.002 , 0.148 ]
## Significant: YES (p < 0.05)
##
## o3-GPT-Image vs GPT-5
## -----
## Proportions: 0.552 vs 0.646
## Difference: -0.094
## Chi-squared: 11.198
## Degrees of freedom: 1
## P-value: 0.0008187
## 95% CI: [ -0.148 , -0.039 ]
## Significant: YES (p < 0.05)
##
## o3-Pro vs GPT-4.1
## -----
## Proportions: 0.64 vs 0.413
## Difference: 0.226
## Chi-squared: 58.734
## Degrees of freedom: 1
## P-value: 0.000000000000001805
## 95% CI: [ 0.168 , 0.284 ]
## Significant: YES (p < 0.05)
##
## o3-Pro vs GPT-4.1-GPT-Image
## -----
## Proportions: 0.64 vs 0.393
## Difference: 0.246
## Chi-squared: 69.483
## Degrees of freedom: 1
## P-value: 0.0000000000000007707
## 95% CI: [ 0.189 , 0.304 ]
## Significant: YES (p < 0.05)
##
## o3-Pro vs ChatGPT-4o
## -----
## Proportions: 0.64 vs 0.422
## Difference: 0.217

```

```

## Chi-squared: 54.21
## Degrees of freedom: 1
## P-value: 0.00000000000001801
## 95% CI: [ 0.159 , 0.276 ]
## Significant: YES (p < 0.05)
##
## o3-Pro vs o4-mini
## -----
## Proportions: 0.64 vs 0.532
## Difference: 0.108
## Chi-squared: 13.607
## Degrees of freedom: 1
## P-value: 0.0002253
## 95% CI: [ 0.05 , 0.167 ]
## Significant: YES (p < 0.05)
##
## o3-Pro vs Gemini-2.5
## -----
## Proportions: 0.64 vs 0.45
## Difference: 0.19
## Chi-squared: 41.502
## Degrees of freedom: 1
## P-value: 0.0000000001177
## 95% CI: [ 0.132 , 0.248 ]
## Significant: YES (p < 0.05)
##
## o3-Pro vs Gemini-2.0-Flash
## -----
## Proportions: 0.64 vs 0.389
## Difference: 0.251
## Chi-squared: 71.765
## Degrees of freedom: 1
## P-value: 0.0000000000000002424
## 95% CI: [ 0.193 , 0.308 ]
## Significant: YES (p < 0.05)
##
## o3-Pro vs Gemini-2.0-Flash-Images
## -----
## Proportions: 0.64 vs 0.328
## Difference: 0.312
## Chi-squared: 69.702
## Degrees of freedom: 1
## P-value: 0.0000000000000006899
## 95% CI: [ 0.24 , 0.383 ]
## Significant: YES (p < 0.05)
##
## o3-Pro vs Sonnet-4
## -----
## Proportions: 0.64 vs 0.407
## Difference: 0.233
## Chi-squared: 61.95
## Degrees of freedom: 1
## P-value: 0.000000000000003524
## 95% CI: [ 0.175 , 0.291 ]

```



```

## Significant: YES (p < 0.05)
##
## o3-Pro vs Opus-4.1
## -----
## Proportions: 0.64 vs 0.476
## Difference: 0.163
## Chi-squared: 19.337
## Degrees of freedom: 1
## P-value: 0.00001096
## 95% CI: [ 0.088 , 0.238 ]
## Significant: YES (p < 0.05)
##
## o3-Pro vs GPT-5
## -----
## Proportions: 0.64 vs 0.646
## Difference: -0.006
## Chi-squared: 0.02
## Degrees of freedom: 1
## P-value: 0.8887
## 95% CI: [ -0.063 , 0.051 ]
## Significant: NO
##
## GPT-4.1 vs GPT-4.1-GPT-Image
## -----
## Proportions: 0.413 vs 0.393
## Difference: 0.02
## Chi-squared: 0.322
## Degrees of freedom: 1
## P-value: 0.5703
## 95% CI: [ -0.044 , 0.084 ]
## Significant: NO
##
## GPT-4.1 vs ChatGPT-4o
## -----
## Proportions: 0.413 vs 0.422
## Difference: -0.009
## Chi-squared: 0.047
## Degrees of freedom: 1
## P-value: 0.8284
## 95% CI: [ -0.073 , 0.055 ]
## Significant: NO
##
## GPT-4.1 vs o4-mini
## -----
## Proportions: 0.413 vs 0.532
## Difference: -0.118
## Chi-squared: 12.951
## Degrees of freedom: 1
## P-value: 0.0003197
## 95% CI: [ -0.183 , -0.053 ]
## Significant: YES (p < 0.05)
##
## GPT-4.1 vs Gemini-2.5
## -----

```

```

## Proportions: 0.413 vs 0.45
## Difference: -0.036
## Chi-squared: 1.155
## Degrees of freedom: 1
## P-value: 0.2825
## 95% CI: [ -0.101 , 0.028 ]
## Significant: NO
##
## GPT-4.1 vs Gemini-2.0-Flash
## -----
## Proportions: 0.413 vs 0.389
## Difference: 0.024
## Chi-squared: 0.485
## Degrees of freedom: 1
## P-value: 0.4863
## 95% CI: [ -0.04 , 0.088 ]
## Significant: NO
##
## GPT-4.1 vs Gemini-2.0-Flash-Images
## -----
## Proportions: 0.413 vs 0.328
## Difference: 0.085
## Chi-squared: 4.539
## Degrees of freedom: 1
## P-value: 0.03313
## 95% CI: [ 0.008 , 0.162 ]
## Significant: YES (p < 0.05)
##
## GPT-4.1 vs Sonnet-4
## -----
## Proportions: 0.413 vs 0.407
## Difference: 0.006
## Chi-squared: 0.017
## Degrees of freedom: 1
## P-value: 0.8973
## 95% CI: [ -0.058 , 0.07 ]
## Significant: NO
##
## GPT-4.1 vs Opus-4.1
## -----
## Proportions: 0.413 vs 0.476
## Difference: -0.063
## Chi-squared: 2.336
## Degrees of freedom: 1
## P-value: 0.1264
## 95% CI: [ -0.143 , 0.017 ]
## Significant: NO
##
## GPT-4.1 vs GPT-5
## -----
## Proportions: 0.413 vs 0.646
## Difference: -0.232
## Chi-squared: 50.978
## Degrees of freedom: 1

```

```

## P-value: 0.0000000000009341
## 95% CI: [ -0.296 , -0.169 ]
## Significant: YES (p < 0.05)
##
## GPT-4.1-GPT-Image vs ChatGPT-4o
## -----
## Proportions: 0.393 vs 0.422
## Difference: -0.029
## Chi-squared: 0.722
## Degrees of freedom: 1
## P-value: 0.3954
## 95% CI: [ -0.093 , 0.035 ]
## Significant: NO
##
## GPT-4.1-GPT-Image vs o4-mini
## -----
## Proportions: 0.393 vs 0.532
## Difference: -0.138
## Chi-squared: 17.865
## Degrees of freedom: 1
## P-value: 0.00002371
## 95% CI: [ -0.203 , -0.074 ]
## Significant: YES (p < 0.05)
##
## GPT-4.1-GPT-Image vs Gemini-2.5
## -----
## Proportions: 0.393 vs 0.45
## Difference: -0.057
## Chi-squared: 2.915
## Degrees of freedom: 1
## P-value: 0.08778
## 95% CI: [ -0.121 , 0.008 ]
## Significant: NO
##
## GPT-4.1-GPT-Image vs Gemini-2.0-Flash
## -----
## Proportions: 0.393 vs 0.389
## Difference: 0.004
## Chi-squared: 0.004
## Degrees of freedom: 1
## P-value: 0.9502
## 95% CI: [ -0.06 , 0.068 ]
## Significant: NO
##
## GPT-4.1-GPT-Image vs Gemini-2.0-Flash-Images
## -----
## Proportions: 0.393 vs 0.328
## Difference: 0.065
## Chi-squared: 2.625
## Degrees of freedom: 1
## P-value: 0.1052
## 95% CI: [ -0.012 , 0.142 ]
## Significant: NO
##

```

```

## GPT-4.1-GPT-Image vs Sonnet-4
## -----
## Proportions: 0.393 vs 0.407
## Difference: -0.014
## Chi-squared: 0.139
## Degrees of freedom: 1
## P-value: 0.7092
## 95% CI: [ -0.078 , 0.05 ]
## Significant: NO
##
## GPT-4.1-GPT-Image vs Opus-4.1
## -----
## Proportions: 0.393 vs 0.476
## Difference: -0.083
## Chi-squared: 4.196
## Degrees of freedom: 1
## P-value: 0.04053
## 95% CI: [ -0.163 , -0.003 ]
## Significant: YES (p < 0.05)
##
## GPT-4.1-GPT-Image vs GPT-5
## -----
## Proportions: 0.393 vs 0.646
## Difference: -0.252
## Chi-squared: 60.137
## Degrees of freedom: 1
## P-value: 0.00000000000000885
## 95% CI: [ -0.315 , -0.189 ]
## Significant: YES (p < 0.05)
##
## ChatGPT-4o vs o4-mini
## -----
## Proportions: 0.422 vs 0.532
## Difference: -0.109
## Chi-squared: 11.012
## Degrees of freedom: 1
## P-value: 0.0009052
## 95% CI: [ -0.174 , -0.044 ]
## Significant: YES (p < 0.05)
##
## ChatGPT-4o vs Gemini-2.5
## -----
## Proportions: 0.422 vs 0.45
## Difference: -0.027
## Chi-squared: 0.628
## Degrees of freedom: 1
## P-value: 0.4279
## 95% CI: [ -0.092 , 0.037 ]
## Significant: NO
##
## ChatGPT-4o vs Gemini-2.0-Flash
## -----
## Proportions: 0.422 vs 0.389
## Difference: 0.033

```

```

## Chi-squared: 0.957
## Degrees of freedom: 1
## P-value: 0.3279
## 95% CI: [ -0.031 , 0.097 ]
## Significant: NO
##
## ChatGPT-4o vs Gemini-2.0-Flash-Images
## -----
## Proportions: 0.422 vs 0.328
## Difference: 0.094
## Chi-squared: 5.557
## Degrees of freedom: 1
## P-value: 0.01841
## 95% CI: [ 0.017 , 0.171 ]
## Significant: YES (p < 0.05)
##
## ChatGPT-4o vs Sonnet-4
## -----
## Proportions: 0.422 vs 0.407
## Difference: 0.015
## Chi-squared: 0.169
## Degrees of freedom: 1
## P-value: 0.6808
## 95% CI: [ -0.049 , 0.08 ]
## Significant: NO
##
## ChatGPT-4o vs Opus-4.1
## -----
## Proportions: 0.422 vs 0.476
## Difference: -0.054
## Chi-squared: 1.683
## Degrees of freedom: 1
## P-value: 0.1946
## 95% CI: [ -0.134 , 0.026 ]
## Significant: NO
##
## ChatGPT-4o vs GPT-5
## -----
## Proportions: 0.422 vs 0.646
## Difference: -0.223
## Chi-squared: 47.127
## Degrees of freedom: 1
## P-value: 0.000000000006653
## 95% CI: [ -0.287 , -0.16 ]
## Significant: YES (p < 0.05)
##
## o4-mini vs Gemini-2.5
## -----
## Proportions: 0.532 vs 0.45
## Difference: 0.082
## Chi-squared: 6.074
## Degrees of freedom: 1
## P-value: 0.01372
## 95% CI: [ 0.016 , 0.147 ]

```

```

## Significant: YES (p < 0.05)
##
## o4-mini vs Gemini-2.0-Flash
## -----
## Proportions: 0.532 vs 0.389
## Difference: 0.142
## Chi-squared: 18.957
## Degrees of freedom: 1
## P-value: 0.00001337
## 95% CI: [ 0.078 , 0.207 ]
## Significant: YES (p < 0.05)
##
## o4-mini vs Gemini-2.0-Flash-Images
## -----
## Proportions: 0.532 vs 0.328
## Difference: 0.203
## Chi-squared: 25.739
## Degrees of freedom: 1
## P-value: 0.0000003908
## 95% CI: [ 0.126 , 0.281 ]
## Significant: YES (p < 0.05)
##
## o4-mini vs Sonnet-4
## -----
## Proportions: 0.532 vs 0.407
## Difference: 0.124
## Chi-squared: 14.379
## Degrees of freedom: 1
## P-value: 0.0001495
## 95% CI: [ 0.06 , 0.189 ]
## Significant: YES (p < 0.05)
##
## o4-mini vs Opus-4.1
## -----
## Proportions: 0.532 vs 0.476
## Difference: 0.055
## Chi-squared: 1.726
## Degrees of freedom: 1
## P-value: 0.1889
## 95% CI: [ -0.025 , 0.136 ]
## Significant: NO
##
## o4-mini vs GPT-5
## -----
## Proportions: 0.532 vs 0.646
## Difference: -0.114
## Chi-squared: 12.427
## Degrees of freedom: 1
## P-value: 0.0004231
## 95% CI: [ -0.178 , -0.05 ]
## Significant: YES (p < 0.05)
##
## Gemini-2.5 vs Gemini-2.0-Flash
## -----

```

```

## Proportions: 0.45 vs 0.389
## Difference: 0.061
## Chi-squared: 3.369
## Degrees of freedom: 1
## P-value: 0.06642
## 95% CI: [ -0.004 , 0.125 ]
## Significant: NO
##
## Gemini-2.5 vs Gemini-2.0-Flash-Images
## -----
## Proportions: 0.45 vs 0.328
## Difference: 0.122
## Chi-squared: 9.277
## Degrees of freedom: 1
## P-value: 0.00232
## 95% CI: [ 0.044 , 0.199 ]
## Significant: YES (p < 0.05)
##
## Gemini-2.5 vs Sonnet-4
## -----
## Proportions: 0.45 vs 0.407
## Difference: 0.043
## Chi-squared: 1.611
## Degrees of freedom: 1
## P-value: 0.2044
## 95% CI: [ -0.022 , 0.107 ]
## Significant: NO
##
## Gemini-2.5 vs Opus-4.1
## -----
## Proportions: 0.45 vs 0.476
## Difference: -0.027
## Chi-squared: 0.354
## Degrees of freedom: 1
## P-value: 0.5517
## 95% CI: [ -0.107 , 0.054 ]
## Significant: NO
##
## Gemini-2.5 vs GPT-5
## -----
## Proportions: 0.45 vs 0.646
## Difference: -0.196
## Chi-squared: 36.309
## Degrees of freedom: 1
## P-value: 0.000000001684
## 95% CI: [ -0.259 , -0.132 ]
## Significant: YES (p < 0.05)
##
## Gemini-2.0-Flash vs Gemini-2.0-Flash-Images
## -----
## Proportions: 0.389 vs 0.328
## Difference: 0.061
## Chi-squared: 2.3
## Degrees of freedom: 1

```

```

## P-value: 0.1294
## 95% CI: [ -0.016 , 0.138 ]
## Significant: NO
##
## Gemini-2.0-Flash vs Sonnet-4
## -----
## Proportions: 0.389 vs 0.407
## Difference: -0.018
## Chi-squared: 0.251
## Degrees of freedom: 1
## P-value: 0.6161
## 95% CI: [ -0.082 , 0.046 ]
## Significant: NO
##
## Gemini-2.0-Flash vs Opus-4.1
## -----
## Proportions: 0.389 vs 0.476
## Difference: -0.087
## Chi-squared: 4.64
## Degrees of freedom: 1
## P-value: 0.03123
## 95% CI: [ -0.167 , -0.007 ]
## Significant: YES (p < 0.05)
##
## Gemini-2.0-Flash vs GPT-5
## -----
## Proportions: 0.389 vs 0.646
## Difference: -0.256
## Chi-squared: 62.083
## Degrees of freedom: 1
## P-value: 0.000000000000003293
## 95% CI: [ -0.319 , -0.193 ]
## Significant: YES (p < 0.05)
##
## Gemini-2.0-Flash-Images vs Sonnet-4
## -----
## Proportions: 0.328 vs 0.407
## Difference: -0.079
## Chi-squared: 3.896
## Degrees of freedom: 1
## P-value: 0.0484
## 95% CI: [ -0.156 , -0.002 ]
## Significant: YES (p < 0.05)
##
## Gemini-2.0-Flash-Images vs Opus-4.1
## -----
## Proportions: 0.328 vs 0.476
## Difference: -0.148
## Chi-squared: 10.339
## Degrees of freedom: 1
## P-value: 0.001303
## 95% CI: [ -0.239 , -0.057 ]
## Significant: YES (p < 0.05)
##

```



```

## Gemini-2.0-Flash-Images vs GPT-5
## -----
## Proportions: 0.328 vs 0.646
## Difference: -0.317
## Chi-squared: 63.537
## Degrees of freedom: 1
## P-value: 0.000000000000001574
## 95% CI: [ -0.394 , -0.241 ]
## Significant: YES (p < 0.05)
##
## Sonnet-4 vs Opus-4.1
## -----
## Proportions: 0.407 vs 0.476
## Difference: -0.069
## Chi-squared: 2.85
## Degrees of freedom: 1
## P-value: 0.0914
## 95% CI: [ -0.149 , 0.011 ]
## Significant: NO
##
## Sonnet-4 vs GPT-5
## -----
## Proportions: 0.407 vs 0.646
## Difference: -0.238
## Chi-squared: 53.717
## Degrees of freedom: 1
## P-value: 0.0000000000002316
## 95% CI: [ -0.302 , -0.175 ]
## Significant: YES (p < 0.05)
##
## Opus-4.1 vs GPT-5
## -----
## Proportions: 0.476 vs 0.646
## Difference: -0.169
## Chi-squared: 18.21
## Degrees of freedom: 1
## P-value: 0.00001978
## 95% CI: [ -0.249 , -0.09 ]
## Significant: YES (p < 0.05)

# Summary table
novel_48_summary <- novel_48_results %>%
  select(comparison, diff, chi_squared, p_value, significant) %>%
  mutate(diff = round(diff, 3),
         p_value = round(p_value, 4))

cat("\n\nSummary Table - 48 Novel Tasks:\n")

##
##
## Summary Table - 48 Novel Tasks:
print(kable(novel_48_summary, format = "simple"))

##

```

##	comparison	diff	chi_squared	p_value	signif
##	-----	-----	-----	-----	-----
## X-squared	Humans vs o3	-0.123	38.8606815	0.0000	TRUE
## X-squared1	Humans vs o3-GPT-Image	-0.026	2.1151564	0.1458	FALSE
## X-squared2	Humans vs o3-Pro	-0.114	33.1116612	0.0000	TRUE
## X-squared3	Humans vs GPT-4.1	0.112	22.0592775	0.0000	TRUE
## X-squared4	Humans vs GPT-4.1-GPT-Image	0.133	30.7158709	0.0000	TRUE
## X-squared5	Humans vs ChatGPT-4o	0.103	18.6444291	0.0000	TRUE
## X-squared6	Humans vs o4-mini	-0.006	0.0354255	0.8507	FALSE
## X-squared7	Humans vs Gemini-2.5	0.076	9.9860525	0.0016	TRUE
## X-squared8	Humans vs Gemini-2.0-Flash	0.137	32.6384035	0.0000	TRUE
## X-squared9	Humans vs Gemini-2.0-Flash-Images	0.198	35.2801051	0.0000	TRUE
## X-squared10	Humans vs Sonnet-4	0.119	24.5745389	0.0000	TRUE
## X-squared11	Humans vs Opus-4.1	0.049	2.0682572	0.1504	FALSE
## X-squared12	Humans vs GPT-5	-0.120	25.0838266	0.0000	TRUE
## X-squared13	o3 vs o3-GPT-Image	0.098	15.8181217	0.0001	TRUE
## X-squared14	o3 vs o3-Pro	0.009	0.1011775	0.7504	FALSE
## X-squared15	o3 vs GPT-4.1	0.236	63.9096051	0.0000	TRUE
## X-squared16	o3 vs GPT-4.1-GPT-Image	0.256	75.0810006	0.0000	TRUE
## X-squared17	o3 vs ChatGPT-4o	0.227	59.1955498	0.0000	TRUE
## X-squared18	o3 vs o4-mini	0.118	16.1910358	0.0001	TRUE
## X-squared19	o3 vs Gemini-2.5	0.199	45.8969507	0.0000	TRUE
## X-squared20	o3 vs Gemini-2.0-Flash	0.260	77.4476316	0.0000	TRUE
## X-squared21	o3 vs Gemini-2.0-Flash-Images	0.321	74.2960065	0.0000	TRUE
## X-squared22	o3 vs Sonnet-4	0.242	67.2562927	0.0000	TRUE
## X-squared23	o3 vs Opus-4.1	0.173	21.8007438	0.0000	TRUE
## X-squared24	o3 vs GPT-5	0.004	0.0049901	0.9437	FALSE
## X-squared25	o3-GPT-Image vs o3-Pro	-0.088	12.8378194	0.0003	TRUE
## X-squared26	o3-GPT-Image vs GPT-4.1	0.138	23.9431768	0.0000	TRUE
## X-squared27	o3-GPT-Image vs GPT-4.1-GPT-Image	0.158	31.4772295	0.0000	TRUE
## X-squared28	o3-GPT-Image vs ChatGPT-4o	0.129	20.9038155	0.0000	TRUE
## X-squared29	o3-GPT-Image vs o4-mini	0.020	0.4513398	0.5017	FALSE
## X-squared30	o3-GPT-Image vs Gemini-2.5	0.102	12.8968083	0.0003	TRUE
## X-squared31	o3-GPT-Image vs Gemini-2.0-Flash	0.162	33.1257777	0.0000	TRUE
## X-squared32	o3-GPT-Image vs Gemini-2.0-Flash-Images	0.223	37.4503448	0.0000	TRUE
## X-squared33	o3-GPT-Image vs Sonnet-4	0.145	26.1542007	0.0000	TRUE
## X-squared34	o3-GPT-Image vs Opus-4.1	0.075	4.0807836	0.0434	TRUE
## X-squared35	o3-GPT-Image vs GPT-5	-0.094	11.1983901	0.0008	TRUE
## X-squared36	o3-Pro vs GPT-4.1	0.226	58.7335492	0.0000	TRUE
## X-squared37	o3-Pro vs GPT-4.1-GPT-Image	0.246	69.4830297	0.0000	TRUE
## X-squared38	o3-Pro vs ChatGPT-4o	0.217	54.2103917	0.0000	TRUE
## X-squared39	o3-Pro vs o4-mini	0.108	13.6072593	0.0002	TRUE
## X-squared40	o3-Pro vs Gemini-2.5	0.190	41.5021036	0.0000	TRUE
## X-squared41	o3-Pro vs Gemini-2.0-Flash	0.251	71.7651322	0.0000	TRUE
## X-squared42	o3-Pro vs Gemini-2.0-Flash-Images	0.312	69.7017215	0.0000	TRUE
## X-squared43	o3-Pro vs Sonnet-4	0.233	61.9496000	0.0000	TRUE
## X-squared44	o3-Pro vs Opus-4.1	0.163	19.3366750	0.0000	TRUE
## X-squared45	o3-Pro vs GPT-5	-0.006	0.0195799	0.8887	FALSE
## X-squared46	GPT-4.1 vs GPT-4.1-GPT-Image	0.020	0.3221521	0.5703	FALSE
## X-squared47	GPT-4.1 vs ChatGPT-4o	-0.009	0.0470018	0.8284	FALSE
## X-squared48	GPT-4.1 vs o4-mini	-0.118	12.9513714	0.0003	TRUE
## X-squared49	GPT-4.1 vs Gemini-2.5	-0.036	1.1551296	0.2825	FALSE
## X-squared50	GPT-4.1 vs Gemini-2.0-Flash	0.024	0.4845990	0.4863	FALSE

## X-squared51	GPT-4.1 vs Gemini-2.0-Flash-Images	0.085	4.5388375	0.0331	TRUE
## X-squared52	GPT-4.1 vs Sonnet-4	0.006	0.0166510	0.8973	FALSE
## X-squared53	GPT-4.1 vs Opus-4.1	-0.063	2.3361536	0.1264	FALSE
## X-squared54	GPT-4.1 vs GPT-5	-0.232	50.9779767	0.0000	TRUE
## X-squared55	GPT-4.1-GPT-Image vs ChatGPT-4o	-0.029	0.7222319	0.3954	FALSE
## X-squared56	GPT-4.1-GPT-Image vs o4-mini	-0.138	17.8652217	0.0000	TRUE
## X-squared57	GPT-4.1-GPT-Image vs Gemini-2.5	-0.057	2.9146207	0.0878	FALSE
## X-squared58	GPT-4.1-GPT-Image vs Gemini-2.0-Flash	0.004	0.0039073	0.9502	FALSE
## X-squared59	GPT-4.1-GPT-Image vs Gemini-2.0-Flash-Images	0.065	2.6252260	0.1052	FALSE
## X-squared60	GPT-4.1-GPT-Image vs Sonnet-4	-0.014	0.1390405	0.7092	FALSE
## X-squared61	GPT-4.1-GPT-Image vs Opus-4.1	-0.083	4.1956974	0.0405	TRUE
## X-squared62	GPT-4.1-GPT-Image vs GPT-5	-0.252	60.1365189	0.0000	TRUE
## X-squared63	ChatGPT-4o vs o4-mini	-0.109	11.0121623	0.0009	TRUE
## X-squared64	ChatGPT-4o vs Gemini-2.5	-0.027	0.6284762	0.4279	FALSE
## X-squared65	ChatGPT-4o vs Gemini-2.0-Flash	0.033	0.9571819	0.3279	FALSE
## X-squared66	ChatGPT-4o vs Gemini-2.0-Flash-Images	0.094	5.5571569	0.0184	TRUE
## X-squared67	ChatGPT-4o vs Sonnet-4	0.015	0.1692220	0.6808	FALSE
## X-squared68	ChatGPT-4o vs Opus-4.1	-0.054	1.6826566	0.1946	FALSE
## X-squared69	ChatGPT-4o vs GPT-5	-0.223	47.1271745	0.0000	TRUE
## X-squared70	o4-mini vs Gemini-2.5	0.082	6.0739338	0.0137	TRUE
## X-squared71	o4-mini vs Gemini-2.0-Flash	0.142	18.9574569	0.0000	TRUE
## X-squared72	o4-mini vs Gemini-2.0-Flash-Images	0.203	25.7394291	0.0000	TRUE
## X-squared73	o4-mini vs Sonnet-4	0.124	14.3789349	0.0001	TRUE
## X-squared74	o4-mini vs Opus-4.1	0.055	1.7259167	0.1889	FALSE
## X-squared75	o4-mini vs GPT-5	-0.114	12.4274222	0.0004	TRUE
## X-squared76	Gemini-2.5 vs Gemini-2.0-Flash	0.061	3.3693265	0.0664	FALSE
## X-squared77	Gemini-2.5 vs Gemini-2.0-Flash-Images	0.122	9.2773966	0.0023	TRUE
## X-squared78	Gemini-2.5 vs Sonnet-4	0.043	1.6108643	0.2044	FALSE
## X-squared79	Gemini-2.5 vs Opus-4.1	-0.027	0.3543462	0.5517	FALSE
## X-squared80	Gemini-2.5 vs GPT-5	-0.196	36.3093587	0.0000	TRUE
## X-squared81	Gemini-2.0-Flash vs Gemini-2.0-Flash-Images	0.061	2.2996419	0.1294	FALSE
## X-squared82	Gemini-2.0-Flash vs Sonnet-4	-0.018	0.2514460	0.6161	FALSE
## X-squared83	Gemini-2.0-Flash vs Opus-4.1	-0.087	4.6400681	0.0312	TRUE
## X-squared84	Gemini-2.0-Flash vs GPT-5	-0.256	62.0826267	0.0000	TRUE
## X-squared85	Gemini-2.0-Flash-Images vs Sonnet-4	-0.079	3.8959604	0.0484	TRUE
## X-squared86	Gemini-2.0-Flash-Images vs Opus-4.1	-0.148	10.3385839	0.0013	TRUE
## X-squared87	Gemini-2.0-Flash-Images vs GPT-5	-0.317	63.5367890	0.0000	TRUE
## X-squared88	Sonnet-4 vs Opus-4.1	-0.069	2.8496179	0.0914	FALSE
## X-squared89	Sonnet-4 vs GPT-5	-0.238	53.7168275	0.0000	TRUE
## X-squared90	Opus-4.1 vs GPT-5	-0.169	18.2100464	0.0000	TRUE

Visualization of All Comparisons

```
# Plot 1: Proportions with confidence intervals for Finke tasks
finke_plot <- ggplot(finke_data, aes(x = reorder(model, proportion), y = proportion)) +
  geom_point(size = 4, aes(color = color)) +
  geom_errorbar(aes(ymin = proportion - 1.96 * sqrt(proportion * (1 - proportion) / max_score),
    ymax = proportion + 1.96 * sqrt(proportion * (1 - proportion) / max_score),
    color = color),
    width = 0.2, size = 1) +
  coord_flip() +
  theme_minimal() +
  labs(title = "Finke et al. Tasks - Proportions with 95% CI",
    x = "Model",
```

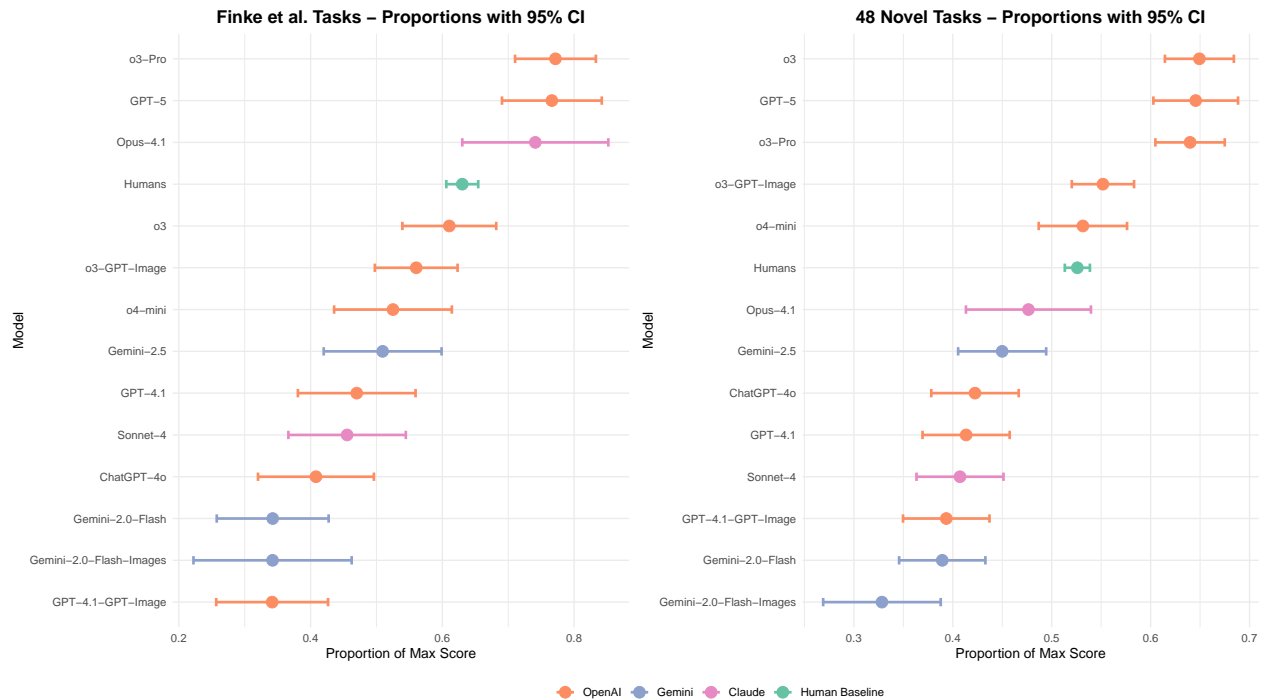
```

    y = "Proportion of Max Score") +
  theme(plot.title = element_text(hjust = 0.5, size = 14, face = "bold")) +
  scale_color_manual(
    values = c("#fc8d62", "#8da0cb", "#e78ac3", "#66c2a5"),
    name = element_blank(),
    breaks = c("#fc8d62", "#8da0cb", "#e78ac3", "#66c2a5"),
    labels = c("OpenAI", "Gemini", "Claude", "Human Baseline")
  )

# Plot 2: Proportions with confidence intervals for 48 Novel tasks
novel_48_plot <- ggplot(novel_data, aes(x = reorder(model, proportion), y = proportion)) +
  geom_point(size = 4, aes(color = color)) +
  geom_errorbar(aes(ymin = proportion - 1.96 * sqrt(proportion * (1 - proportion) / max_score),
    ymax = proportion + 1.96 * sqrt(proportion * (1 - proportion) / max_score),
    color = color),
    width = 0.2, size = 1) +
  coord_flip() +
  theme_minimal() +
  labs(title = "48 Novel Tasks - Proportions with 95% CI",
    x = "Model",
    y = "Proportion of Max Score") +
  theme(plot.title = element_text(hjust = 0.5, size = 14, face = "bold")) +
  scale_color_manual(
    values = c("#fc8d62", "#8da0cb", "#e78ac3", "#66c2a5"),
    name = element_blank(),
    breaks = c("#fc8d62", "#8da0cb", "#e78ac3", "#66c2a5"),
    labels = c("OpenAI", "Gemini", "Claude", "Human Baseline")
  )

# Combine plots
combined_plot <- (finke_plot + novel_48_plot & theme(legend.position = "bottom")) + plot_layout(ncol = 2)
print(combined_plot)

```



```
# red #66c2a5
# blue #fc8d62
# green #8da0cb
# purple #e78ac3
```

Heatmap of P-values

```
# Create matrix of p-values for Finke tasks
finke_models <- finke_data$model
finke_pval_matrix <- matrix(NA, nrow = length(finke_models), ncol = length(finke_models))
rownames(finke_pval_matrix) <- finke_models
colnames(finke_pval_matrix) <- finke_models

for (i in 1:nrow(finke_results)) {
  row_idx <- which(finke_models == finke_results$model1[i])
  col_idx <- which(finke_models == finke_results$model2[i])
  finke_pval_matrix[row_idx, col_idx] <- finke_results$p_value[i]
  finke_pval_matrix[col_idx, row_idx] <- finke_results$p_value[i]
}

# Set diagonal to NA
diag(finke_pval_matrix) <- NA

# Create matrix of p-values for 48 Novel tasks
novel_models <- novel_data$model
novel_pval_matrix <- matrix(NA, nrow = length(novel_models), ncol = length(novel_models))
rownames(novel_pval_matrix) <- novel_models
colnames(novel_pval_matrix) <- novel_models

for (i in 1:nrow(novel_48_results)) {
  row_idx <- which(novel_models == novel_48_results$model1[i])
```

```

col_idx <- which(novel_models == novel_48_results$model2[i])
novel_pval_matrix[row_idx, col_idx] <- novel_48_results$p_value[i]
novel_pval_matrix[col_idx, row_idx] <- novel_48_results$p_value[i]
}

# Set diagonal to NA
diag(novel_pval_matrix) <- NA

# Plot heatmaps
par(mfrow = c(2, 1), mar = c(6, 6, 3, 2)) # Increase margins for labels

# Define color palette
col_palette <- colorRampPalette(c("lightcyan", "lightblue", "lightskyblue", "steelblue4"))(20)

# Finke heatmap
image(finke_pval_matrix, axes = FALSE, col = col_palette, main = "P-values Heatmap - Finke Tasks")
axis(1, at = seq(0, 1, length.out = length(finke_models)), labels = finke_models,
     las = 2, cex.axis = 0.8) # las=2 makes labels perpendicular, cex.axis makes them smaller
axis(2, at = seq(0, 1, length.out = length(finke_models)), labels = finke_models,
     las = 2, cex.axis = 0.8)

# Add gray color for diagonal
for (i in 1:length(finke_models)) {
  x_pos <- (i - 1) / (length(finke_models) - 1)
  y_pos <- (i - 1) / (length(finke_models) - 1)
  rect(x_pos - 0.5 / (length(finke_models) - 1), y_pos - 0.5 / (length(finke_models) - 1),
       x_pos + 0.5 / (length(finke_models) - 1), y_pos + 0.5 / (length(finke_models) - 1),
       col = "gray80", border = NA)
}

# Add p-values to the plot
for (i in 1:nrow(finke_pval_matrix)) {
  for (j in 1:ncol(finke_pval_matrix)) {
    if (!is.na(finke_pval_matrix[i, j])) {
      x_pos <- (j - 1) / (ncol(finke_pval_matrix) - 1)
      y_pos <- (i - 1) / (nrow(finke_pval_matrix) - 1)
      text(x_pos, y_pos, sprintf("%.3f", finke_pval_matrix[i, j]), cex = 0.7)
    }
  }
}

# 48 Novel heatmap
image(novel_pval_matrix, axes = FALSE, col = col_palette, main = "P-values Heatmap - 48 Novel Tasks")
axis(1, at = seq(0, 1, length.out = length(novel_models)), labels = novel_models,
     las = 2, cex.axis = 0.8) # las=2 makes labels perpendicular, cex.axis makes them smaller
axis(2, at = seq(0, 1, length.out = length(novel_models)), labels = novel_models,
     las = 2, cex.axis = 0.8)

# Add gray color for diagonal
for (i in 1:length(novel_models)) {
  x_pos <- (i - 1) / (length(novel_models) - 1)
  y_pos <- (i - 1) / (length(novel_models) - 1)
  rect(x_pos - 0.5 / (length(novel_models) - 1), y_pos - 0.5 / (length(novel_models) - 1),

```

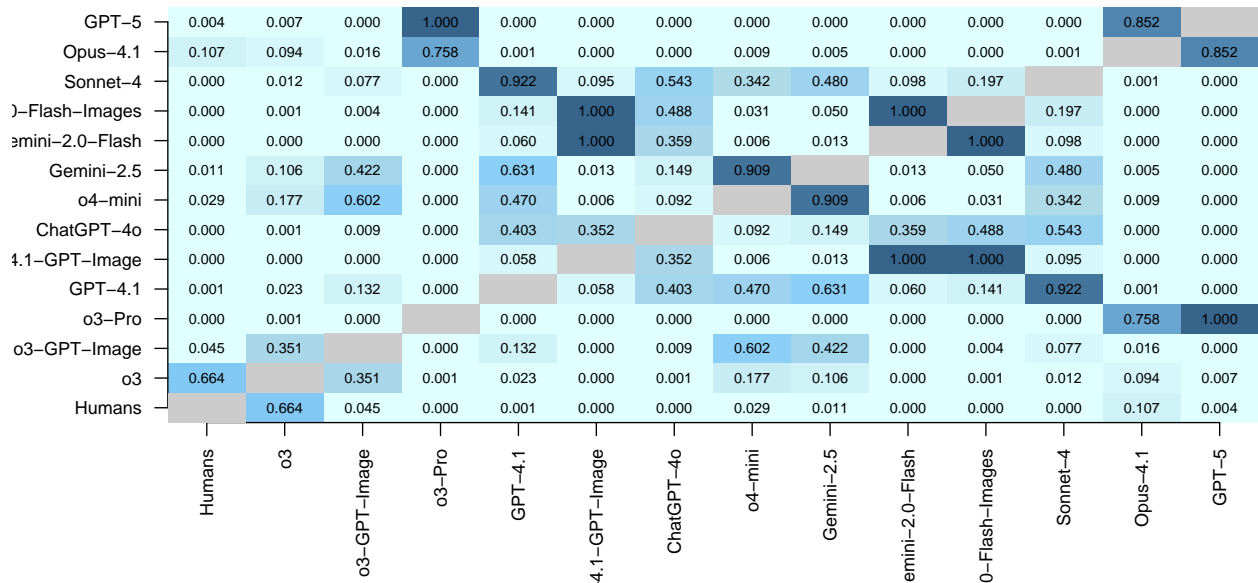
```

    x_pos + 0.5 / (length(novel_models) - 1), y_pos + 0.5 / (length(novel_models) - 1),
    col = "gray80", border = NA)
}

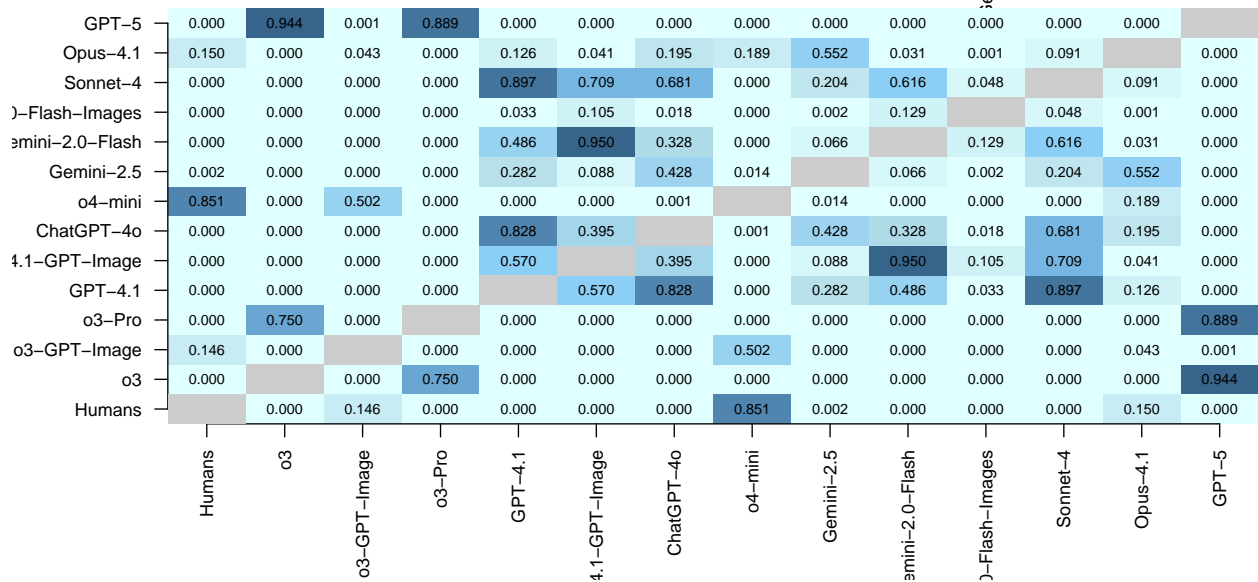
# Add p-values to the plot
for (i in 1:nrow(novel_pval_matrix)) {
  for (j in 1:ncol(novel_pval_matrix)) {
    if (!is.na(novel_pval_matrix[i, j])) {
      x_pos <- (j - 1) / (ncol(novel_pval_matrix) - 1)
      y_pos <- (i - 1) / (nrow(novel_pval_matrix) - 1)
      text(x_pos, y_pos, sprintf("%.3f", novel_pval_matrix[i, j]), cex = 0.7)
    }
  }
}

```

P-values Heatmap – Finke Tasks



P-values Heatmap – 48 Novel Tasks



Summary of Significant Differences

```
# Count significant differences for each task
finke_sig_count <- sum(finke_results$significant)
novel_48_sig_count <- sum(novel_48_results$significant)

cat("Summary of Significant Differences:\n")

## Summary of Significant Differences:
cat(paste(rep("=", 50), collapse = ""), "\n")

## =====
```



```

cat("Finke Tasks:\n")

## Finke Tasks:
cat("  Total comparisons:", nrow(finke_results), "\n")

##  Total comparisons: 91
cat("  Significant differences:", finke_sig_count, "\n")

##  Significant differences: 56
cat("  Percentage significant:", round(finke_sig_count / nrow(finke_results) * 100, 1), "%\n\n")

##  Percentage significant: 61.5 %
cat("48 Novel Tasks:\n")

## 48 Novel Tasks:
cat("  Total comparisons:", nrow(novel_48_results), "\n")

##  Total comparisons: 91
cat("  Significant differences:", novel_48_sig_count, "\n")

##  Significant differences: 62
cat("  Percentage significant:", round(novel_48_sig_count / nrow(novel_48_results) * 100, 1), "%\n\n")

##  Percentage significant: 68.1 %
# Show which comparisons are significant
cat("Significant Comparisons in Finke Tasks:\n")

## Significant Comparisons in Finke Tasks:
finke_sig <- finke_results[finke_results$significant, c("comparison", "diff", "p_value")]
if (nrow(finke_sig) > 0) {
  print(kable(finke_sig, format = "simple", digits = 4))
} else {
  cat("  None\n")
}

##
##
##
## -----
## comparison                                diff    p_value
## -----
## X-squared1    Humans vs o3-GPT-Image        0.0699    0.0452
## X-squared2    Humans vs o3-Pro             -0.1415    0.0002
## X-squared3    Humans vs GPT-4.1            0.1602    0.0007
## X-squared4    Humans vs GPT-4.1-GPT-Image   0.2886    0.0000
## X-squared5    Humans vs ChatGPT-4o         0.2221    0.0000
## X-squared6    Humans vs o4-mini            0.1052    0.0285
## X-squared7    Humans vs Gemini-2.5          0.1209    0.0114
## X-squared8    Humans vs Gemini-2.0-Flash    0.2877    0.0000
## X-squared9    Humans vs Gemini-2.0-Flash-Images 0.2879    0.0000
## X-squared10   Humans vs Sonnet-4           0.1748    0.0002
## X-squared12   Humans vs GPT-5             -0.1360    0.0038
## X-squared14   o3 vs o3-Pro                 -0.1612    0.0014
## X-squared15   o3 vs GPT-4.1                0.1405    0.0226

```

## X-squared16	o3 vs GPT-4.1-GPT-Image	0.2689	0.0000
## X-squared17	o3 vs ChatGPT-4o	0.2024	0.0009
## X-squared20	o3 vs Gemini-2.0-Flash	0.2681	0.0000
## X-squared21	o3 vs Gemini-2.0-Flash-Images	0.2683	0.0005
## X-squared22	o3 vs Sonnet-4	0.1551	0.0115
## X-squared24	o3 vs GPT-5	-0.1557	0.0071
## X-squared25	o3-GPT-Image vs o3-Pro	-0.2114	0.0000
## X-squared27	o3-GPT-Image vs GPT-4.1-GPT-Image	0.2187	0.0001
## X-squared28	o3-GPT-Image vs ChatGPT-4o	0.1522	0.0090
## X-squared31	o3-GPT-Image vs Gemini-2.0-Flash	0.2178	0.0002
## X-squared32	o3-GPT-Image vs Gemini-2.0-Flash-Images	0.2180	0.0040
## X-squared34	o3-GPT-Image vs Opus-4.1	-0.1808	0.0161
## X-squared35	o3-GPT-Image vs GPT-5	-0.2059	0.0002
## X-squared36	o3-Pro vs GPT-4.1	0.3017	0.0000
## X-squared37	o3-Pro vs GPT-4.1-GPT-Image	0.4300	0.0000
## X-squared38	o3-Pro vs ChatGPT-4o	0.3635	0.0000
## X-squared39	o3-Pro vs o4-mini	0.2466	0.0000
## X-squared40	o3-Pro vs Gemini-2.5	0.2623	0.0000
## X-squared41	o3-Pro vs Gemini-2.0-Flash	0.4292	0.0000
## X-squared42	o3-Pro vs Gemini-2.0-Flash-Images	0.4294	0.0000
## X-squared43	o3-Pro vs Sonnet-4	0.3163	0.0000
## X-squared53	GPT-4.1 vs Opus-4.1	-0.2711	0.0010
## X-squared54	GPT-4.1 vs GPT-5	-0.2962	0.0000
## X-squared56	GPT-4.1-GPT-Image vs o4-mini	-0.1834	0.0062
## X-squared57	GPT-4.1-GPT-Image vs Gemini-2.5	-0.1677	0.0125
## X-squared61	GPT-4.1-GPT-Image vs Opus-4.1	-0.3994	0.0000
## X-squared62	GPT-4.1-GPT-Image vs GPT-5	-0.4246	0.0000
## X-squared68	ChatGPT-4o vs Opus-4.1	-0.3329	0.0000
## X-squared69	ChatGPT-4o vs GPT-5	-0.3581	0.0000
## X-squared71	o4-mini vs Gemini-2.0-Flash	0.1826	0.0065
## X-squared72	o4-mini vs Gemini-2.0-Flash-Images	0.1828	0.0308
## X-squared74	o4-mini vs Opus-4.1	-0.2160	0.0087
## X-squared75	o4-mini vs GPT-5	-0.2412	0.0002
## X-squared76	Gemini-2.5 vs Gemini-2.0-Flash	0.1669	0.0130
## X-squared77	Gemini-2.5 vs Gemini-2.0-Flash-Images	0.1671	0.0496
## X-squared79	Gemini-2.5 vs Opus-4.1	-0.2317	0.0049
## X-squared80	Gemini-2.5 vs GPT-5	-0.2569	0.0001
## X-squared83	Gemini-2.0-Flash vs Opus-4.1	-0.3986	0.0000
## X-squared84	Gemini-2.0-Flash vs GPT-5	-0.4237	0.0000
## X-squared86	Gemini-2.0-Flash-Images vs Opus-4.1	-0.3988	0.0000
## X-squared87	Gemini-2.0-Flash-Images vs GPT-5	-0.4239	0.0000
## X-squared88	Sonnet-4 vs Opus-4.1	-0.2857	0.0005
## X-squared89	Sonnet-4 vs GPT-5	-0.3108	0.0000

```
cat("\nSignificant Comparisons in 48 Novel Tasks:\n")
```

```
##
```

```
## Significant Comparisons in 48 Novel Tasks:
```

```
novel_sig <- novel_48_results[novel_48_results$significant, c("comparison", "diff", "p_value")]
if (nrow(novel_sig) > 0) {
  print(kable(novel_sig, format = "simple", digits = 4))
} else {
  cat(" None\n")
}
```

```

##
##
## comparison diff p_value
## -----
## X-squared Humans vs o3 -0.1234 0.0000
## X-squared2 Humans vs o3-Pro -0.1140 0.0000
## X-squared3 Humans vs GPT-4.1 0.1125 0.0000
## X-squared4 Humans vs GPT-4.1-GPT-Image 0.1325 0.0000
## X-squared5 Humans vs ChatGPT-4o 0.1035 0.0000
## X-squared7 Humans vs Gemini-2.5 0.0760 0.0016
## X-squared8 Humans vs Gemini-2.0-Flash 0.1366 0.0000
## X-squared9 Humans vs Gemini-2.0-Flash-Images 0.1976 0.0000
## X-squared10 Humans vs Sonnet-4 0.1187 0.0000
## X-squared12 Humans vs GPT-5 -0.1196 0.0000
## X-squared13 o3 vs o3-GPT-Image 0.0975 0.0001
## X-squared15 o3 vs GPT-4.1 0.2358 0.0000
## X-squared16 o3 vs GPT-4.1-GPT-Image 0.2559 0.0000
## X-squared17 o3 vs ChatGPT-4o 0.2269 0.0000
## X-squared18 o3 vs o4-mini 0.1178 0.0001
## X-squared19 o3 vs Gemini-2.5 0.1994 0.0000
## X-squared20 o3 vs Gemini-2.0-Flash 0.2600 0.0000
## X-squared21 o3 vs Gemini-2.0-Flash-Images 0.3209 0.0000
## X-squared22 o3 vs Sonnet-4 0.2420 0.0000
## X-squared23 o3 vs Opus-4.1 0.1728 0.0000
## X-squared25 o3-GPT-Image vs o3-Pro -0.0881 0.0003
## X-squared26 o3-GPT-Image vs GPT-4.1 0.1383 0.0000
## X-squared27 o3-GPT-Image vs GPT-4.1-GPT-Image 0.1584 0.0000
## X-squared28 o3-GPT-Image vs ChatGPT-4o 0.1293 0.0000
## X-squared30 o3-GPT-Image vs Gemini-2.5 0.1019 0.0003
## X-squared31 o3-GPT-Image vs Gemini-2.0-Flash 0.1624 0.0000
## X-squared32 o3-GPT-Image vs Gemini-2.0-Flash-Images 0.2234 0.0000
## X-squared33 o3-GPT-Image vs Sonnet-4 0.1445 0.0000
## X-squared34 o3-GPT-Image vs Opus-4.1 0.0753 0.0434
## X-squared35 o3-GPT-Image vs GPT-5 -0.0938 0.0008
## X-squared36 o3-Pro vs GPT-4.1 0.2264 0.0000
## X-squared37 o3-Pro vs GPT-4.1-GPT-Image 0.2465 0.0000
## X-squared38 o3-Pro vs ChatGPT-4o 0.2174 0.0000
## X-squared39 o3-Pro vs o4-mini 0.1084 0.0002
## X-squared40 o3-Pro vs Gemini-2.5 0.1900 0.0000
## X-squared41 o3-Pro vs Gemini-2.0-Flash 0.2505 0.0000
## X-squared42 o3-Pro vs Gemini-2.0-Flash-Images 0.3115 0.0000
## X-squared43 o3-Pro vs Sonnet-4 0.2326 0.0000
## X-squared44 o3-Pro vs Opus-4.1 0.1634 0.0000
## X-squared48 GPT-4.1 vs o4-mini -0.1181 0.0003
## X-squared51 GPT-4.1 vs Gemini-2.0-Flash-Images 0.0851 0.0331
## X-squared54 GPT-4.1 vs GPT-5 -0.2321 0.0000
## X-squared56 GPT-4.1-GPT-Image vs o4-mini -0.1381 0.0000
## X-squared61 GPT-4.1-GPT-Image vs Opus-4.1 -0.0831 0.0405
## X-squared62 GPT-4.1-GPT-Image vs GPT-5 -0.2522 0.0000
## X-squared63 ChatGPT-4o vs o4-mini -0.1091 0.0009
## X-squared66 ChatGPT-4o vs Gemini-2.0-Flash-Images 0.0941 0.0184
## X-squared69 ChatGPT-4o vs GPT-5 -0.2231 0.0000
## X-squared70 o4-mini vs Gemini-2.5 0.0816 0.0137
## X-squared71 o4-mini vs Gemini-2.0-Flash 0.1422 0.0000

```

## X-squared72	o4-mini vs Gemini-2.0-Flash-Images	0.2031	0.0000
## X-squared73	o4-mini vs Sonnet-4	0.1242	0.0001
## X-squared75	o4-mini vs GPT-5	-0.1141	0.0004
## X-squared77	Gemini-2.5 vs Gemini-2.0-Flash-Images	0.1215	0.0023
## X-squared80	Gemini-2.5 vs GPT-5	-0.1957	0.0000
## X-squared83	Gemini-2.0-Flash vs Opus-4.1	-0.0871	0.0312
## X-squared84	Gemini-2.0-Flash vs GPT-5	-0.2562	0.0000
## X-squared85	Gemini-2.0-Flash-Images vs Sonnet-4	-0.0789	0.0484
## X-squared86	Gemini-2.0-Flash-Images vs Opus-4.1	-0.1481	0.0013
## X-squared87	Gemini-2.0-Flash-Images vs GPT-5	-0.3172	0.0000
## X-squared89	Sonnet-4 vs GPT-5	-0.2383	0.0000
## X-squared90	Opus-4.1 vs GPT-5	-0.1691	0.0000

Collapsed Analysis - Finke + 48 Novel Tasks Combined

```
# Test all combinations for collapsed data
collapsed_results <- test_all_combinations(collapsed_data, "Collapsed (Finke + 48 Novel)")

# Display results
cat("All Pairwise Comparisons for Collapsed Data (Finke + 48 Novel Tasks):\n")

## All Pairwise Comparisons for Collapsed Data (Finke + 48 Novel Tasks):
cat(paste(rep("=", 80), collapse = ""), "\n")

## =====
for (i in 1:nrow(collapsed_results)) {
  cat("\n", collapsed_results$comparison[i], "\n")
  cat(paste(rep("-", 40), collapse = ""), "\n")
  cat("Proportions: ", round(collapsed_results$prop1[i], 3), " vs ",
      round(collapsed_results$prop2[i], 3), "\n")
  cat("Difference: ", round(collapsed_results$diff[i], 3), "\n")
  cat("Chi-squared: ", round(collapsed_results$chi_squared[i], 3), "\n")
  cat("Degrees of freedom: ", round(collapsed_results$df[i], 3), "\n")
  cat("P-value: ", format(collapsed_results$p_value[i], scientific = FALSE, digits = 4), "\n")
  cat("95% CI: [", round(collapsed_results$ci_lower[i], 3), ", ",
      round(collapsed_results$ci_upper[i], 3), "]\n")
  cat("Significant: ", ifelse(collapsed_results$significant[i], "YES (p < 0.05)", "NO"), "\n")
}

##
## Humans vs o3
## -----
## Proportions: 0.547 vs 0.642
## Difference: -0.094
## Chi-squared: 28.631
## Degrees of freedom: 1
## P-value: 0.00000008757
## 95% CI: [ -0.128 , -0.06 ]
## Significant: YES (p < 0.05)
##
## Humans vs o3-GPT-Image
## -----
## Proportions: 0.547 vs 0.553
```

```

## Difference: -0.006
## Chi-squared: 0.143
## Degrees of freedom: 1
## P-value: 0.7057
## 95% CI: [ -0.037 , 0.024 ]
## Significant: NO
##
## Humans vs o3-Pro
## -----
## Proportions: 0.547 vs 0.666
## Difference: -0.119
## Chi-squared: 45.76
## Degrees of freedom: 1
## P-value: 0.00000000001336
## 95% CI: [ -0.153 , -0.086 ]
## Significant: YES (p < 0.05)
##
## Humans vs GPT-4.1
## -----
## Proportions: 0.547 vs 0.425
## Difference: 0.122
## Chi-squared: 32.987
## Degrees of freedom: 1
## P-value: 0.000000009278
## 95% CI: [ 0.08 , 0.164 ]
## Significant: YES (p < 0.05)
##
## Humans vs GPT-4.1-GPT-Image
## -----
## Proportions: 0.547 vs 0.383
## Difference: 0.164
## Chi-squared: 59.482
## Degrees of freedom: 1
## P-value: 0.0000000000001234
## 95% CI: [ 0.123 , 0.206 ]
## Significant: YES (p < 0.05)
##
## Humans vs ChatGPT-4o
## -----
## Proportions: 0.547 vs 0.42
## Difference: 0.128
## Chi-squared: 35.86
## Degrees of freedom: 1
## P-value: 0.00000000212
## 95% CI: [ 0.086 , 0.17 ]
## Significant: YES (p < 0.05)
##
## Humans vs o4-mini
## -----
## Proportions: 0.547 vs 0.53
## Difference: 0.017
## Chi-squared: 0.577
## Degrees of freedom: 1
## P-value: 0.4477

```

```

## 95% CI: [ -0.025 ,  0.059 ]
## Significant:  NO
##
## Humans vs Gemini-2.5
## -----
## Proportions:  0.547  vs  0.462
## Difference:   0.085
## Chi-squared:  15.96
## Degrees of freedom:  1
## P-value:      0.00006468
## 95% CI: [ 0.043 ,  0.128 ]
## Significant:  YES (p < 0.05)
##
## Humans vs Gemini-2.0-Flash
## -----
## Proportions:  0.547  vs  0.38
## Difference:   0.167
## Chi-squared:  61.741
## Degrees of freedom:  1
## P-value:      0.00000000000003918
## 95% CI: [ 0.126 ,  0.209 ]
## Significant:  YES (p < 0.05)
##
## Humans vs Gemini-2.0-Flash-Images
## -----
## Proportions:  0.547  vs  0.331
## Difference:   0.216
## Chi-squared:  53.296
## Degrees of freedom:  1
## P-value:      0.0000000000002869
## 95% CI: [ 0.16 ,  0.272 ]
## Significant:  YES (p < 0.05)
##
## Humans vs Sonnet-4
## -----
## Proportions:  0.547  vs  0.417
## Difference:   0.13
## Chi-squared:  37.392
## Degrees of freedom:  1
## P-value:      0.0000000009662
## 95% CI: [ 0.088 ,  0.172 ]
## Significant:  YES (p < 0.05)
##
## Humans vs Opus-4.1
## -----
## Proportions:  0.547  vs  0.529
## Difference:   0.018
## Chi-squared:  0.299
## Degrees of freedom:  1
## P-value:      0.5845
## 95% CI: [ -0.042 ,  0.077 ]
## Significant:  NO
##
## Humans vs GPT-5

```

```

## -----
## Proportions: 0.547 vs 0.67
## Difference: -0.123
## Chi-squared: 33.302
## Degrees of freedom: 1
## P-value: 0.00000000789
## 95% CI: [ -0.163 , -0.082 ]
## Significant: YES (p < 0.05)
##
## o3 vs o3-GPT-Image
## -----
## Proportions: 0.642 vs 0.553
## Difference: 0.088
## Chi-squared: 16.139
## Degrees of freedom: 1
## P-value: 0.00005886
## 95% CI: [ 0.045 , 0.131 ]
## Significant: YES (p < 0.05)
##
## o3 vs o3-Pro
## -----
## Proportions: 0.642 vs 0.666
## Difference: -0.025
## Chi-squared: 1.106
## Degrees of freedom: 1
## P-value: 0.2928
## 95% CI: [ -0.07 , 0.02 ]
## Significant: NO
##
## o3 vs GPT-4.1
## -----
## Proportions: 0.642 vs 0.425
## Difference: 0.217
## Chi-squared: 67.617
## Degrees of freedom: 1
## P-value: 0.00000000000000001986
## 95% CI: [ 0.165 , 0.269 ]
## Significant: YES (p < 0.05)
##
## o3 vs GPT-4.1-GPT-Image
## -----
## Proportions: 0.642 vs 0.383
## Difference: 0.258
## Chi-squared: 95.75
## Degrees of freedom: 1
## P-value: 0.000000000000000000001304
## 95% CI: [ 0.207 , 0.31 ]
## Significant: YES (p < 0.05)
##
## o3 vs ChatGPT-4o
## -----
## Proportions: 0.642 vs 0.42
## Difference: 0.222
## Chi-squared: 70.849

```

```

## Degrees of freedom: 1
## P-value: 0.00000000000000003855
## 95% CI: [ 0.17 , 0.274 ]
## Significant: YES (p < 0.05)
##
## o3 vs o4-mini
## -----
## Proportions: 0.642 vs 0.53
## Difference: 0.111
## Chi-squared: 18.085
## Degrees of freedom: 1
## P-value: 0.00002112
## 95% CI: [ 0.059 , 0.163 ]
## Significant: YES (p < 0.05)
##
## o3 vs Gemini-2.5
## -----
## Proportions: 0.642 vs 0.462
## Difference: 0.18
## Chi-squared: 46.719
## Degrees of freedom: 1
## P-value: 0.000000000008192
## 95% CI: [ 0.128 , 0.232 ]
## Significant: YES (p < 0.05)
##
## o3 vs Gemini-2.0-Flash
## -----
## Proportions: 0.642 vs 0.38
## Difference: 0.262
## Chi-squared: 98.017
## Degrees of freedom: 1
## P-value: 0.0000000000000000004147
## 95% CI: [ 0.21 , 0.313 ]
## Significant: YES (p < 0.05)
##
## o3 vs Gemini-2.0-Flash-Images
## -----
## Proportions: 0.642 vs 0.331
## Difference: 0.31
## Chi-squared: 86.894
## Degrees of freedom: 1
## P-value: 0.0000000000000000001145
## 95% CI: [ 0.246 , 0.374 ]
## Significant: YES (p < 0.05)
##
## o3 vs Sonnet-4
## -----
## Proportions: 0.642 vs 0.417
## Difference: 0.225
## Chi-squared: 72.549
## Degrees of freedom: 1
## P-value: 0.00000000000000001629
## 95% CI: [ 0.173 , 0.276 ]
## Significant: YES (p < 0.05)

```



```

##
## o3 vs Opus-4.1
## -----
## Proportions: 0.642 vs 0.529
## Difference: 0.112
## Chi-squared: 11.466
## Degrees of freedom: 1
## P-value: 0.0007087
## 95% CI: [ 0.045 , 0.179 ]
## Significant: YES (p < 0.05)
##
## o3 vs GPT-5
## -----
## Proportions: 0.642 vs 0.67
## Difference: -0.028
## Chi-squared: 1.138
## Degrees of freedom: 1
## P-value: 0.286
## 95% CI: [ -0.079 , 0.022 ]
## Significant: NO
##
## o3-GPT-Image vs o3-Pro
## -----
## Proportions: 0.553 vs 0.666
## Difference: -0.113
## Chi-squared: 26.82
## Degrees of freedom: 1
## P-value: 0.0000002234
## 95% CI: [ -0.155 , -0.07 ]
## Significant: YES (p < 0.05)
##
## o3-GPT-Image vs GPT-4.1
## -----
## Proportions: 0.553 vs 0.425
## Difference: 0.129
## Chi-squared: 26.007
## Degrees of freedom: 1
## P-value: 0.0000003401
## 95% CI: [ 0.079 , 0.178 ]
## Significant: YES (p < 0.05)
##
## o3-GPT-Image vs GPT-4.1-GPT-Image
## -----
## Proportions: 0.553 vs 0.383
## Difference: 0.17
## Chi-squared: 45.802
## Degrees of freedom: 1
## P-value: 0.0000000001308
## 95% CI: [ 0.121 , 0.22 ]
## Significant: YES (p < 0.05)
##
## o3-GPT-Image vs ChatGPT-4o
## -----
## Proportions: 0.553 vs 0.42

```

```

## Difference: 0.134
## Chi-squared: 28.164
## Degrees of freedom: 1
## P-value: 0.0000001115
## 95% CI: [ 0.084 , 0.184 ]
## Significant: YES (p < 0.05)
##
## o3-GPT-Image vs o4-mini
## -----
## Proportions: 0.553 vs 0.53
## Difference: 0.023
## Chi-squared: 0.782
## Degrees of freedom: 1
## P-value: 0.3765
## 95% CI: [ -0.027 , 0.073 ]
## Significant: NO
##
## o3-GPT-Image vs Gemini-2.5
## -----
## Proportions: 0.553 vs 0.462
## Difference: 0.092
## Chi-squared: 13.116
## Degrees of freedom: 1
## P-value: 0.0002928
## 95% CI: [ 0.042 , 0.142 ]
## Significant: YES (p < 0.05)
##
## o3-GPT-Image vs Gemini-2.0-Flash
## -----
## Proportions: 0.553 vs 0.38
## Difference: 0.174
## Chi-squared: 47.484
## Degrees of freedom: 1
## P-value: 0.00000000005546
## 95% CI: [ 0.124 , 0.223 ]
## Significant: YES (p < 0.05)
##
## o3-GPT-Image vs Gemini-2.0-Flash-Images
## -----
## Proportions: 0.553 vs 0.331
## Difference: 0.222
## Chi-squared: 46.585
## Degrees of freedom: 1
## P-value: 0.00000000008772
## 95% CI: [ 0.16 , 0.285 ]
## Significant: YES (p < 0.05)
##
## o3-GPT-Image vs Sonnet-4
## -----
## Proportions: 0.553 vs 0.417
## Difference: 0.137
## Chi-squared: 29.312
## Degrees of freedom: 1
## P-value: 0.00000006161

```

```

## 95% CI: [ 0.087 , 0.186 ]
## Significant: YES (p < 0.05)
##
## o3-GPT-Image vs Opus-4.1
## -----
## Proportions: 0.553 vs 0.529
## Difference: 0.024
## Chi-squared: 0.469
## Degrees of freedom: 1
## P-value: 0.4933
## 95% CI: [ -0.041 , 0.089 ]
## Significant: NO
##
## o3-GPT-Image vs GPT-5
## -----
## Proportions: 0.553 vs 0.67
## Difference: -0.116
## Chi-squared: 21.894
## Degrees of freedom: 1
## P-value: 0.000002882
## 95% CI: [ -0.164 , -0.068 ]
## Significant: YES (p < 0.05)
##
## o3-Pro vs GPT-4.1
## -----
## Proportions: 0.666 vs 0.425
## Difference: 0.241
## Chi-squared: 84.647
## Degrees of freedom: 1
## P-value: 0.00000000000000000003567
## 95% CI: [ 0.19 , 0.293 ]
## Significant: YES (p < 0.05)
##
## o3-Pro vs GPT-4.1-GPT-Image
## -----
## Proportions: 0.666 vs 0.383
## Difference: 0.283
## Chi-squared: 115.659
## Degrees of freedom: 1
## P-value: 0.0000000000000000000005644
## 95% CI: [ 0.232 , 0.334 ]
## Significant: YES (p < 0.05)
##
## o3-Pro vs ChatGPT-4o
## -----
## Proportions: 0.666 vs 0.42
## Difference: 0.247
## Chi-squared: 88.243
## Degrees of freedom: 1
## P-value: 0.00000000000000000005789
## 95% CI: [ 0.195 , 0.298 ]
## Significant: YES (p < 0.05)
##
## o3-Pro vs o4-mini

```

[illegible]

```

## Degrees of freedom: 1
## P-value: 0.00002821
## 95% CI: [ 0.07 , 0.203 ]
## Significant: YES (p < 0.05)
##
## o3-Pro vs GPT-5
## -----
## Proportions: 0.666 vs 0.67
## Difference: -0.003
## Chi-squared: 0.007
## Degrees of freedom: 1
## P-value: 0.9336
## 95% CI: [ -0.053 , 0.047 ]
## Significant: NO
##
## GPT-4.1 vs GPT-4.1-GPT-Image
## -----
## Proportions: 0.425 vs 0.383
## Difference: 0.042
## Chi-squared: 1.999
## Degrees of freedom: 1
## P-value: 0.1574
## 95% CI: [ -0.015 , 0.099 ]
## Significant: NO
##
## GPT-4.1 vs ChatGPT-4o
## -----
## Proportions: 0.425 vs 0.42
## Difference: 0.005
## Chi-squared: 0.015
## Degrees of freedom: 1
## P-value: 0.9017
## 95% CI: [ -0.052 , 0.063 ]
## Significant: NO
##
## GPT-4.1 vs o4-mini
## -----
## Proportions: 0.425 vs 0.53
## Difference: -0.105
## Chi-squared: 12.951
## Degrees of freedom: 1
## P-value: 0.0003197
## 95% CI: [ -0.163 , -0.048 ]
## Significant: YES (p < 0.05)
##
## GPT-4.1 vs Gemini-2.5
## -----
## Proportions: 0.425 vs 0.462
## Difference: -0.037
## Chi-squared: 1.519
## Degrees of freedom: 1
## P-value: 0.2177
## 95% CI: [ -0.095 , 0.021 ]
## Significant: NO

```

```

##
## GPT-4.1 vs Gemini-2.0-Flash
## -----
## Proportions: 0.425 vs 0.38
## Difference: 0.045
## Chi-squared: 2.321
## Degrees of freedom: 1
## P-value: 0.1276
## 95% CI: [ -0.012 , 0.102 ]
## Significant: NO
##
## GPT-4.1 vs Gemini-2.0-Flash-Images
## -----
## Proportions: 0.425 vs 0.331
## Difference: 0.094
## Chi-squared: 6.957
## Degrees of freedom: 1
## P-value: 0.008347
## 95% CI: [ 0.025 , 0.162 ]
## Significant: YES (p < 0.05)
##
## GPT-4.1 vs Sonnet-4
## -----
## Proportions: 0.425 vs 0.417
## Difference: 0.008
## Chi-squared: 0.047
## Degrees of freedom: 1
## P-value: 0.8277
## 95% CI: [ -0.05 , 0.065 ]
## Significant: NO
##
## GPT-4.1 vs Opus-4.1
## -----
## Proportions: 0.425 vs 0.529
## Difference: -0.105
## Chi-squared: 8.399
## Degrees of freedom: 1
## P-value: 0.003755
## 95% CI: [ -0.176 , -0.033 ]
## Significant: YES (p < 0.05)
##
## GPT-4.1 vs GPT-5
## -----
## Proportions: 0.425 vs 0.67
## Difference: -0.245
## Chi-squared: 71.655
## Degrees of freedom: 1
## P-value: 0.00000000000000002564
## 95% CI: [ -0.301 , -0.189 ]
## Significant: YES (p < 0.05)
##
## GPT-4.1-GPT-Image vs ChatGPT-4o
## -----
## Proportions: 0.383 vs 0.42

```

```

## Difference: -0.037
## Chi-squared: 1.518
## Degrees of freedom: 1
## P-value: 0.2179
## 95% CI: [ -0.094 , 0.021 ]
## Significant: NO
##
## GPT-4.1-GPT-Image vs o4-mini
## -----
## Proportions: 0.383 vs 0.53
## Difference: -0.147
## Chi-squared: 25.599
## Degrees of freedom: 1
## P-value: 0.0000004203
## 95% CI: [ -0.205 , -0.09 ]
## Significant: YES (p < 0.05)
##
## GPT-4.1-GPT-Image vs Gemini-2.5
## -----
## Proportions: 0.383 vs 0.462
## Difference: -0.079
## Chi-squared: 7.305
## Degrees of freedom: 1
## P-value: 0.006876
## 95% CI: [ -0.136 , -0.021 ]
## Significant: YES (p < 0.05)
##
## GPT-4.1-GPT-Image vs Gemini-2.0-Flash
## -----
## Proportions: 0.383 vs 0.38
## Difference: 0.003
## Chi-squared: 0.003
## Degrees of freedom: 1
## P-value: 0.9599
## 95% CI: [ -0.054 , 0.06 ]
## Significant: NO
##
## GPT-4.1-GPT-Image vs Gemini-2.0-Flash-Images
## -----
## Proportions: 0.383 vs 0.331
## Difference: 0.052
## Chi-squared: 2.104
## Degrees of freedom: 1
## P-value: 0.147
## 95% CI: [ -0.017 , 0.12 ]
## Significant: NO
##
## GPT-4.1-GPT-Image vs Sonnet-4
## -----
## Proportions: 0.383 vs 0.417
## Difference: -0.034
## Chi-squared: 1.295
## Degrees of freedom: 1
## P-value: 0.2551

```

```

## 95% CI: [ -0.091 ,  0.023 ]
## Significant:  NO
##
## GPT-4.1-GPT-Image vs Opus-4.1
## -----
## Proportions:  0.383  vs  0.529
## Difference:   -0.146
## Chi-squared:  16.868
## Degrees of freedom:  1
## P-value:      0.00004007
## 95% CI: [ -0.217 ,  -0.075 ]
## Significant:   YES (p < 0.05)
##
## GPT-4.1-GPT-Image vs GPT-5
## -----
## Proportions:  0.383  vs  0.67
## Difference:   -0.287
## Chi-squared:  97.737
## Degrees of freedom:  1
## P-value:      0.00000000000000000000000004779
## 95% CI: [ -0.342 ,  -0.231 ]
## Significant:   YES (p < 0.05)
##
## ChatGPT-4o vs o4-mini
## -----
## Proportions:  0.42   vs  0.53
## Difference:   -0.111
## Chi-squared:  14.285
## Degrees of freedom:  1
## P-value:      0.0001571
## 95% CI: [ -0.168 ,  -0.053 ]
## Significant:   YES (p < 0.05)
##
## ChatGPT-4o vs Gemini-2.5
## -----
## Proportions:  0.42   vs  0.462
## Difference:   -0.042
## Chi-squared:  2.001
## Degrees of freedom:  1
## P-value:      0.1572
## 95% CI: [ -0.1 ,  0.016 ]
## Significant:   NO
##
## ChatGPT-4o vs Gemini-2.0-Flash
## -----
## Proportions:  0.42   vs  0.38
## Difference:    0.04
## Chi-squared:  1.8
## Degrees of freedom:  1
## P-value:      0.1797
## 95% CI: [ -0.017 ,  0.097 ]
## Significant:   NO
##
## ChatGPT-4o vs Gemini-2.0-Flash-Images

```



```

## -----
## Proportions: 0.42 vs 0.331
## Difference: 0.088
## Chi-squared: 6.207
## Degrees of freedom: 1
## P-value: 0.01272
## 95% CI: [ 0.02 , 0.157 ]
## Significant: YES (p < 0.05)
##
## ChatGPT-4o vs Sonnet-4
## -----
## Proportions: 0.42 vs 0.417
## Difference: 0.003
## Chi-squared: 0.001
## Degrees of freedom: 1
## P-value: 0.9716
## 95% CI: [ -0.055 , 0.06 ]
## Significant: NO
##
## ChatGPT-4o vs Opus-4.1
## -----
## Proportions: 0.42 vs 0.529
## Difference: -0.11
## Chi-squared: 9.285
## Degrees of freedom: 1
## P-value: 0.002311
## 95% CI: [ -0.181 , -0.038 ]
## Significant: YES (p < 0.05)
##
## ChatGPT-4o vs GPT-5
## -----
## Proportions: 0.42 vs 0.67
## Difference: -0.25
## Chi-squared: 74.672
## Degrees of freedom: 1
## P-value: 0.00000000000000005558
## 95% CI: [ -0.306 , -0.194 ]
## Significant: YES (p < 0.05)
##
## o4-mini vs Gemini-2.5
## -----
## Proportions: 0.53 vs 0.462
## Difference: 0.068
## Chi-squared: 5.349
## Degrees of freedom: 1
## P-value: 0.02074
## 95% CI: [ 0.01 , 0.127 ]
## Significant: YES (p < 0.05)
##
## o4-mini vs Gemini-2.0-Flash
## -----
## Proportions: 0.53 vs 0.38
## Difference: 0.15
## Chi-squared: 26.707

```

```

## Degrees of freedom: 1
## P-value: 0.0000002367
## 95% CI: [ 0.093 , 0.208 ]
## Significant: YES (p < 0.05)
##
## o4-mini vs Gemini-2.0-Flash-Images
## -----
## Proportions: 0.53 vs 0.331
## Difference: 0.199
## Chi-squared: 31.073
## Degrees of freedom: 1
## P-value: 0.00000002485
## 95% CI: [ 0.13 , 0.268 ]
## Significant: YES (p < 0.05)
##
## o4-mini vs Sonnet-4
## -----
## Proportions: 0.53 vs 0.417
## Difference: 0.113
## Chi-squared: 15.001
## Degrees of freedom: 1
## P-value: 0.0001075
## 95% CI: [ 0.056 , 0.171 ]
## Significant: YES (p < 0.05)
##
## o4-mini vs Opus-4.1
## -----
## Proportions: 0.53 vs 0.529
## Difference: 0.001
## Chi-squared: 0
## Degrees of freedom: 1
## P-value: 1
## 95% CI: [ -0.069 , 0.071 ]
## Significant: NO
##
## o4-mini vs GPT-5
## -----
## Proportions: 0.53 vs 0.67
## Difference: -0.139
## Chi-squared: 23.742
## Degrees of freedom: 1
## P-value: 0.000001102
## 95% CI: [ -0.196 , -0.083 ]
## Significant: YES (p < 0.05)
##
## Gemini-2.5 vs Gemini-2.0-Flash
## -----
## Proportions: 0.462 vs 0.38
## Difference: 0.082
## Chi-squared: 7.907
## Degrees of freedom: 1
## P-value: 0.004923
## 95% CI: [ 0.024 , 0.139 ]
## Significant: YES (p < 0.05)

```

```

##
## Gemini-2.5 vs Gemini-2.0-Flash-Images
## -----
## Proportions: 0.462 vs 0.331
## Difference: 0.131
## Chi-squared: 13.497
## Degrees of freedom: 1
## P-value: 0.000239
## 95% CI: [ 0.062 , 0.2 ]
## Significant: YES (p < 0.05)
##
## Gemini-2.5 vs Sonnet-4
## -----
## Proportions: 0.462 vs 0.417
## Difference: 0.045
## Chi-squared: 2.275
## Degrees of freedom: 1
## P-value: 0.1315
## 95% CI: [ -0.013 , 0.103 ]
## Significant: NO
##
## Gemini-2.5 vs Opus-4.1
## -----
## Proportions: 0.462 vs 0.529
## Difference: -0.068
## Chi-squared: 3.394
## Degrees of freedom: 1
## P-value: 0.06541
## 95% CI: [ -0.139 , 0.004 ]
## Significant: NO
##
## Gemini-2.5 vs GPT-5
## -----
## Proportions: 0.462 vs 0.67
## Difference: -0.208
## Chi-squared: 51.944
## Degrees of freedom: 1
## P-value: 0.0000000000005711
## 95% CI: [ -0.264 , -0.151 ]
## Significant: YES (p < 0.05)
##
## Gemini-2.0-Flash vs Gemini-2.0-Flash-Images
## -----
## Proportions: 0.38 vs 0.331
## Difference: 0.049
## Chi-squared: 1.854
## Degrees of freedom: 1
## P-value: 0.1733
## 95% CI: [ -0.02 , 0.117 ]
## Significant: NO
##
## Gemini-2.0-Flash vs Sonnet-4
## -----
## Proportions: 0.38 vs 0.417

```

[illegible]

```
## 95% CI: [ -0.406 , -0.271 ]
## Significant: YES (p < 0.05)
##
## Sonnet-4 vs Opus-4.1
## -----
## Proportions: 0.417 vs 0.529
## Difference: -0.112
## Chi-squared: 9.76
## Degrees of freedom: 1
## P-value: 0.001783
## 95% CI: [ -0.184 , -0.041 ]
## Significant: YES (p < 0.05)
##
## Sonnet-4 vs GPT-5
## -----
## Proportions: 0.417 vs 0.67
## Difference: -0.253
## Chi-squared: 76.256
## Degrees of freedom: 1
## P-value: 0.0000000000000000002492
## 95% CI: [ -0.309 , -0.197 ]
## Significant: YES (p < 0.05)
##
## Opus-4.1 vs GPT-5
## -----
## Proportions: 0.529 vs 0.67
## Difference: -0.14
## Chi-squared: 16.17
## Degrees of freedom: 1
## P-value: 0.0000579
## 95% CI: [ -0.211 , -0.07 ]
## Significant: YES (p < 0.05)
```

```
# Summary table
collapsed_summary <- collapsed_results %>%
  select(comparison, diff, chi_squared, p_value, significant) %>%
  mutate(diff = round(diff, 3),
         p_value = round(p_value, 4))

cat("\n\nSummary Table - Collapsed Data:\n")
```

```
##
##
## Summary Table - Collapsed Data:
```

```
print(kable(collapsed_summary, format = "simple"))
```

```
##
##
## comparison diff chi_squared p_value signif
## -----
## X-squared Humans vs o3 -0.094 28.6308876 0.0000 TRUE
## X-squared1 Humans vs o3-GPT-Image -0.006 0.1425741 0.7057 FALSE
## X-squared2 Humans vs o3-Pro -0.119 45.7603911 0.0000 TRUE
## X-squared3 Humans vs GPT-4.1 0.122 32.9868982 0.0000 TRUE
```

## X-squared4	Humans vs GPT-4.1-GPT-Image	0.164	59.4818080	0.0000	TRUE
## X-squared5	Humans vs ChatGPT-4o	0.128	35.8604451	0.0000	TRUE
## X-squared6	Humans vs o4-mini	0.017	0.5765459	0.4477	FALSE
## X-squared7	Humans vs Gemini-2.5	0.085	15.9603007	0.0001	TRUE
## X-squared8	Humans vs Gemini-2.0-Flash	0.167	61.7405958	0.0000	TRUE
## X-squared9	Humans vs Gemini-2.0-Flash-Images	0.216	53.2959199	0.0000	TRUE
## X-squared10	Humans vs Sonnet-4	0.130	37.3919075	0.0000	TRUE
## X-squared11	Humans vs Opus-4.1	0.018	0.2989942	0.5845	FALSE
## X-squared12	Humans vs GPT-5	-0.123	33.3019857	0.0000	TRUE
## X-squared13	o3 vs o3-GPT-Image	0.088	16.1391378	0.0001	TRUE
## X-squared14	o3 vs o3-Pro	-0.025	1.1064986	0.2928	FALSE
## X-squared15	o3 vs GPT-4.1	0.217	67.6166340	0.0000	TRUE
## X-squared16	o3 vs GPT-4.1-GPT-Image	0.258	95.7496135	0.0000	TRUE
## X-squared17	o3 vs ChatGPT-4o	0.222	70.8494853	0.0000	TRUE
## X-squared18	o3 vs o4-mini	0.111	18.0851641	0.0000	TRUE
## X-squared19	o3 vs Gemini-2.5	0.180	46.7193652	0.0000	TRUE
## X-squared20	o3 vs Gemini-2.0-Flash	0.262	98.0174945	0.0000	TRUE
## X-squared21	o3 vs Gemini-2.0-Flash-Images	0.310	86.8942530	0.0000	TRUE
## X-squared22	o3 vs Sonnet-4	0.225	72.5490940	0.0000	TRUE
## X-squared23	o3 vs Opus-4.1	0.112	11.4662661	0.0007	TRUE
## X-squared24	o3 vs GPT-5	-0.028	1.1383107	0.2860	FALSE
## X-squared25	o3-GPT-Image vs o3-Pro	-0.113	26.8195138	0.0000	TRUE
## X-squared26	o3-GPT-Image vs GPT-4.1	0.129	26.0074801	0.0000	TRUE
## X-squared27	o3-GPT-Image vs GPT-4.1-GPT-Image	0.170	45.8021597	0.0000	TRUE
## X-squared28	o3-GPT-Image vs ChatGPT-4o	0.134	28.1640608	0.0000	TRUE
## X-squared29	o3-GPT-Image vs o4-mini	0.023	0.7821301	0.3765	FALSE
## X-squared30	o3-GPT-Image vs Gemini-2.5	0.092	13.1161642	0.0003	TRUE
## X-squared31	o3-GPT-Image vs Gemini-2.0-Flash	0.174	47.4839020	0.0000	TRUE
## X-squared32	o3-GPT-Image vs Gemini-2.0-Flash-Images	0.222	46.5852344	0.0000	TRUE
## X-squared33	o3-GPT-Image vs Sonnet-4	0.137	29.3120309	0.0000	TRUE
## X-squared34	o3-GPT-Image vs Opus-4.1	0.024	0.4692957	0.4933	FALSE
## X-squared35	o3-GPT-Image vs GPT-5	-0.116	21.8935396	0.0000	TRUE
## X-squared36	o3-Pro vs GPT-4.1	0.241	84.6471507	0.0000	TRUE
## X-squared37	o3-Pro vs GPT-4.1-GPT-Image	0.283	115.6594014	0.0000	TRUE
## X-squared38	o3-Pro vs ChatGPT-4o	0.247	88.2427557	0.0000	TRUE
## X-squared39	o3-Pro vs o4-mini	0.136	27.4784870	0.0000	TRUE
## X-squared40	o3-Pro vs Gemini-2.5	0.204	61.1246804	0.0000	TRUE
## X-squared41	o3-Pro vs Gemini-2.0-Flash	0.286	118.1359936	0.0000	TRUE
## X-squared42	o3-Pro vs Gemini-2.0-Flash-Images	0.335	102.5130386	0.0000	TRUE
## X-squared43	o3-Pro vs Sonnet-4	0.249	90.1292627	0.0000	TRUE
## X-squared44	o3-Pro vs Opus-4.1	0.137	17.5347059	0.0000	TRUE
## X-squared45	o3-Pro vs GPT-5	-0.003	0.0069479	0.9336	FALSE
## X-squared46	GPT-4.1 vs GPT-4.1-GPT-Image	0.042	1.9993745	0.1574	FALSE
## X-squared47	GPT-4.1 vs ChatGPT-4o	0.005	0.0152534	0.9017	FALSE
## X-squared48	GPT-4.1 vs o4-mini	-0.105	12.9510207	0.0003	TRUE
## X-squared49	GPT-4.1 vs Gemini-2.5	-0.037	1.5193687	0.2177	FALSE
## X-squared50	GPT-4.1 vs Gemini-2.0-Flash	0.045	2.3210330	0.1276	FALSE
## X-squared51	GPT-4.1 vs Gemini-2.0-Flash-Images	0.094	6.9574196	0.0083	TRUE
## X-squared52	GPT-4.1 vs Sonnet-4	0.008	0.0473504	0.8277	FALSE
## X-squared53	GPT-4.1 vs Opus-4.1	-0.105	8.3986450	0.0038	TRUE
## X-squared54	GPT-4.1 vs GPT-5	-0.245	71.6546450	0.0000	TRUE
## X-squared55	GPT-4.1-GPT-Image vs ChatGPT-4o	-0.037	1.5181623	0.2179	FALSE
## X-squared56	GPT-4.1-GPT-Image vs o4-mini	-0.147	25.5989635	0.0000	TRUE
## X-squared57	GPT-4.1-GPT-Image vs Gemini-2.5	-0.079	7.3049825	0.0069	TRUE

## X-squared58	GPT-4.1-GPT-Image vs Gemini-2.0-Flash	0.003	0.0025231	0.9599	FALSE
## X-squared59	GPT-4.1-GPT-Image vs Gemini-2.0-Flash-Images	0.052	2.1035348	0.1470	FALSE
## X-squared60	GPT-4.1-GPT-Image vs Sonnet-4	-0.034	1.2951527	0.2551	FALSE
## X-squared61	GPT-4.1-GPT-Image vs Opus-4.1	-0.146	16.8680920	0.0000	TRUE
## X-squared62	GPT-4.1-GPT-Image vs GPT-5	-0.287	97.7365295	0.0000	TRUE
## X-squared63	ChatGPT-4o vs o4-mini	-0.111	14.2854157	0.0002	TRUE
## X-squared64	ChatGPT-4o vs Gemini-2.5	-0.042	2.0005049	0.1572	FALSE
## X-squared65	ChatGPT-4o vs Gemini-2.0-Flash	0.040	1.8000628	0.1797	FALSE
## X-squared66	ChatGPT-4o vs Gemini-2.0-Flash-Images	0.088	6.2071015	0.0127	TRUE
## X-squared67	ChatGPT-4o vs Sonnet-4	0.003	0.0012675	0.9716	FALSE
## X-squared68	ChatGPT-4o vs Opus-4.1	-0.110	9.2845807	0.0023	TRUE
## X-squared69	ChatGPT-4o vs GPT-5	-0.250	74.6719492	0.0000	TRUE
## X-squared70	o4-mini vs Gemini-2.5	0.068	5.3489240	0.0207	TRUE
## X-squared71	o4-mini vs Gemini-2.0-Flash	0.150	26.7071233	0.0000	TRUE
## X-squared72	o4-mini vs Gemini-2.0-Flash-Images	0.199	31.0733308	0.0000	TRUE
## X-squared73	o4-mini vs Sonnet-4	0.113	15.0010285	0.0001	TRUE
## X-squared74	o4-mini vs Opus-4.1	0.001	0.0000000	1.0000	FALSE
## X-squared75	o4-mini vs GPT-5	-0.139	23.7419837	0.0000	TRUE
## X-squared76	Gemini-2.5 vs Gemini-2.0-Flash	0.082	7.9073611	0.0049	TRUE
## X-squared77	Gemini-2.5 vs Gemini-2.0-Flash-Images	0.131	13.4965103	0.0002	TRUE
## X-squared78	Gemini-2.5 vs Sonnet-4	0.045	2.2752755	0.1315	FALSE
## X-squared79	Gemini-2.5 vs Opus-4.1	-0.068	3.3944881	0.0654	FALSE
## X-squared80	Gemini-2.5 vs GPT-5	-0.208	51.9440409	0.0000	TRUE
## X-squared81	Gemini-2.0-Flash vs Gemini-2.0-Flash-Images	0.049	1.8541845	0.1733	FALSE
## X-squared82	Gemini-2.0-Flash vs Sonnet-4	-0.037	1.5564724	0.2122	FALSE
## X-squared83	Gemini-2.0-Flash vs Opus-4.1	-0.149	17.6174219	0.0000	TRUE
## X-squared84	Gemini-2.0-Flash vs GPT-5	-0.290	99.8257607	0.0000	TRUE
## X-squared85	Gemini-2.0-Flash-Images vs Sonnet-4	-0.086	5.8355995	0.0157	TRUE
## X-squared86	Gemini-2.0-Flash-Images vs Opus-4.1	-0.198	23.2466529	0.0000	TRUE
## X-squared87	Gemini-2.0-Flash-Images vs GPT-5	-0.339	91.5289929	0.0000	TRUE
## X-squared88	Sonnet-4 vs Opus-4.1	-0.112	9.7604857	0.0018	TRUE
## X-squared89	Sonnet-4 vs GPT-5	-0.253	76.2556458	0.0000	TRUE
## X-squared90	Opus-4.1 vs GPT-5	-0.140	16.1702630	0.0001	TRUE

```
# Count significant differences
```

```
collapsed_sig_count <- sum(collapsed_results$significant)
```

```
cat("\n\nCollapsed Data Summary:\n")
```

```
##
```

```
##
```

```
## Collapsed Data Summary:
```

```
cat("  Total comparisons:", nrow(collapsed_results), "\n")
```

```
##  Total comparisons: 91
```

```
cat("  Significant differences:", collapsed_sig_count, "\n")
```

```
##  Significant differences: 66
```

```
cat("  Percentage significant:", round(collapsed_sig_count / nrow(collapsed_results) * 100, 1), "%\n\n")
```

```
##  Percentage significant: 72.5 %
```

```
# Show significant comparisons
```

```
cat("Significant Comparisons in Collapsed Data:\n")
```

```
## Significant Comparisons in Collapsed Data:
```

```
collapsed_sig <- collapsed_results[collapsed_results$significant, c("comparison", "diff", "p_value")]
if (nrow(collapsed_sig) > 0) {
  print(kable(collapsed_sig, format = "simple", digits = 4))
} else {
  cat("  None\n")
}
```

```
##
##
##      comparison      diff  p_value
## -----
## X-squared  Humans vs o3      -0.0944  0.0000
## X-squared2 Humans vs o3-Pro   -0.1191  0.0000
## X-squared3 Humans vs GPT-4.1    0.1224  0.0000
## X-squared4 Humans vs GPT-4.1-GPT-Image 0.1641  0.0000
## X-squared5 Humans vs ChatGPT-4o    0.1276  0.0000
## X-squared7 Humans vs Gemini-2.5    0.0854  0.0001
## X-squared8 Humans vs Gemini-2.0-Flash 0.1672  0.0000
## X-squared9 Humans vs Gemini-2.0-Flash-Images 0.2160  0.0000
## X-squared10 Humans vs Sonnet-4    0.1303  0.0000
## X-squared12 Humans vs GPT-5      -0.1225  0.0000
## X-squared13 o3 vs o3-GPT-Image    0.0881  0.0001
## X-squared15 o3 vs GPT-4.1        0.2168  0.0000
## X-squared16 o3 vs GPT-4.1-GPT-Image 0.2585  0.0000
## X-squared17 o3 vs ChatGPT-4o    0.2220  0.0000
## X-squared18 o3 vs o4-mini        0.1113  0.0000
## X-squared19 o3 vs Gemini-2.5      0.1798  0.0000
## X-squared20 o3 vs Gemini-2.0-Flash 0.2616  0.0000
## X-squared21 o3 vs Gemini-2.0-Flash-Images 0.3104  0.0000
## X-squared22 o3 vs Sonnet-4      0.2246  0.0000
## X-squared23 o3 vs Opus-4.1       0.1121  0.0007
## X-squared25 o3-GPT-Image vs o3-Pro -0.1128  0.0000
## X-squared26 o3-GPT-Image vs GPT-4.1 0.1287  0.0000
## X-squared27 o3-GPT-Image vs GPT-4.1-GPT-Image 0.1704  0.0000
## X-squared28 o3-GPT-Image vs ChatGPT-4o 0.1339  0.0000
## X-squared30 o3-GPT-Image vs Gemini-2.5 0.0917  0.0003
## X-squared31 o3-GPT-Image vs Gemini-2.0-Flash 0.1735  0.0000
## X-squared32 o3-GPT-Image vs Gemini-2.0-Flash-Images 0.2223  0.0000
## X-squared33 o3-GPT-Image vs Sonnet-4 0.1366  0.0000
## X-squared35 o3-GPT-Image vs GPT-5    -0.1162  0.0000
## X-squared36 o3-Pro vs GPT-4.1      0.2415  0.0000
## X-squared37 o3-Pro vs GPT-4.1-GPT-Image 0.2832  0.0000
## X-squared38 o3-Pro vs ChatGPT-4o    0.2467  0.0000
## X-squared39 o3-Pro vs o4-mini      0.1360  0.0000
## X-squared40 o3-Pro vs Gemini-2.5    0.2045  0.0000
## X-squared41 o3-Pro vs Gemini-2.0-Flash 0.2863  0.0000
## X-squared42 o3-Pro vs Gemini-2.0-Flash-Images 0.3351  0.0000
## X-squared43 o3-Pro vs Sonnet-4     0.2493  0.0000
## X-squared44 o3-Pro vs Opus-4.1     0.1368  0.0000
## X-squared48 GPT-4.1 vs o4-mini     -0.1054  0.0003
## X-squared51 GPT-4.1 vs Gemini-2.0-Flash-Images 0.0936  0.0083
## X-squared53 GPT-4.1 vs Opus-4.1    -0.1046  0.0038
## X-squared54 GPT-4.1 vs GPT-5      -0.2449  0.0000
```

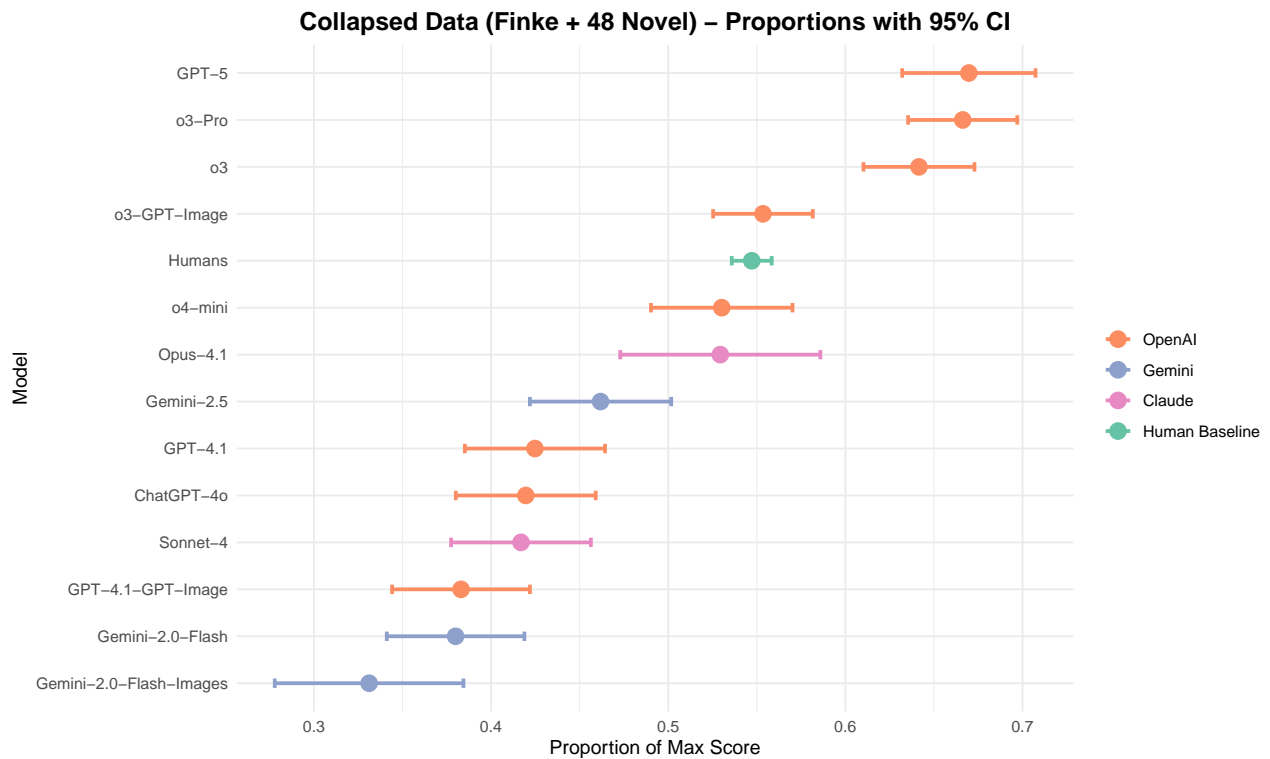

## X-squared56	GPT-4.1-GPT-Image vs o4-mini	-0.1472	0.0000
## X-squared57	GPT-4.1-GPT-Image vs Gemini-2.5	-0.0787	0.0069
## X-squared61	GPT-4.1-GPT-Image vs Opus-4.1	-0.1464	0.0000
## X-squared62	GPT-4.1-GPT-Image vs GPT-5	-0.2867	0.0000
## X-squared63	ChatGPT-4o vs o4-mini	-0.1106	0.0002
## X-squared66	ChatGPT-4o vs Gemini-2.0-Flash-Images	0.0884	0.0127
## X-squared68	ChatGPT-4o vs Opus-4.1	-0.1098	0.0023
## X-squared69	ChatGPT-4o vs GPT-5	-0.2501	0.0000
## X-squared70	o4-mini vs Gemini-2.5	0.0684	0.0207
## X-squared71	o4-mini vs Gemini-2.0-Flash	0.1502	0.0000
## X-squared72	o4-mini vs Gemini-2.0-Flash-Images	0.1991	0.0000
## X-squared73	o4-mini vs Sonnet-4	0.1133	0.0001
## X-squared75	o4-mini vs GPT-5	-0.1395	0.0000
## X-squared76	Gemini-2.5 vs Gemini-2.0-Flash	0.0818	0.0049
## X-squared77	Gemini-2.5 vs Gemini-2.0-Flash-Images	0.1306	0.0002
## X-squared80	Gemini-2.5 vs GPT-5	-0.2079	0.0000
## X-squared83	Gemini-2.0-Flash vs Opus-4.1	-0.1494	0.0000
## X-squared84	Gemini-2.0-Flash vs GPT-5	-0.2897	0.0000
## X-squared85	Gemini-2.0-Flash-Images vs Sonnet-4	-0.0858	0.0157
## X-squared86	Gemini-2.0-Flash-Images vs Opus-4.1	-0.1982	0.0000
## X-squared87	Gemini-2.0-Flash-Images vs GPT-5	-0.3386	0.0000
## X-squared88	Sonnet-4 vs Opus-4.1	-0.1125	0.0018
## X-squared89	Sonnet-4 vs GPT-5	-0.2528	0.0000
## X-squared90	Opus-4.1 vs GPT-5	-0.1403	0.0001

Visualization of Collapsed Data

```
# Plot proportions with confidence intervals for collapsed data
collapsed_plot <- ggplot(collapsed_data, aes(x = reorder(model, proportion), y = proportion)) +
  geom_point(aes(color = color), size = 4) +
  geom_errorbar(aes(ymin = proportion - 1.96 * sqrt(proportion * (1 - proportion) / max_score),
                    ymax = proportion + 1.96 * sqrt(proportion * (1 - proportion) / max_score),
                    color = color),
                width = 0.2, size = 1) +
  coord_flip() +
  theme_minimal() +
  labs(title = "Collapsed Data (Finke + 48 Novel) - Proportions with 95% CI",
       x = "Model",
       y = "Proportion of Max Score") +
  theme(plot.title = element_text(hjust = 0.5, size = 14, face = "bold")) +
  scale_color_manual(
    values = c("#fc8d62", "#8da0cb", "#e78ac3", "#66c2a5"),
    name = element_blank(),
    breaks = c("#fc8d62", "#8da0cb", "#e78ac3", "#66c2a5"),
    labels = c("OpenAI", "Gemini", "Claude", "Human Baseline")
  )

# red #66c2a5
# blue #fc8d62
# green #8da0cb
# purple #e78ac3

print(collapsed_plot)
```

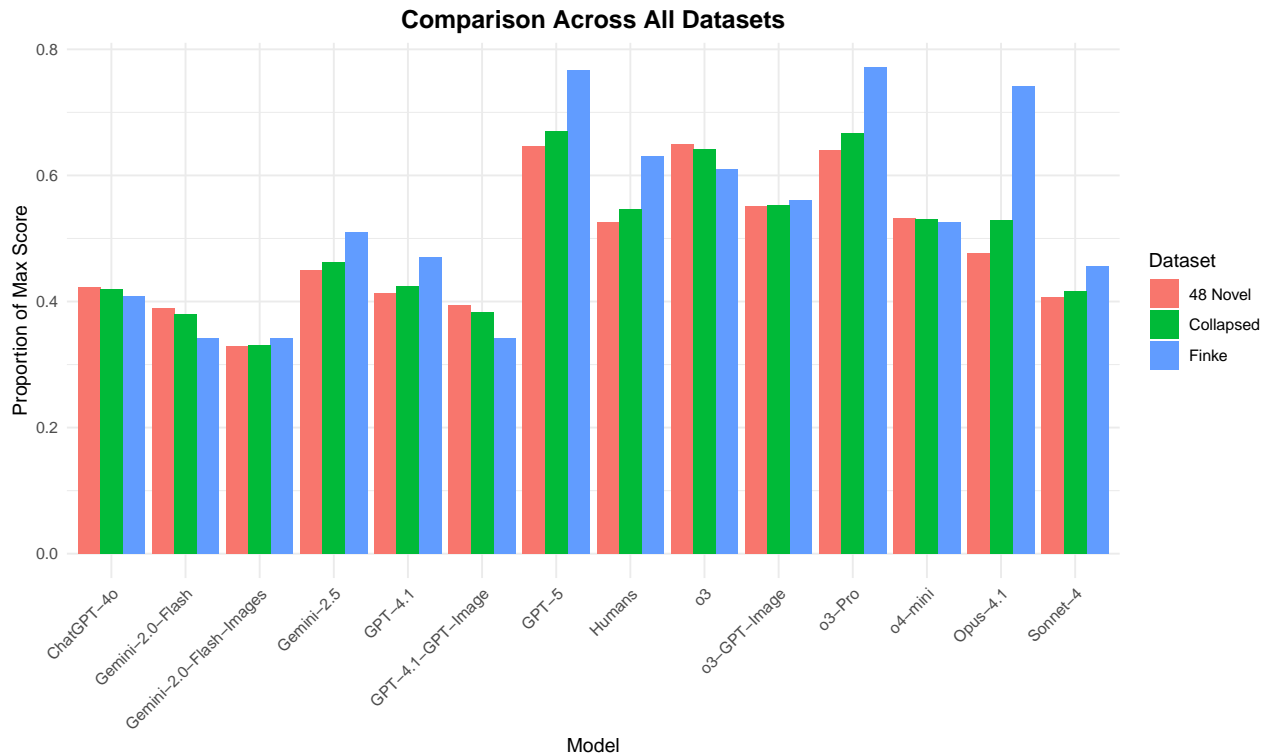


Create a comparison plot showing all three datasets

```
comparison_data <- bind_rows(
  finke_data %>% mutate(dataset = "Finke"),
  novel_data %>% mutate(dataset = "48 Novel"),
  collapsed_data %>% mutate(dataset = "Collapsed")
)

comparison_plot <- ggplot(comparison_data, aes(x = model, y = proportion, fill = dataset)) +
  geom_bar(stat = "identity", position = "dodge") +
  theme_minimal() +
  labs(title = "Comparison Across All Datasets",
       x = "Model",
       y = "Proportion of Max Score",
       fill = "Dataset") +
  theme(plot.title = element_text(hjust = 0.5, size = 14, face = "bold"),
        axis.text.x = element_text(angle = 45, hjust = 1))

print(comparison_plot)
```



Heatmap for Collapsed Data

```
# Create matrix of p-values for collapsed data
collapsed_models <- collapsed_data$model
collapsed_pval_matrix <- matrix(NA, nrow = length(collapsed_models), ncol = length(collapsed_models))
rownames(collapsed_pval_matrix) <- collapsed_models
colnames(collapsed_pval_matrix) <- collapsed_models

for (i in 1:nrow(collapsed_results)) {
  row_idx <- which(collapsed_models == collapsed_results$model1[i])
  col_idx <- which(collapsed_models == collapsed_results$model2[i])
  collapsed_pval_matrix[row_idx, col_idx] <- collapsed_results$p_value[i]
  collapsed_pval_matrix[col_idx, row_idx] <- collapsed_results$p_value[i]
}

# Set diagonal to NA
diag(collapsed_pval_matrix) <- NA

# Set margins for better label display
par(mar = c(6, 6, 3, 2))

# Plot heatmap with same color palette
image(collapsed_pval_matrix, axes = FALSE, col = col_palette,
      main = "P-values Heatmap - Collapsed Data (Finke + 48 Novel)")
axis(1, at = seq(0, 1, length.out = length(collapsed_models)), labels = collapsed_models,
     las = 2, cex.axis = 0.8) # las=2 makes labels perpendicular, cex.axis makes them smaller
axis(2, at = seq(0, 1, length.out = length(collapsed_models)), labels = collapsed_models,
     las = 2, cex.axis = 0.8)
```

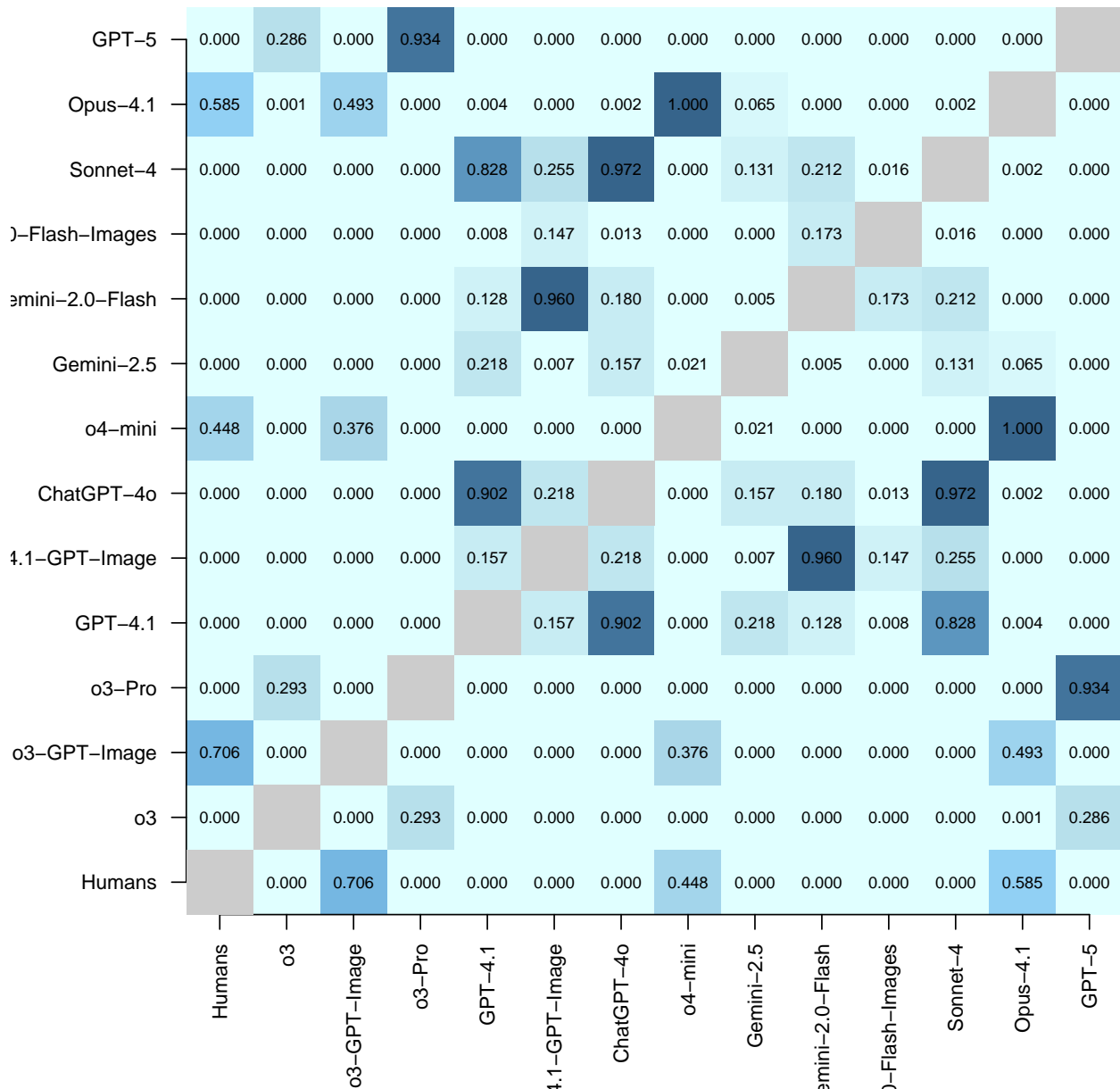
```

# Add gray color for diagonal
for (i in 1:length(collapsed_models)) {
  x_pos <- (i - 1) / (length(collapsed_models) - 1)
  y_pos <- (i - 1) / (length(collapsed_models) - 1)
  rect(x_pos - 0.5 / (length(collapsed_models) - 1), y_pos - 0.5 / (length(collapsed_models) - 1),
       x_pos + 0.5 / (length(collapsed_models) - 1), y_pos + 0.5 / (length(collapsed_models) - 1),
       col = "gray80", border = NA)
}

# Add p-values to the plot
for (i in 1:nrow(collapsed_pval_matrix)) {
  for (j in 1:ncol(collapsed_pval_matrix)) {
    if (!is.na(collapsed_pval_matrix[i, j])) {
      x_pos <- (j - 1) / (ncol(collapsed_pval_matrix) - 1)
      y_pos <- (i - 1) / (nrow(collapsed_pval_matrix) - 1)
      text(x_pos, y_pos, sprintf("%.3f", collapsed_pval_matrix[i, j]), cex = 0.7)
    }
  }
}

```

P-values Heatmap – Collapsed Data (Finke + 48 Novel)



Reasoning Variation Analysis

Finke

```
# Test all combinations for Finke reasoning variations
finke_reasoning_results <- test_all_combinations(finke_reasoning_data, "Finke Reasoning Variations")
# Display results
cat("All Pairwise Comparisons for Finke Reasoning Variations:\n")

## All Pairwise Comparisons for Finke Reasoning Variations:
cat(paste(rep("=", 80), collapse = ""), "\n")

## =====
```

```

for (i in 1:nrow(finke_reasoning_results)) {
  cat("\n", finke_reasoning_results$comparison[i], "\n")
  cat(paste(rep("-", 40), collapse = ""), "\n")
  cat("Proportions: ", round(finke_reasoning_results$prop1[i], 3), " vs ",
      round(finke_reasoning_results$prop2[i], 3), "\n")
  cat("Difference: ", round(finke_reasoning_results$diff[i], 3), "\n")
  cat("Chi-squared: ", round(finke_reasoning_results$chi_squared[i], 3), "\n")
  cat("Degrees of freedom: ", round(finke_reasoning_results$df[i], 3), "\n")
  cat("P-value: ", format(finke_reasoning_results$p_value[i], scientific = FALSE, digits = 4), "\n")
  cat("95% CI: [", round(finke_reasoning_results$ci_lower[i], 3), ", ",
      round(finke_reasoning_results$ci_upper[i], 3), "]\n")
  cat("Significant: ", ifelse(finke_reasoning_results$significant[i], "YES (p < 0.05)", "NO"), "\n")
}

```

```

##
## Humans vs o3-High
## -----
## Proportions: 0.63 vs 0.611
## Difference: 0.02
## Chi-squared: 0.189
## Degrees of freedom: 1
## P-value: 0.6636
## 95% CI: [ -0.059 , 0.098 ]
## Significant: NO
##
## Humans vs o3-Medium
## -----
## Proportions: 0.63 vs 0.574
## Difference: 0.057
## Chi-squared: 0.568
## Degrees of freedom: 1
## P-value: 0.4509
## 95% CI: [ -0.08 , 0.193 ]
## Significant: NO
##
## Humans vs o3-Low
## -----
## Proportions: 0.63 vs 0.623
## Difference: 0.007
## Chi-squared: 0
## Degrees of freedom: 1
## P-value: 1
## 95% CI: [ -0.125 , 0.139 ]
## Significant: NO
##
## Humans vs GPT-5-High
## -----
## Proportions: 0.63 vs 0.766
## Difference: -0.136
## Chi-squared: 8.354
## Degrees of freedom: 1
## P-value: 0.003847
## 95% CI: [ -0.22 , -0.052 ]
## Significant: YES (p < 0.05)

```

```

##
## Humans vs o3-Pro
## -----
## Proportions: 0.63 vs 0.772
## Difference: -0.141
## Chi-squared: 13.467
## Degrees of freedom: 1
## P-value: 0.0002428
## 95% CI: [ -0.211 , -0.072 ]
## Significant: YES (p < 0.05)
##
## Humans vs GPT-5-Medium
## -----
## Proportions: 0.63 vs 0.633
## Difference: -0.003
## Chi-squared: 0
## Degrees of freedom: 1
## P-value: 1
## 95% CI: [ -0.131 , 0.124 ]
## Significant: NO
##
## Humans vs GPT-5-Low
## -----
## Proportions: 0.63 vs 0.556
## Difference: 0.074
## Chi-squared: 1.063
## Degrees of freedom: 1
## P-value: 0.3026
## 95% CI: [ -0.062 , 0.211 ]
## Significant: NO
##
## Humans vs GPT-5-Minimal
## -----
## Proportions: 0.63 vs 0.366
## Difference: 0.265
## Chi-squared: 16.06
## Degrees of freedom: 1
## P-value: 0.00006135
## 95% CI: [ 0.132 , 0.398 ]
## Significant: YES (p < 0.05)
##
## Humans vs o4-mini-High
## -----
## Proportions: 0.63 vs 0.525
## Difference: 0.105
## Chi-squared: 4.797
## Degrees of freedom: 1
## P-value: 0.0285
## 95% CI: [ 0.008 , 0.202 ]
## Significant: YES (p < 0.05)
##
## Humans vs o4-mini-Medium
## -----
## Proportions: 0.63 vs 0.467

```

```

## Difference: 0.163
## Chi-squared: 11.896
## Degrees of freedom: 1
## P-value: 0.0005627
## 95% CI: [ 0.066 , 0.26 ]
## Significant: YES (p < 0.05)
##
## Humans vs o3-GPT-Image-High
## -----
## Proportions: 0.63 vs 0.56
## Difference: 0.07
## Chi-squared: 4.009
## Degrees of freedom: 1
## P-value: 0.04525
## 95% CI: [ 0 , 0.14 ]
## Significant: YES (p < 0.05)
##
## Humans vs o3-GPT-Image-Medium
## -----
## Proportions: 0.63 vs 0.506
## Difference: 0.125
## Chi-squared: 3.312
## Degrees of freedom: 1
## P-value: 0.06877
## 95% CI: [ -0.013 , 0.262 ]
## Significant: NO
##
## o3-High vs o3-Medium
## -----
## Proportions: 0.611 vs 0.574
## Difference: 0.037
## Chi-squared: 0.125
## Degrees of freedom: 1
## P-value: 0.7234
## 95% CI: [ -0.118 , 0.192 ]
## Significant: NO
##
## o3-High vs o3-Low
## -----
## Proportions: 0.611 vs 0.623
## Difference: -0.012
## Chi-squared: 0
## Degrees of freedom: 1
## P-value: 0.9847
## 95% CI: [ -0.165 , 0.14 ]
## Significant: NO
##
## o3-High vs GPT-5-High
## -----
## Proportions: 0.611 vs 0.766
## Difference: -0.156
## Chi-squared: 7.237
## Degrees of freedom: 1
## P-value: 0.007141

```



```

## 95% CI: [ -0.267 , -0.045 ]
## Significant: YES (p < 0.05)
##
## o3-High vs o3-Pro
## -----
## Proportions: 0.611 vs 0.772
## Difference: -0.161
## Chi-squared: 10.208
## Degrees of freedom: 1
## P-value: 0.001398
## 95% CI: [ -0.261 , -0.062 ]
## Significant: YES (p < 0.05)
##
## o3-High vs GPT-5-Medium
## -----
## Proportions: 0.611 vs 0.633
## Difference: -0.023
## Chi-squared: 0.027
## Degrees of freedom: 1
## P-value: 0.8706
## 95% CI: [ -0.175 , 0.129 ]
## Significant: NO
##
## o3-High vs GPT-5-Low
## -----
## Proportions: 0.611 vs 0.556
## Difference: 0.055
## Chi-squared: 0.353
## Degrees of freedom: 1
## P-value: 0.5522
## 95% CI: [ -0.101 , 0.21 ]
## Significant: NO
##
## o3-High vs GPT-5-Minimal
## -----
## Proportions: 0.611 vs 0.366
## Difference: 0.245
## Chi-squared: 9.942
## Degrees of freedom: 1
## P-value: 0.001616
## 95% CI: [ 0.093 , 0.397 ]
## Significant: YES (p < 0.05)
##
## o3-High vs o4-mini-High
## -----
## Proportions: 0.611 vs 0.525
## Difference: 0.085
## Chi-squared: 1.819
## Degrees of freedom: 1
## P-value: 0.1774
## 95% CI: [ -0.036 , 0.207 ]
## Significant: NO
##
## o3-High vs o4-mini-Medium

```

```

## -----
## Proportions: 0.611 vs 0.467
## Difference: 0.144
## Chi-squared: 5.446
## Degrees of freedom: 1
## P-value: 0.01961
## 95% CI: [ 0.023 , 0.265 ]
## Significant: YES (p < 0.05)
##
## o3-High vs o3-GPT-Image-High
## -----
## Proportions: 0.611 vs 0.56
## Difference: 0.05
## Chi-squared: 0.869
## Degrees of freedom: 1
## P-value: 0.3511
## 95% CI: [ -0.05 , 0.15 ]
## Significant: NO
##
## o3-High vs o3-GPT-Image-Medium
## -----
## Proportions: 0.611 vs 0.506
## Difference: 0.105
## Chi-squared: 1.63
## Degrees of freedom: 1
## P-value: 0.2016
## 95% CI: [ -0.051 , 0.261 ]
## Significant: NO
##
## o3-Medium vs o3-Low
## -----
## Proportions: 0.574 vs 0.623
## Difference: -0.049
## Chi-squared: 0.134
## Degrees of freedom: 1
## P-value: 0.7142
## 95% CI: [ -0.241 , 0.142 ]
## Significant: NO
##
## o3-Medium vs GPT-5-High
## -----
## Proportions: 0.574 vs 0.766
## Difference: -0.193
## Chi-squared: 6.205
## Degrees of freedom: 1
## P-value: 0.01274
## 95% CI: [ -0.351 , -0.034 ]
## Significant: YES (p < 0.05)
##
## o3-Medium vs o3-Pro
## -----
## Proportions: 0.574 vs 0.772
## Difference: -0.198
## Chi-squared: 7.842

```

```

## Degrees of freedom: 1
## P-value: 0.005103
## 95% CI: [ -0.349 , -0.048 ]
## Significant: YES (p < 0.05)
##
## o3-Medium vs GPT-5-Medium
## -----
## Proportions: 0.574 vs 0.633
## Difference: -0.06
## Chi-squared: 0.234
## Degrees of freedom: 1
## P-value: 0.6286
## 95% CI: [ -0.251 , 0.132 ]
## Significant: NO
##
## o3-Medium vs GPT-5-Low
## -----
## Proportions: 0.574 vs 0.556
## Difference: 0.018
## Chi-squared: 0
## Degrees of freedom: 1
## P-value: 0.9914
## 95% CI: [ -0.176 , 0.212 ]
## Significant: NO
##
## o3-Medium vs GPT-5-Minimal
## -----
## Proportions: 0.574 vs 0.366
## Difference: 0.208
## Chi-squared: 4.411
## Degrees of freedom: 1
## P-value: 0.03571
## 95% CI: [ 0.017 , 0.399 ]
## Significant: YES (p < 0.05)
##
## o3-Medium vs o4-mini-High
## -----
## Proportions: 0.574 vs 0.525
## Difference: 0.049
## Chi-squared: 0.209
## Degrees of freedom: 1
## P-value: 0.6473
## 95% CI: [ -0.118 , 0.215 ]
## Significant: NO
##
## o3-Medium vs o4-mini-Medium
## -----
## Proportions: 0.574 vs 0.467
## Difference: 0.107
## Chi-squared: 1.421
## Degrees of freedom: 1
## P-value: 0.2333
## 95% CI: [ -0.059 , 0.273 ]
## Significant: NO

```

```

##
## o3-Medium vs o3-GPT-Image-High
## -----
## Proportions: 0.574 vs 0.56
## Difference: 0.013
## Chi-squared: 0.002
## Degrees of freedom: 1
## P-value: 0.9683
## 95% CI: [ -0.137 , 0.164 ]
## Significant: NO
##
## o3-Medium vs o3-GPT-Image-Medium
## -----
## Proportions: 0.574 vs 0.506
## Difference: 0.068
## Chi-squared: 0.318
## Degrees of freedom: 1
## P-value: 0.5729
## 95% CI: [ -0.127 , 0.263 ]
## Significant: NO
##
## o3-Low vs GPT-5-High
## -----
## Proportions: 0.623 vs 0.766
## Difference: -0.143
## Chi-squared: 3.378
## Degrees of freedom: 1
## P-value: 0.06606
## 95% CI: [ -0.3 , 0.013 ]
## Significant: NO
##
## o3-Low vs o3-Pro
## -----
## Proportions: 0.623 vs 0.772
## Difference: -0.149
## Chi-squared: 4.366
## Degrees of freedom: 1
## P-value: 0.03666
## 95% CI: [ -0.297 , 0 ]
## Significant: YES (p < 0.05)
##
## o3-Low vs GPT-5-Medium
## -----
## Proportions: 0.623 vs 0.633
## Difference: -0.01
## Chi-squared: 0
## Degrees of freedom: 1
## P-value: 1
## 95% CI: [ -0.194 , 0.173 ]
## Significant: NO
##
## o3-Low vs GPT-5-Low
## -----
## Proportions: 0.623 vs 0.556

```

```

## Difference: 0.067
## Chi-squared: 0.315
## Degrees of freedom: 1
## P-value: 0.5746
## 95% CI: [ -0.125 , 0.259 ]
## Significant: NO
##
## o3-Low vs GPT-5-Minimal
## -----
## Proportions: 0.623 vs 0.366
## Difference: 0.257
## Chi-squared: 6.96
## Degrees of freedom: 1
## P-value: 0.008336
## 95% CI: [ 0.068 , 0.447 ]
## Significant: YES (p < 0.05)
##
## o3-Low vs o4-mini-High
## -----
## Proportions: 0.623 vs 0.525
## Difference: 0.098
## Chi-squared: 1.185
## Degrees of freedom: 1
## P-value: 0.2763
## 95% CI: [ -0.066 , 0.262 ]
## Significant: NO
##
## o3-Low vs o4-mini-Medium
## -----
## Proportions: 0.623 vs 0.467
## Difference: 0.156
## Chi-squared: 3.308
## Degrees of freedom: 1
## P-value: 0.06895
## 95% CI: [ -0.008 , 0.32 ]
## Significant: NO
##
## o3-Low vs o3-GPT-Image-High
## -----
## Proportions: 0.623 vs 0.56
## Difference: 0.063
## Chi-squared: 0.536
## Degrees of freedom: 1
## P-value: 0.4639
## 95% CI: [ -0.085 , 0.211 ]
## Significant: NO
##
## o3-Low vs o3-GPT-Image-Medium
## -----
## Proportions: 0.623 vs 0.506
## Difference: 0.117
## Chi-squared: 1.239
## Degrees of freedom: 1
## P-value: 0.2657

```

```

## 95% CI: [ -0.075 ,  0.31 ]
## Significant:  NO
##
## GPT-5-High vs o3-Pro
## -----
## Proportions:  0.766  vs  0.772
## Difference:   -0.005
## Chi-squared:   0
## Degrees of freedom:  1
## P-value:      1
## 95% CI: [ -0.108 ,  0.097 ]
## Significant:   NO
##
## GPT-5-High vs GPT-5-Medium
## -----
## Proportions:  0.766  vs  0.633
## Difference:    0.133
## Chi-squared:   2.883
## Degrees of freedom:  1
## P-value:      0.08952
## 95% CI: [ -0.023 ,  0.289 ]
## Significant:   NO
##
## GPT-5-High vs GPT-5-Low
## -----
## Proportions:  0.766  vs  0.556
## Difference:    0.21
## Chi-squared:   7.397
## Degrees of freedom:  1
## P-value:      0.006533
## 95% CI: [ 0.051 ,  0.37 ]
## Significant:   YES (p < 0.05)
##
## GPT-5-High vs GPT-5-Minimal
## -----
## Proportions:  0.766  vs  0.366
## Difference:    0.401
## Chi-squared:   25.935
## Degrees of freedom:  1
## P-value:      0.0000003531
## 95% CI: [ 0.245 ,  0.557 ]
## Significant:   YES (p < 0.05)
##
## GPT-5-High vs o4-mini-High
## -----
## Proportions:  0.766  vs  0.525
## Difference:    0.241
## Chi-squared:   14.219
## Degrees of freedom:  1
## P-value:      0.0001627
## 95% CI: [ 0.116 ,  0.367 ]
## Significant:   YES (p < 0.05)
##
## GPT-5-High vs o4-mini-Medium

```

```

## -----
## Proportions: 0.766 vs 0.467
## Difference: 0.299
## Chi-squared: 21.498
## Degrees of freedom: 1
## P-value: 0.000003543
## 95% CI: [ 0.174 , 0.425 ]
## Significant: YES (p < 0.05)
##
## GPT-5-High vs o3-GPT-Image-High
## -----
## Proportions: 0.766 vs 0.56
## Difference: 0.206
## Chi-squared: 13.665
## Degrees of freedom: 1
## P-value: 0.0002185
## 95% CI: [ 0.101 , 0.311 ]
## Significant: YES (p < 0.05)
##
## GPT-5-High vs o3-GPT-Image-Medium
## -----
## Proportions: 0.766 vs 0.506
## Difference: 0.261
## Chi-squared: 11.305
## Degrees of freedom: 1
## P-value: 0.0007731
## 95% CI: [ 0.101 , 0.421 ]
## Significant: YES (p < 0.05)
##
## o3-Pro vs GPT-5-Medium
## -----
## Proportions: 0.772 vs 0.633
## Difference: 0.138
## Chi-squared: 3.754
## Degrees of freedom: 1
## P-value: 0.05269
## 95% CI: [ -0.009 , 0.286 ]
## Significant: NO
##
## o3-Pro vs GPT-5-Low
## -----
## Proportions: 0.772 vs 0.556
## Difference: 0.216
## Chi-squared: 9.302
## Degrees of freedom: 1
## P-value: 0.002289
## 95% CI: [ 0.065 , 0.367 ]
## Significant: YES (p < 0.05)
##
## o3-Pro vs GPT-5-Minimal
## -----
## Proportions: 0.772 vs 0.366
## Difference: 0.406
## Chi-squared: 31.768

```

```

## Degrees of freedom: 1
## P-value: 0.00000001737
## 95% CI: [ 0.259 , 0.554 ]
## Significant: YES (p < 0.05)
##
## o3-Pro vs o4-mini-High
## -----
## Proportions: 0.772 vs 0.525
## Difference: 0.247
## Chi-squared: 18.799
## Degrees of freedom: 1
## P-value: 0.00001452
## 95% CI: [ 0.131 , 0.362 ]
## Significant: YES (p < 0.05)
##
## o3-Pro vs o4-mini-Medium
## -----
## Proportions: 0.772 vs 0.467
## Difference: 0.305
## Chi-squared: 28.077
## Degrees of freedom: 1
## P-value: 0.0000001166
## 95% CI: [ 0.19 , 0.42 ]
## Significant: YES (p < 0.05)
##
## o3-Pro vs o3-GPT-Image-High
## -----
## Proportions: 0.772 vs 0.56
## Difference: 0.211
## Chi-squared: 19.304
## Degrees of freedom: 1
## P-value: 0.00001115
## 95% CI: [ 0.119 , 0.304 ]
## Significant: YES (p < 0.05)
##
## o3-Pro vs o3-GPT-Image-Medium
## -----
## Proportions: 0.772 vs 0.506
## Difference: 0.266
## Chi-squared: 14.071
## Degrees of freedom: 1
## P-value: 0.000176
## 95% CI: [ 0.114 , 0.418 ]
## Significant: YES (p < 0.05)
##
## GPT-5-Medium vs GPT-5-Low
## -----
## Proportions: 0.633 vs 0.556
## Difference: 0.078
## Chi-squared: 0.461
## Degrees of freedom: 1
## P-value: 0.4973
## 95% CI: [ -0.114 , 0.269 ]
## Significant: NO

```



```

##
## GPT-5-Medium vs GPT-5-Minimal
## -----
## Proportions: 0.633 vs 0.366
## Difference: 0.268
## Chi-squared: 7.574
## Degrees of freedom: 1
## P-value: 0.005922
## 95% CI: [ 0.079 , 0.457 ]
## Significant: YES (p < 0.05)
##
## GPT-5-Medium vs o4-mini-High
## -----
## Proportions: 0.633 vs 0.525
## Difference: 0.108
## Chi-squared: 1.494
## Degrees of freedom: 1
## P-value: 0.2216
## 95% CI: [ -0.055 , 0.272 ]
## Significant: NO
##
## GPT-5-Medium vs o4-mini-Medium
## -----
## Proportions: 0.633 vs 0.467
## Difference: 0.167
## Chi-squared: 3.807
## Degrees of freedom: 1
## P-value: 0.05104
## 95% CI: [ 0.003 , 0.33 ]
## Significant: NO
##
## GPT-5-Medium vs o3-GPT-Image-High
## -----
## Proportions: 0.633 vs 0.56
## Difference: 0.073
## Chi-squared: 0.772
## Degrees of freedom: 1
## P-value: 0.3795
## 95% CI: [ -0.074 , 0.221 ]
## Significant: NO
##
## GPT-5-Medium vs o3-GPT-Image-Medium
## -----
## Proportions: 0.633 vs 0.506
## Difference: 0.128
## Chi-squared: 1.512
## Degrees of freedom: 1
## P-value: 0.2188
## 95% CI: [ -0.065 , 0.32 ]
## Significant: NO
##
## GPT-5-Low vs GPT-5-Minimal
## -----
## Proportions: 0.556 vs 0.366

```

```

## Difference: 0.19
## Chi-squared: 3.644
## Degrees of freedom: 1
## P-value: 0.05626
## 95% CI: [ -0.001 , 0.382 ]
## Significant: NO
##
## GPT-5-Low vs o4-mini-High
## -----
## Proportions: 0.556 vs 0.525
## Difference: 0.031
## Chi-squared: 0.054
## Degrees of freedom: 1
## P-value: 0.8155
## 95% CI: [ -0.136 , 0.198 ]
## Significant: NO
##
## GPT-5-Low vs o4-mini-Medium
## -----
## Proportions: 0.556 vs 0.467
## Difference: 0.089
## Chi-squared: 0.939
## Degrees of freedom: 1
## P-value: 0.3326
## 95% CI: [ -0.078 , 0.256 ]
## Significant: NO
##
## GPT-5-Low vs o3-GPT-Image-High
## -----
## Proportions: 0.556 vs 0.56
## Difference: -0.004
## Chi-squared: 0
## Degrees of freedom: 1
## P-value: 1
## 95% CI: [ -0.149 , 0.141 ]
## Significant: NO
##
## GPT-5-Low vs o3-GPT-Image-Medium
## -----
## Proportions: 0.556 vs 0.506
## Difference: 0.05
## Chi-squared: 0.137
## Degrees of freedom: 1
## P-value: 0.7117
## 95% CI: [ -0.145 , 0.245 ]
## Significant: NO
##
## GPT-5-Minimal vs o4-mini-High
## -----
## Proportions: 0.366 vs 0.525
## Difference: -0.159
## Chi-squared: 3.468
## Degrees of freedom: 1
## P-value: 0.06256

```

```

## 95% CI: [ -0.323 ,  0.004 ]
## Significant:  NO
##
## GPT-5-Minimal vs o4-mini-Medium
## -----
## Proportions:  0.366  vs  0.467
## Difference:   -0.101
## Chi-squared:  1.285
## Degrees of freedom:  1
## P-value:      0.257
## 95% CI: [ -0.265 ,  0.062 ]
## Significant:  NO
##
## GPT-5-Minimal vs o3-GPT-Image-High
## -----
## Proportions:  0.366  vs  0.56
## Difference:   -0.195
## Chi-squared:  6.537
## Degrees of freedom:  1
## P-value:      0.01056
## 95% CI: [ -0.342 ,  -0.047 ]
## Significant:  YES (p < 0.05)
##
## GPT-5-Minimal vs o3-GPT-Image-Medium
## -----
## Proportions:  0.366  vs  0.506
## Difference:   -0.14
## Chi-squared:  1.858
## Degrees of freedom:  1
## P-value:      0.1729
## 95% CI: [ -0.332 ,  0.052 ]
## Significant:  NO
##
## o4-mini-High vs o4-mini-Medium
## -----
## Proportions:  0.525  vs  0.467
## Difference:    0.058
## Chi-squared:  0.597
## Degrees of freedom:  1
## P-value:      0.4398
## 95% CI: [ -0.076 ,  0.193 ]
## Significant:  NO
##
## o4-mini-High vs o3-GPT-Image-High
## -----
## Proportions:  0.525  vs  0.56
## Difference:   -0.035
## Chi-squared:  0.272
## Degrees of freedom:  1
## P-value:      0.6019
## 95% CI: [ -0.151 ,  0.08 ]
## Significant:  NO
##
## o4-mini-High vs o3-GPT-Image-Medium

```

```

## -----
## Proportions: 0.525 vs 0.506
## Difference: 0.019
## Chi-squared: 0.008
## Degrees of freedom: 1
## P-value: 0.9301
## 95% CI: [ -0.148 , 0.187 ]
## Significant: NO
##
## o4-mini-Medium vs o3-GPT-Image-High
## -----
## Proportions: 0.467 vs 0.56
## Difference: -0.093
## Chi-squared: 2.443
## Degrees of freedom: 1
## P-value: 0.1181
## 95% CI: [ -0.209 , 0.022 ]
## Significant: NO
##
## o4-mini-Medium vs o3-GPT-Image-Medium
## -----
## Proportions: 0.467 vs 0.506
## Difference: -0.039
## Chi-squared: 0.111
## Degrees of freedom: 1
## P-value: 0.7396
## 95% CI: [ -0.206 , 0.129 ]
## Significant: NO
##
## o3-GPT-Image-High vs o3-GPT-Image-Medium
## -----
## Proportions: 0.56 vs 0.506
## Difference: 0.055
## Chi-squared: 0.38
## Degrees of freedom: 1
## P-value: 0.5374
## 95% CI: [ -0.097 , 0.206 ]
## Significant: NO

# Summary table
finke_reasoning_summary <- finke_reasoning_results %>%
  select(comparison, diff, chi_squared, p_value, significant) %>%
  mutate(diff = round(diff, 3),
         p_value = round(p_value, 4))
cat("\n\nSummary Table - Finke Reasoning Variations:\n")

##
##
## Summary Table - Finke Reasoning Variations:
print(kable(finke_reasoning_summary, format = "simple"))

##
##
## comparison diff chi_squared p_value significant

```

##	-----	-----	-----	-----	-----
##	X-squared	Humans vs o3-High	0.020	0.1891561	0.6636 FALSE
##	X-squared1	Humans vs o3-Medium	0.057	0.5683218	0.4509 FALSE
##	X-squared2	Humans vs o3-Low	0.007	0.0000000	1.0000 FALSE
##	X-squared3	Humans vs GPT-5-High	-0.136	8.3544955	0.0038 TRUE
##	X-squared4	Humans vs o3-Pro	-0.141	13.4669053	0.0002 TRUE
##	X-squared5	Humans vs GPT-5-Medium	-0.003	0.0000000	1.0000 FALSE
##	X-squared6	Humans vs GPT-5-Low	0.074	1.0625196	0.3026 FALSE
##	X-squared7	Humans vs GPT-5-Minimal	0.265	16.0604213	0.0001 TRUE
##	X-squared8	Humans vs o4-mini-High	0.105	4.7972861	0.0285 TRUE
##	X-squared9	Humans vs o4-mini-Medium	0.163	11.8955544	0.0006 TRUE
##	X-squared10	Humans vs o3-GPT-Image-High	0.070	4.0094812	0.0452 TRUE
##	X-squared11	Humans vs o3-GPT-Image-Medium	0.125	3.3122048	0.0688 FALSE
##	X-squared12	o3-High vs o3-Medium	0.037	0.1252689	0.7234 FALSE
##	X-squared13	o3-High vs o3-Low	-0.012	0.0003661	0.9847 FALSE
##	X-squared14	o3-High vs GPT-5-High	-0.156	7.2371887	0.0071 TRUE
##	X-squared15	o3-High vs o3-Pro	-0.161	10.2079814	0.0014 TRUE
##	X-squared16	o3-High vs GPT-5-Medium	-0.023	0.0265213	0.8706 FALSE
##	X-squared17	o3-High vs GPT-5-Low	0.055	0.3534477	0.5522 FALSE
##	X-squared18	o3-High vs GPT-5-Minimal	0.245	9.9417462	0.0016 TRUE
##	X-squared19	o3-High vs o4-mini-High	0.085	1.8190399	0.1774 FALSE
##	X-squared20	o3-High vs o4-mini-Medium	0.144	5.4460525	0.0196 TRUE
##	X-squared21	o3-High vs o3-GPT-Image-High	0.050	0.8693549	0.3511 FALSE
##	X-squared22	o3-High vs o3-GPT-Image-Medium	0.105	1.6304149	0.2016 FALSE
##	X-squared23	o3-Medium vs o3-Low	-0.049	0.1341131	0.7142 FALSE
##	X-squared24	o3-Medium vs GPT-5-High	-0.193	6.2051551	0.0127 TRUE
##	X-squared25	o3-Medium vs o3-Pro	-0.198	7.8424357	0.0051 TRUE
##	X-squared26	o3-Medium vs GPT-5-Medium	-0.060	0.2339226	0.6286 FALSE
##	X-squared27	o3-Medium vs GPT-5-Low	0.018	0.0001154	0.9914 FALSE
##	X-squared28	o3-Medium vs GPT-5-Minimal	0.208	4.4109665	0.0357 TRUE
##	X-squared29	o3-Medium vs o4-mini-High	0.049	0.2092646	0.6473 FALSE
##	X-squared30	o3-Medium vs o4-mini-Medium	0.107	1.4209054	0.2333 FALSE
##	X-squared31	o3-Medium vs o3-GPT-Image-High	0.013	0.0015816	0.9683 FALSE
##	X-squared32	o3-Medium vs o3-GPT-Image-Medium	0.068	0.3179166	0.5729 FALSE
##	X-squared33	o3-Low vs GPT-5-High	-0.143	3.3782085	0.0661 FALSE
##	X-squared34	o3-Low vs o3-Pro	-0.149	4.3662115	0.0367 TRUE
##	X-squared35	o3-Low vs GPT-5-Medium	-0.010	0.0000000	1.0000 FALSE
##	X-squared36	o3-Low vs GPT-5-Low	0.067	0.3151208	0.5746 FALSE
##	X-squared37	o3-Low vs GPT-5-Minimal	0.257	6.9598362	0.0083 TRUE
##	X-squared38	o3-Low vs o4-mini-High	0.098	1.1850589	0.2763 FALSE
##	X-squared39	o3-Low vs o4-mini-Medium	0.156	3.3078003	0.0690 FALSE
##	X-squared40	o3-Low vs o3-GPT-Image-High	0.063	0.5364076	0.4639 FALSE
##	X-squared41	o3-Low vs o3-GPT-Image-Medium	0.117	1.2386775	0.2657 FALSE
##	X-squared42	GPT-5-High vs o3-Pro	-0.005	0.0000000	1.0000 FALSE
##	X-squared43	GPT-5-High vs GPT-5-Medium	0.133	2.8829685	0.0895 FALSE
##	X-squared44	GPT-5-High vs GPT-5-Low	0.210	7.3970555	0.0065 TRUE
##	X-squared45	GPT-5-High vs GPT-5-Minimal	0.401	25.9353072	0.0000 TRUE
##	X-squared46	GPT-5-High vs o4-mini-High	0.241	14.2190034	0.0002 TRUE
##	X-squared47	GPT-5-High vs o4-mini-Medium	0.299	21.4975960	0.0000 TRUE
##	X-squared48	GPT-5-High vs o3-GPT-Image-High	0.206	13.6649251	0.0002 TRUE
##	X-squared49	GPT-5-High vs o3-GPT-Image-Medium	0.261	11.3047700	0.0008 TRUE
##	X-squared50	o3-Pro vs GPT-5-Medium	0.138	3.7535757	0.0527 FALSE
##	X-squared51	o3-Pro vs GPT-5-Low	0.216	9.3018286	0.0023 TRUE
##	X-squared52	o3-Pro vs GPT-5-Minimal	0.406	31.7684094	0.0000 TRUE

## X-squared53	o3-Pro vs o4-mini-High	0.247	18.7992418	0.0000	TRUE
## X-squared54	o3-Pro vs o4-mini-Medium	0.305	28.0766993	0.0000	TRUE
## X-squared55	o3-Pro vs o3-GPT-Image-High	0.211	19.3040615	0.0000	TRUE
## X-squared56	o3-Pro vs o3-GPT-Image-Medium	0.266	14.0713197	0.0002	TRUE
## X-squared57	GPT-5-Medium vs GPT-5-Low	0.078	0.4606144	0.4973	FALSE
## X-squared58	GPT-5-Medium vs GPT-5-Minimal	0.268	7.5739980	0.0059	TRUE
## X-squared59	GPT-5-Medium vs o4-mini-High	0.108	1.4939597	0.2216	FALSE
## X-squared60	GPT-5-Medium vs o4-mini-Medium	0.167	3.8069985	0.0510	FALSE
## X-squared61	GPT-5-Medium vs o3-GPT-Image-High	0.073	0.7723739	0.3795	FALSE
## X-squared62	GPT-5-Medium vs o3-GPT-Image-Medium	0.128	1.5123341	0.2188	FALSE
## X-squared63	GPT-5-Low vs GPT-5-Minimal	0.190	3.6442900	0.0563	FALSE
## X-squared64	GPT-5-Low vs o4-mini-High	0.031	0.0544585	0.8155	FALSE
## X-squared65	GPT-5-Low vs o4-mini-Medium	0.089	0.9387856	0.3326	FALSE
## X-squared66	GPT-5-Low vs o3-GPT-Image-High	-0.004	0.0000000	1.0000	FALSE
## X-squared67	GPT-5-Low vs o3-GPT-Image-Medium	0.050	0.1365637	0.7117	FALSE
## X-squared68	GPT-5-Minimal vs o4-mini-High	-0.159	3.4681101	0.0626	FALSE
## X-squared69	GPT-5-Minimal vs o4-mini-Medium	-0.101	1.2846517	0.2570	FALSE
## X-squared70	GPT-5-Minimal vs o3-GPT-Image-High	-0.195	6.5374379	0.0106	TRUE
## X-squared71	GPT-5-Minimal vs o3-GPT-Image-Medium	-0.140	1.8579125	0.1729	FALSE
## X-squared72	o4-mini-High vs o4-mini-Medium	0.058	0.5967100	0.4398	FALSE
## X-squared73	o4-mini-High vs o3-GPT-Image-High	-0.035	0.2722063	0.6019	FALSE
## X-squared74	o4-mini-High vs o3-GPT-Image-Medium	0.019	0.0077047	0.9301	FALSE
## X-squared75	o4-mini-Medium vs o3-GPT-Image-High	-0.093	2.4427946	0.1181	FALSE
## X-squared76	o4-mini-Medium vs o3-GPT-Image-Medium	-0.039	0.1105138	0.7396	FALSE
## X-squared77	o3-GPT-Image-High vs o3-GPT-Image-Medium	0.055	0.3804382	0.5374	FALSE

Heatmap for Finke Reasoning Variations

```
# Create matrix of p-values for Finke reasoning variations
finke_reasoning_models <- finke_reasoning_data$model
finke_reasoning_pval_matrix <- matrix(NA, nrow = length(finke_reasoning_models), ncol = length(finke_reasoning_models),
rownames(finke_reasoning_pval_matrix) <- finke_reasoning_models
colnames(finke_reasoning_pval_matrix) <- finke_reasoning_models

for (i in 1:nrow(finke_reasoning_results)) {
  row_idx <- which(finke_reasoning_models == finke_reasoning_results$model1[i])
  col_idx <- which(finke_reasoning_models == finke_reasoning_results$model2[i])
  finke_reasoning_pval_matrix[row_idx, col_idx] <- finke_reasoning_results$p_value[i]
  finke_reasoning_pval_matrix[col_idx, row_idx] <- finke_reasoning_results$p_value[i]
}

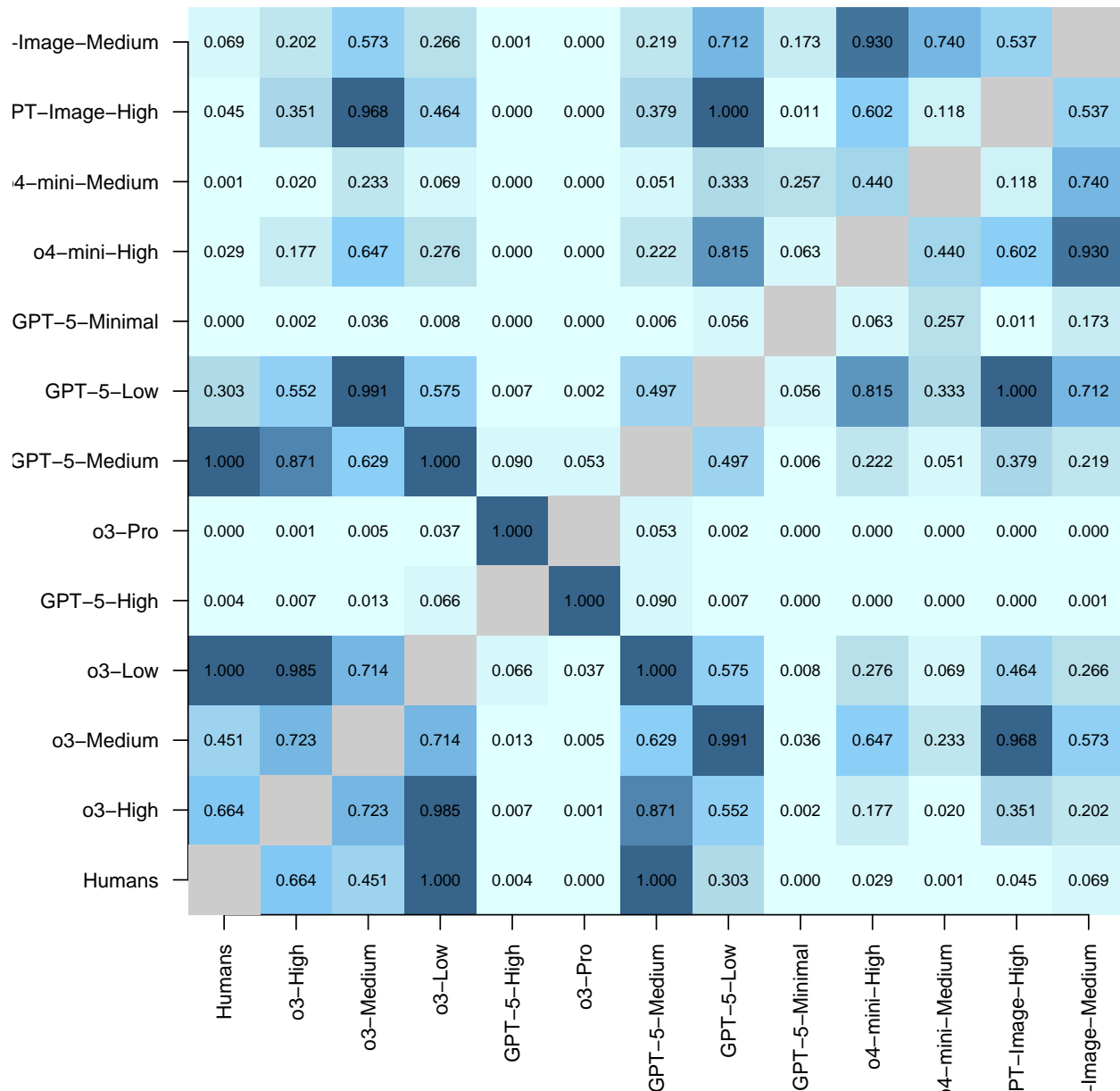
# Set diagonal to NA
diag(finke_reasoning_pval_matrix) <- NA
# Set margins for better label display
par(mar = c(6, 6, 3, 2))
# Plot heatmap with same color palette
image(finke_reasoning_pval_matrix, axes = FALSE, col = col_palette,
      main = "P-values Heatmap - Finke Reasoning Variations")
axis(1, at = seq(0, 1, length.out = length(finke_reasoning_models)), labels = finke_reasoning_models,
     las = 2, cex.axis = 0.8) # las= 2 makes labels perpendicular, cex.axis makes them smaller
axis(2, at = seq(0, 1, length.out = length(finke_reasoning_models)), labels = finke_reasoning_models,
     las = 2, cex.axis = 0.8)
# Add gray color for diagonal
for (i in 1:length(finke_reasoning_models)) {
  x_pos <- (i - 1) / (length(finke_reasoning_models) - 1)
```

```

y_pos <- (i - 1) / (length(finke_reasoning_models) - 1)
rect(x_pos - 0.5 / (length(finke_reasoning_models) - 1), y_pos - 0.5 / (length(finke_reasoning_models) - 1),
     x_pos + 0.5 / (length(finke_reasoning_models) - 1), y_pos + 0.5 / (length(finke_reasoning_models) - 1),
     col = "gray80", border = NA)
}
# Add p-values to the plot
for (i in 1:nrow(finke_reasoning_pval_matrix)) {
  for (j in 1:ncol(finke_reasoning_pval_matrix)) {
    if (!is.na(finke_reasoning_pval_matrix[i, j])) {
      x_pos <- (j - 1) / (ncol(finke_reasoning_pval_matrix) - 1)
      y_pos <- (i - 1) / (nrow(finke_reasoning_pval_matrix) - 1)
      text(x_pos, y_pos, sprintf("%.3f", finke_reasoning_pval_matrix[i, j]), cex = 0.7)
    }
  }
}

```

P-values Heatmap – Finke Reasoning Variations



Summary of Significant Differences - Finke Reasoning Variations

```
# Count significant differences for Finke reasoning variations
finke_reasoning_sig_count <- sum(finke_reasoning_results$significant)
cat("Summary of Significant Differences - Finke Reasoning Variations:\n")

## Summary of Significant Differences - Finke Reasoning Variations:
cat(paste(rep("=", 50), collapse = ""), "\n")

## =====
cat(" Total comparisons:", nrow(finke_reasoning_results), "\n")
```



```

## Total comparisons: 78
cat(" Significant differences:", finke_reasoning_sig_count, "\n")

## Significant differences: 29
cat(" Percentage significant:", round(finke_reasoning_sig_count / nrow(finke_reasoning_results) * 100,

## Percentage significant: 37.2 %
# Show which comparisons are significant
cat("Significant Comparisons in Finke Reasoning Variations:\n")

## Significant Comparisons in Finke Reasoning Variations:
finke_reasoning_sig <- finke_reasoning_results[finke_reasoning_results$significant, c("comparison", "di
if (nrow(finke_reasoning_sig) > 0) {
  print(kable(finke_reasoning_sig, format = "simple", digits = 4))
} else {
  cat(" None\n")
}

##
##
## comparison diff p_value
## -----
## X-squared3 Humans vs GPT-5-High -0.1360 0.0038
## X-squared4 Humans vs o3-Pro -0.1415 0.0002
## X-squared7 Humans vs GPT-5-Minimal 0.2647 0.0001
## X-squared8 Humans vs o4-mini-High 0.1052 0.0285
## X-squared9 Humans vs o4-mini-Medium 0.1634 0.0006
## X-squared10 Humans vs o3-GPT-Image-High 0.0699 0.0452
## X-squared14 o3-High vs GPT-5-High -0.1557 0.0071
## X-squared15 o3-High vs o3-Pro -0.1612 0.0014
## X-squared18 o3-High vs GPT-5-Minimal 0.2450 0.0016
## X-squared20 o3-High vs o4-mini-Medium 0.1437 0.0196
## X-squared24 o3-Medium vs GPT-5-High -0.1926 0.0127
## X-squared25 o3-Medium vs o3-Pro -0.1981 0.0051
## X-squared28 o3-Medium vs GPT-5-Minimal 0.2080 0.0357
## X-squared34 o3-Low vs o3-Pro -0.1487 0.0367
## X-squared37 o3-Low vs GPT-5-Minimal 0.2575 0.0083
## X-squared44 GPT-5-High vs GPT-5-Low 0.2103 0.0065
## X-squared45 GPT-5-High vs GPT-5-Minimal 0.4007 0.0000
## X-squared46 GPT-5-High vs o4-mini-High 0.2412 0.0002
## X-squared47 GPT-5-High vs o4-mini-Medium 0.2994 0.0000
## X-squared48 GPT-5-High vs o3-GPT-Image-High 0.2059 0.0002
## X-squared49 GPT-5-High vs o3-GPT-Image-Medium 0.2606 0.0008
## X-squared51 o3-Pro vs GPT-5-Low 0.2157 0.0023
## X-squared52 o3-Pro vs GPT-5-Minimal 0.4061 0.0000
## X-squared53 o3-Pro vs o4-mini-High 0.2466 0.0000
## X-squared54 o3-Pro vs o4-mini-Medium 0.3048 0.0000
## X-squared55 o3-Pro vs o3-GPT-Image-High 0.2114 0.0000
## X-squared56 o3-Pro vs o3-GPT-Image-Medium 0.2661 0.0002
## X-squared58 GPT-5-Medium vs GPT-5-Minimal 0.2679 0.0059
## X-squared70 GPT-5-Minimal vs o3-GPT-Image-High -0.1948 0.0106

```

48 Novel

```
# Test all combinations for 48 Novel reasoning variations
novel_48_reasoning_results <- test_all_combinations(novel_reasoning_data, "48 Novel Reasoning Variations")
# Display results
cat("All Pairwise Comparisons for 48 Novel Reasoning Variations:\n")

## All Pairwise Comparisons for 48 Novel Reasoning Variations:
cat(paste(rep("=", 80), collapse = ""), "\n")

## =====
for (i in 1:nrow(novel_48_reasoning_results)) {
  cat("\n", novel_48_reasoning_results$comparison[i], "\n")
  cat(paste(rep("-", 40), collapse = ""), "\n")
  cat("Proportions: ", round(novel_48_reasoning_results$prop1[i], 3), " vs ",
      round(novel_48_reasoning_results$prop2[i], 3), "\n")
  cat("Difference: ", round(novel_48_reasoning_results$diff[i], 3), "\n")
  cat("Chi-squared: ", round(novel_48_reasoning_results$chi_squared[i], 3), "\n")
  cat("Degrees of freedom: ", round(novel_48_reasoning_results$df[i], 3), "\n")
  cat("P-value: ", format(novel_48_reasoning_results$p_value[i], scientific = FALSE, digits = 4), "\n")
  cat("95% CI: [", round(novel_48_reasoning_results$ci_lower[i], 3), ", ",
      round(novel_48_reasoning_results$ci_upper[i], 3), "]\n")
  cat("Significant: ", ifelse(novel_48_reasoning_results$significant[i], "YES (p < 0.05)", "NO"), "\n")
}

##
## Humans vs o3-High
## -----
## Proportions: 0.526 vs 0.649
## Difference: -0.123
## Chi-squared: 38.861
## Degrees of freedom: 1
## P-value: 0.0000000004552
## 95% CI: [ -0.161 , -0.086 ]
## Significant: YES (p < 0.05)
##
## Humans vs o3-Medium
## -----
## Proportions: 0.526 vs 0.562
## Difference: -0.036
## Chi-squared: 1.055
## Degrees of freedom: 1
## P-value: 0.3043
## 95% CI: [ -0.102 , 0.03 ]
## Significant: NO
##
## Humans vs o3-Low
## -----
## Proportions: 0.526 vs 0.518
## Difference: 0.008
## Chi-squared: 0.027
## Degrees of freedom: 1
## P-value: 0.8702
## 95% CI: [ -0.059 , 0.074 ]
```

```

## Significant:  NO
##
## Humans vs GPT-5-High
## -----
## Proportions:  0.526  vs  0.646
## Difference:   -0.12
## Chi-squared:  25.084
## Degrees of freedom:  1
## P-value:      0.0000005489
## 95% CI: [ -0.165 ,  -0.074 ]
## Significant:  YES (p < 0.05)
##
## Humans vs o3-Pro
## -----
## Proportions:  0.526  vs  0.585
## Difference:   -0.059
## Chi-squared:  2.995
## Degrees of freedom:  1
## P-value:      0.08352
## 95% CI: [ -0.125 ,  0.007 ]
## Significant:  NO
##
## Humans vs GPT-5-Medium
## -----
## Proportions:  0.526  vs  0.64
## Difference:   -0.114
## Chi-squared:  33.112
## Degrees of freedom:  1
## P-value:      0.000000008702
## 95% CI: [ -0.152 ,  -0.076 ]
## Significant:  YES (p < 0.05)
##
## Humans vs GPT-5-Low
## -----
## Proportions:  0.526  vs  0.493
## Difference:    0.033
## Chi-squared:  0.881
## Degrees of freedom:  1
## P-value:      0.3479
## 95% CI: [ -0.034 ,  0.1 ]
## Significant:  NO
##
## Humans vs GPT-5-Minimal
## -----
## Proportions:  0.526  vs  0.418
## Difference:    0.108
## Chi-squared:  10.381
## Degrees of freedom:  1
## P-value:      0.001273
## 95% CI: [ 0.042 ,  0.174 ]
## Significant:  YES (p < 0.05)
##
## Humans vs o4-mini-High
## -----

```

```

## Proportions: 0.526 vs 0.532
## Difference: -0.006
## Chi-squared: 0.035
## Degrees of freedom: 1
## P-value: 0.8507
## 95% CI: [ -0.053 , 0.042 ]
## Significant: NO
##
## Humans vs o4-mini-Medium
## -----
## Proportions: 0.526 vs 0.495
## Difference: 0.031
## Chi-squared: 1.563
## Degrees of freedom: 1
## P-value: 0.2112
## 95% CI: [ -0.017 , 0.078 ]
## Significant: NO
##
## Humans vs o3-GPT-Image-High
## -----
## Proportions: 0.526 vs 0.552
## Difference: -0.026
## Chi-squared: 2.115
## Degrees of freedom: 1
## P-value: 0.1458
## 95% CI: [ -0.06 , 0.009 ]
## Significant: NO
##
## Humans vs o3-GPT-Image-Medium
## -----
## Proportions: 0.526 vs 0.559
## Difference: -0.033
## Chi-squared: 0.897
## Degrees of freedom: 1
## P-value: 0.3435
## 95% CI: [ -0.1 , 0.033 ]
## Significant: NO
##
## o3-High vs o3-Medium
## -----
## Proportions: 0.649 vs 0.562
## Difference: 0.087
## Chi-squared: 5.52
## Degrees of freedom: 1
## P-value: 0.01881
## 95% CI: [ 0.013 , 0.162 ]
## Significant: YES (p < 0.05)
##
## o3-High vs o3-Low
## -----
## Proportions: 0.649 vs 0.518
## Difference: 0.131
## Chi-squared: 12.5
## Degrees of freedom: 1

```

```

## P-value: 0.0004069
## 95% CI: [ 0.056 , 0.206 ]
## Significant: YES (p < 0.05)
##
## o3-High vs GPT-5-High
## -----
## Proportions: 0.649 vs 0.646
## Difference: 0.004
## Chi-squared: 0.005
## Degrees of freedom: 1
## P-value: 0.9437
## 95% CI: [ -0.053 , 0.061 ]
## Significant: NO
##
## o3-High vs o3-Pro
## -----
## Proportions: 0.649 vs 0.585
## Difference: 0.064
## Chi-squared: 2.936
## Degrees of freedom: 1
## P-value: 0.08663
## 95% CI: [ -0.01 , 0.139 ]
## Significant: NO
##
## o3-High vs GPT-5-Medium
## -----
## Proportions: 0.649 vs 0.64
## Difference: 0.009
## Chi-squared: 0.101
## Degrees of freedom: 1
## P-value: 0.7504
## 95% CI: [ -0.041 , 0.06 ]
## Significant: NO
##
## o3-High vs GPT-5-Low
## -----
## Proportions: 0.649 vs 0.493
## Difference: 0.156
## Chi-squared: 17.859
## Degrees of freedom: 1
## P-value: 0.00002378
## 95% CI: [ 0.081 , 0.231 ]
## Significant: YES (p < 0.05)
##
## o3-High vs GPT-5-Minimal
## -----
## Proportions: 0.649 vs 0.418
## Difference: 0.231
## Chi-squared: 38.969
## Degrees of freedom: 1
## P-value: 0.0000000004307
## 95% CI: [ 0.157 , 0.306 ]
## Significant: YES (p < 0.05)
##

```

```

## o3-High vs o4-mini-High
## -----
## Proportions: 0.649 vs 0.532
## Difference: 0.118
## Chi-squared: 16.191
## Degrees of freedom: 1
## P-value: 0.00005726
## 95% CI: [ 0.059 , 0.176 ]
## Significant: YES (p < 0.05)
##
## o3-High vs o4-mini-Medium
## -----
## Proportions: 0.649 vs 0.495
## Difference: 0.154
## Chi-squared: 27.6
## Degrees of freedom: 1
## P-value: 0.0000001492
## 95% CI: [ 0.096 , 0.213 ]
## Significant: YES (p < 0.05)
##
## o3-High vs o3-GPT-Image-High
## -----
## Proportions: 0.649 vs 0.552
## Difference: 0.098
## Chi-squared: 15.818
## Degrees of freedom: 1
## P-value: 0.00006973
## 95% CI: [ 0.049 , 0.146 ]
## Significant: YES (p < 0.05)
##
## o3-High vs o3-GPT-Image-Medium
## -----
## Proportions: 0.649 vs 0.559
## Difference: 0.09
## Chi-squared: 5.863
## Degrees of freedom: 1
## P-value: 0.01546
## 95% CI: [ 0.015 , 0.165 ]
## Significant: YES (p < 0.05)
##
## o3-Medium vs o3-Low
## -----
## Proportions: 0.562 vs 0.518
## Difference: 0.043
## Chi-squared: 0.746
## Degrees of freedom: 1
## P-value: 0.3877
## 95% CI: [ -0.05 , 0.137 ]
## Significant: NO
##
## o3-Medium vs GPT-5-High
## -----
## Proportions: 0.562 vs 0.646
## Difference: -0.084

```

```

## Chi-squared: 4.401
## Degrees of freedom: 1
## P-value: 0.03593
## 95% CI: [ -0.163 , -0.005 ]
## Significant: YES (p < 0.05)
##
## o3-Medium vs o3-Pro
## -----
## Proportions: 0.562 vs 0.585
## Difference: -0.023
## Chi-squared: 0.176
## Degrees of freedom: 1
## P-value: 0.6747
## 95% CI: [ -0.116 , 0.07 ]
## Significant: NO
##
## o3-Medium vs GPT-5-Medium
## -----
## Proportions: 0.562 vs 0.64
## Difference: -0.078
## Chi-squared: 4.328
## Degrees of freedom: 1
## P-value: 0.03749
## 95% CI: [ -0.153 , -0.003 ]
## Significant: YES (p < 0.05)
##
## o3-Medium vs GPT-5-Low
## -----
## Proportions: 0.562 vs 0.493
## Difference: 0.069
## Chi-squared: 2.021
## Degrees of freedom: 1
## P-value: 0.1551
## 95% CI: [ -0.024 , 0.162 ]
## Significant: NO
##
## o3-Medium vs GPT-5-Minimal
## -----
## Proportions: 0.562 vs 0.418
## Difference: 0.144
## Chi-squared: 9.397
## Degrees of freedom: 1
## P-value: 0.002173
## 95% CI: [ 0.051 , 0.237 ]
## Significant: YES (p < 0.05)
##
## o3-Medium vs o4-mini-High
## -----
## Proportions: 0.562 vs 0.532
## Difference: 0.03
## Chi-squared: 0.477
## Degrees of freedom: 1
## P-value: 0.4896
## 95% CI: [ -0.05 , 0.11 ]

```

```

## Significant: NO
##
## o3-Medium vs o4-mini-Medium
## -----
## Proportions: 0.562 vs 0.495
## Difference: 0.067
## Chi-squared: 2.588
## Degrees of freedom: 1
## P-value: 0.1077
## 95% CI: [ -0.014 , 0.147 ]
## Significant: NO
##
## o3-Medium vs o3-GPT-Image-High
## -----
## Proportions: 0.562 vs 0.552
## Difference: 0.01
## Chi-squared: 0.043
## Degrees of freedom: 1
## P-value: 0.8349
## 95% CI: [ -0.063 , 0.083 ]
## Significant: NO
##
## o3-Medium vs o3-GPT-Image-Medium
## -----
## Proportions: 0.562 vs 0.559
## Difference: 0.003
## Chi-squared: 0
## Degrees of freedom: 1
## P-value: 1
## 95% CI: [ -0.089 , 0.094 ]
## Significant: NO
##
## o3-Low vs GPT-5-High
## -----
## Proportions: 0.518 vs 0.646
## Difference: -0.127
## Chi-squared: 10.288
## Degrees of freedom: 1
## P-value: 0.001339
## 95% CI: [ -0.207 , -0.048 ]
## Significant: YES (p < 0.05)
##
## o3-Low vs o3-Pro
## -----
## Proportions: 0.518 vs 0.585
## Difference: -0.067
## Chi-squared: 1.89
## Degrees of freedom: 1
## P-value: 0.1692
## 95% CI: [ -0.16 , 0.026 ]
## Significant: NO
##
## o3-Low vs GPT-5-Medium
## -----

```



```

## Proportions: 0.518 vs 0.64
## Difference: -0.121
## Chi-squared: 10.659
## Degrees of freedom: 1
## P-value: 0.001095
## 95% CI: [ -0.197 , -0.046 ]
## Significant: YES (p < 0.05)
##
## o3-Low vs GPT-5-Low
## -----
## Proportions: 0.518 vs 0.493
## Difference: 0.025
## Chi-squared: 0.218
## Degrees of freedom: 1
## P-value: 0.6403
## 95% CI: [ -0.068 , 0.119 ]
## Significant: NO
##
## o3-Low vs GPT-5-Minimal
## -----
## Proportions: 0.518 vs 0.418
## Difference: 0.101
## Chi-squared: 4.481
## Degrees of freedom: 1
## P-value: 0.03427
## 95% CI: [ 0.008 , 0.194 ]
## Significant: YES (p < 0.05)
##
## o3-Low vs o4-mini-High
## -----
## Proportions: 0.518 vs 0.532
## Difference: -0.013
## Chi-squared: 0.064
## Degrees of freedom: 1
## P-value: 0.8
## 95% CI: [ -0.094 , 0.067 ]
## Significant: NO
##
## o3-Low vs o4-mini-Medium
## -----
## Proportions: 0.518 vs 0.495
## Difference: 0.023
## Chi-squared: 0.258
## Degrees of freedom: 1
## P-value: 0.6113
## 95% CI: [ -0.057 , 0.104 ]
## Significant: NO
##
## o3-Low vs o3-GPT-Image-High
## -----
## Proportions: 0.518 vs 0.552
## Difference: -0.033
## Chi-squared: 0.734
## Degrees of freedom: 1

```

```

## P-value: 0.3917
## 95% CI: [ -0.107 , 0.04 ]
## Significant: NO
##
## o3-Low vs o3-GPT-Image-Medium
## -----
## Proportions: 0.518 vs 0.559
## Difference: -0.041
## Chi-squared: 0.649
## Degrees of freedom: 1
## P-value: 0.4203
## 95% CI: [ -0.134 , 0.052 ]
## Significant: NO
##
## GPT-5-High vs o3-Pro
## -----
## Proportions: 0.646 vs 0.585
## Difference: 0.061
## Chi-squared: 2.256
## Degrees of freedom: 1
## P-value: 0.1331
## 95% CI: [ -0.018 , 0.139 ]
## Significant: NO
##
## GPT-5-High vs GPT-5-Medium
## -----
## Proportions: 0.646 vs 0.64
## Difference: 0.006
## Chi-squared: 0.02
## Degrees of freedom: 1
## P-value: 0.8887
## 95% CI: [ -0.051 , 0.063 ]
## Significant: NO
##
## GPT-5-High vs GPT-5-Low
## -----
## Proportions: 0.646 vs 0.493
## Difference: 0.153
## Chi-squared: 14.846
## Degrees of freedom: 1
## P-value: 0.0001166
## 95% CI: [ 0.073 , 0.232 ]
## Significant: YES (p < 0.05)
##
## GPT-5-High vs GPT-5-Minimal
## -----
## Proportions: 0.646 vs 0.418
## Difference: 0.228
## Chi-squared: 32.938
## Degrees of freedom: 1
## P-value: 0.000000009513
## 95% CI: [ 0.149 , 0.307 ]
## Significant: YES (p < 0.05)
##

```

```

## GPT-5-High vs o4-mini-High
## -----
## Proportions: 0.646 vs 0.532
## Difference: 0.114
## Chi-squared: 12.427
## Degrees of freedom: 1
## P-value: 0.0004231
## 95% CI: [ 0.05 , 0.178 ]
## Significant: YES (p < 0.05)
##
## GPT-5-High vs o4-mini-Medium
## -----
## Proportions: 0.646 vs 0.495
## Difference: 0.15
## Chi-squared: 21.544
## Degrees of freedom: 1
## P-value: 0.000003457
## 95% CI: [ 0.086 , 0.214 ]
## Significant: YES (p < 0.05)
##
## GPT-5-High vs o3-GPT-Image-High
## -----
## Proportions: 0.646 vs 0.552
## Difference: 0.094
## Chi-squared: 11.198
## Degrees of freedom: 1
## P-value: 0.0008187
## 95% CI: [ 0.039 , 0.148 ]
## Significant: YES (p < 0.05)
##
## GPT-5-High vs o3-GPT-Image-Medium
## -----
## Proportions: 0.646 vs 0.559
## Difference: 0.086
## Chi-squared: 4.688
## Degrees of freedom: 1
## P-value: 0.03037
## 95% CI: [ 0.007 , 0.165 ]
## Significant: YES (p < 0.05)
##
## o3-Pro vs GPT-5-Medium
## -----
## Proportions: 0.585 vs 0.64
## Difference: -0.055
## Chi-squared: 2.09
## Degrees of freedom: 1
## P-value: 0.1483
## 95% CI: [ -0.129 , 0.019 ]
## Significant: NO
##
## o3-Pro vs GPT-5-Low
## -----
## Proportions: 0.585 vs 0.493
## Difference: 0.092

```

```

## Chi-squared: 3.732
## Degrees of freedom: 1
## P-value: 0.05338
## 95% CI: [ -0.001 , 0.185 ]
## Significant: NO
##
## o3-Pro vs GPT-5-Minimal
## -----
## Proportions: 0.585 vs 0.418
## Difference: 0.167
## Chi-squared: 12.754
## Degrees of freedom: 1
## P-value: 0.0003552
## 95% CI: [ 0.075 , 0.26 ]
## Significant: YES (p < 0.05)
##
## o3-Pro vs o4-mini-High
## -----
## Proportions: 0.585 vs 0.532
## Difference: 0.053
## Chi-squared: 1.637
## Degrees of freedom: 1
## P-value: 0.2007
## 95% CI: [ -0.026 , 0.133 ]
## Significant: NO
##
## o3-Pro vs o4-mini-Medium
## -----
## Proportions: 0.585 vs 0.495
## Difference: 0.09
## Chi-squared: 4.82
## Degrees of freedom: 1
## P-value: 0.02813
## 95% CI: [ 0.01 , 0.17 ]
## Significant: YES (p < 0.05)
##
## o3-Pro vs o3-GPT-Image-High
## -----
## Proportions: 0.585 vs 0.552
## Difference: 0.033
## Chi-squared: 0.729
## Degrees of freedom: 1
## P-value: 0.3933
## 95% CI: [ -0.039 , 0.106 ]
## Significant: NO
##
## o3-Pro vs o3-GPT-Image-Medium
## -----
## Proportions: 0.585 vs 0.559
## Difference: 0.026
## Chi-squared: 0.228
## Degrees of freedom: 1
## P-value: 0.6328
## 95% CI: [ -0.067 , 0.118 ]

```

```

## Significant: NO
##
## GPT-5-Medium vs GPT-5-Low
## -----
## Proportions: 0.64 vs 0.493
## Difference: 0.147
## Chi-squared: 15.639
## Degrees of freedom: 1
## P-value: 0.00007667
## 95% CI: [ 0.072 , 0.222 ]
## Significant: YES (p < 0.05)
##
## GPT-5-Medium vs GPT-5-Minimal
## -----
## Proportions: 0.64 vs 0.418
## Difference: 0.222
## Chi-squared: 35.644
## Degrees of freedom: 1
## P-value: 0.000000002369
## 95% CI: [ 0.148 , 0.296 ]
## Significant: YES (p < 0.05)
##
## GPT-5-Medium vs o4-mini-High
## -----
## Proportions: 0.64 vs 0.532
## Difference: 0.108
## Chi-squared: 13.607
## Degrees of freedom: 1
## P-value: 0.0002253
## 95% CI: [ 0.05 , 0.167 ]
## Significant: YES (p < 0.05)
##
## GPT-5-Medium vs o4-mini-Medium
## -----
## Proportions: 0.64 vs 0.495
## Difference: 0.145
## Chi-squared: 24.2
## Degrees of freedom: 1
## P-value: 0.0000008685
## 95% CI: [ 0.086 , 0.203 ]
## Significant: YES (p < 0.05)
##
## GPT-5-Medium vs o3-GPT-Image-High
## -----
## Proportions: 0.64 vs 0.552
## Difference: 0.088
## Chi-squared: 12.838
## Degrees of freedom: 1
## P-value: 0.0003397
## 95% CI: [ 0.04 , 0.136 ]
## Significant: YES (p < 0.05)
##
## GPT-5-Medium vs o3-GPT-Image-Medium
## -----

```

```

## Proportions: 0.64 vs 0.559
## Difference: 0.081
## Chi-squared: 4.633
## Degrees of freedom: 1
## P-value: 0.03137
## 95% CI: [ 0.006 , 0.155 ]
## Significant: YES (p < 0.05)
##
## GPT-5-Low vs GPT-5-Minimal
## -----
## Proportions: 0.493 vs 0.418
## Difference: 0.075
## Chi-squared: 2.435
## Degrees of freedom: 1
## P-value: 0.1187
## 95% CI: [ -0.018 , 0.168 ]
## Significant: NO
##
## GPT-5-Low vs o4-mini-High
## -----
## Proportions: 0.493 vs 0.532
## Difference: -0.039
## Chi-squared: 0.807
## Degrees of freedom: 1
## P-value: 0.369
## 95% CI: [ -0.119 , 0.042 ]
## Significant: NO
##
## GPT-5-Low vs o4-mini-Medium
## -----
## Proportions: 0.493 vs 0.495
## Difference: -0.002
## Chi-squared: 0
## Degrees of freedom: 1
## P-value: 1
## 95% CI: [ -0.082 , 0.077 ]
## Significant: NO
##
## GPT-5-Low vs o3-GPT-Image-High
## -----
## Proportions: 0.493 vs 0.552
## Difference: -0.059
## Chi-squared: 2.448
## Degrees of freedom: 1
## P-value: 0.1177
## 95% CI: [ -0.132 , 0.014 ]
## Significant: NO
##
## GPT-5-Low vs o3-GPT-Image-Medium
## -----
## Proportions: 0.493 vs 0.559
## Difference: -0.066
## Chi-squared: 1.86
## Degrees of freedom: 1

```

```

## P-value: 0.1726
## 95% CI: [ -0.16 , 0.027 ]
## Significant: NO
##
## GPT-5-Minimal vs o4-mini-High
## -----
## Proportions: 0.418 vs 0.532
## Difference: -0.114
## Chi-squared: 7.828
## Degrees of freedom: 1
## P-value: 0.005144
## 95% CI: [ -0.194 , -0.034 ]
## Significant: YES (p < 0.05)
##
## GPT-5-Minimal vs o4-mini-Medium
## -----
## Proportions: 0.418 vs 0.495
## Difference: -0.077
## Chi-squared: 3.542
## Degrees of freedom: 1
## P-value: 0.05984
## 95% CI: [ -0.157 , 0.003 ]
## Significant: NO
##
## GPT-5-Minimal vs o3-GPT-Image-High
## -----
## Proportions: 0.418 vs 0.552
## Difference: -0.134
## Chi-squared: 13.288
## Degrees of freedom: 1
## P-value: 0.0002671
## 95% CI: [ -0.206 , -0.061 ]
## Significant: YES (p < 0.05)
##
## GPT-5-Minimal vs o3-GPT-Image-Medium
## -----
## Proportions: 0.418 vs 0.559
## Difference: -0.141
## Chi-squared: 9.048
## Degrees of freedom: 1
## P-value: 0.002629
## 95% CI: [ -0.234 , -0.049 ]
## Significant: YES (p < 0.05)
##
## o4-mini-High vs o4-mini-Medium
## -----
## Proportions: 0.532 vs 0.495
## Difference: 0.036
## Chi-squared: 1.127
## Degrees of freedom: 1
## P-value: 0.2884
## 95% CI: [ -0.029 , 0.102 ]
## Significant: NO
##

```

```

## o4-mini-High vs o3-GPT-Image-High
## -----
## Proportions: 0.532 vs 0.552
## Difference: -0.02
## Chi-squared: 0.451
## Degrees of freedom: 1
## P-value: 0.5017
## 95% CI: [ -0.076 , 0.036 ]
## Significant: NO
##
## o4-mini-High vs o3-GPT-Image-Medium
## -----
## Proportions: 0.532 vs 0.559
## Difference: -0.028
## Chi-squared: 0.39
## Degrees of freedom: 1
## P-value: 0.5325
## 95% CI: [ -0.108 , 0.052 ]
## Significant: NO
##
## o4-mini-Medium vs o3-GPT-Image-High
## -----
## Proportions: 0.495 vs 0.552
## Difference: -0.057
## Chi-squared: 3.894
## Degrees of freedom: 1
## P-value: 0.04845
## 95% CI: [ -0.113 , 0 ]
## Significant: YES (p < 0.05)
##
## o4-mini-Medium vs o3-GPT-Image-Medium
## -----
## Proportions: 0.495 vs 0.559
## Difference: -0.064
## Chi-squared: 2.378
## Degrees of freedom: 1
## P-value: 0.123
## 95% CI: [ -0.144 , 0.016 ]
## Significant: NO
##
## o3-GPT-Image-High vs o3-GPT-Image-Medium
## -----
## Proportions: 0.552 vs 0.559
## Difference: -0.007
## Chi-squared: 0.018
## Degrees of freedom: 1
## P-value: 0.8925
## 95% CI: [ -0.08 , 0.065 ]
## Significant: NO

# Summary table
novel_48_reasoning_summary <- novel_48_reasoning_results %>%
  select(comparison, diff, chi_squared, p_value, significant) %>%
  mutate(diff = round(diff, 3),

```



```

        p_value = round(p_value, 4))
cat("\n\nSummary Table - 48 Novel Reasoning Variations:\n")

```

```

##
##
## Summary Table - 48 Novel Reasoning Variations:

```

```

print(kable(novel_48_reasoning_summary, format = "simple"))

```

```

##
##
## -----
## comparison ----- diff chi_squared p_value significant
## X-squared Humans vs o3-High -0.123 38.8606815 0.0000 TRUE
## X-squared1 Humans vs o3-Medium -0.036 1.0550879 0.3043 FALSE
## X-squared2 Humans vs o3-Low 0.008 0.0266943 0.8702 FALSE
## X-squared3 Humans vs GPT-5-High -0.120 25.0838266 0.0000 TRUE
## X-squared4 Humans vs o3-Pro -0.059 2.9949910 0.0835 FALSE
## X-squared5 Humans vs GPT-5-Medium -0.114 33.1116612 0.0000 TRUE
## X-squared6 Humans vs GPT-5-Low 0.033 0.8811517 0.3479 FALSE
## X-squared7 Humans vs GPT-5-Minimal 0.108 10.3814323 0.0013 TRUE
## X-squared8 Humans vs o4-mini-High -0.006 0.0354255 0.8507 FALSE
## X-squared9 Humans vs o4-mini-Medium 0.031 1.5632859 0.2112 FALSE
## X-squared10 Humans vs o3-GPT-Image-High -0.026 2.1151564 0.1458 FALSE
## X-squared11 Humans vs o3-GPT-Image-Medium -0.033 0.8971500 0.3435 FALSE
## X-squared12 o3-High vs o3-Medium 0.087 5.5195207 0.0188 TRUE
## X-squared13 o3-High vs o3-Low 0.131 12.5001282 0.0004 TRUE
## X-squared14 o3-High vs GPT-5-High 0.004 0.0049901 0.9437 FALSE
## X-squared15 o3-High vs o3-Pro 0.064 2.9359820 0.0866 FALSE
## X-squared16 o3-High vs GPT-5-Medium 0.009 0.1011775 0.7504 FALSE
## X-squared17 o3-High vs GPT-5-Low 0.156 17.8593660 0.0000 TRUE
## X-squared18 o3-High vs GPT-5-Minimal 0.231 38.9685289 0.0000 TRUE
## X-squared19 o3-High vs o4-mini-High 0.118 16.1910358 0.0001 TRUE
## X-squared20 o3-High vs o4-mini-Medium 0.154 27.5997132 0.0000 TRUE
## X-squared21 o3-High vs o3-GPT-Image-High 0.098 15.8181217 0.0001 TRUE
## X-squared22 o3-High vs o3-GPT-Image-Medium 0.090 5.8634324 0.0155 TRUE
## X-squared23 o3-Medium vs o3-Low 0.043 0.7461811 0.3877 FALSE
## X-squared24 o3-Medium vs GPT-5-High -0.084 4.4006182 0.0359 TRUE
## X-squared25 o3-Medium vs o3-Pro -0.023 0.1761369 0.6747 FALSE
## X-squared26 o3-Medium vs GPT-5-Medium -0.078 4.3280310 0.0375 TRUE
## X-squared27 o3-Medium vs GPT-5-Low 0.069 2.0210774 0.1551 FALSE
## X-squared28 o3-Medium vs GPT-5-Minimal 0.144 9.3972334 0.0022 TRUE
## X-squared29 o3-Medium vs o4-mini-High 0.030 0.4774938 0.4896 FALSE
## X-squared30 o3-Medium vs o4-mini-Medium 0.067 2.5883714 0.1077 FALSE
## X-squared31 o3-Medium vs o3-GPT-Image-High 0.010 0.0434316 0.8349 FALSE
## X-squared32 o3-Medium vs o3-GPT-Image-Medium 0.003 0.0000000 1.0000 FALSE
## X-squared33 o3-Low vs GPT-5-High -0.127 10.2882273 0.0013 TRUE
## X-squared34 o3-Low vs o3-Pro -0.067 1.8901321 0.1692 FALSE
## X-squared35 o3-Low vs GPT-5-Medium -0.121 10.6590196 0.0011 TRUE
## X-squared36 o3-Low vs GPT-5-Low 0.025 0.2182983 0.6403 FALSE
## X-squared37 o3-Low vs GPT-5-Minimal 0.101 4.4810600 0.0343 TRUE
## X-squared38 o3-Low vs o4-mini-High -0.013 0.0641572 0.8000 FALSE
## X-squared39 o3-Low vs o4-mini-Medium 0.023 0.2582995 0.6113 FALSE
## X-squared40 o3-Low vs o3-GPT-Image-High -0.033 0.7336947 0.3917 FALSE

```

## X-squared41	o3-Low vs o3-GPT-Image-Medium	-0.041	0.6494190	0.4203	FALSE
## X-squared42	GPT-5-High vs o3-Pro	0.061	2.2561993	0.1331	FALSE
## X-squared43	GPT-5-High vs GPT-5-Medium	0.006	0.0195799	0.8887	FALSE
## X-squared44	GPT-5-High vs GPT-5-Low	0.153	14.8462373	0.0001	TRUE
## X-squared45	GPT-5-High vs GPT-5-Minimal	0.228	32.9383855	0.0000	TRUE
## X-squared46	GPT-5-High vs o4-mini-High	0.114	12.4274222	0.0004	TRUE
## X-squared47	GPT-5-High vs o4-mini-Medium	0.150	21.5444489	0.0000	TRUE
## X-squared48	GPT-5-High vs o3-GPT-Image-High	0.094	11.1983901	0.0008	TRUE
## X-squared49	GPT-5-High vs o3-GPT-Image-Medium	0.086	4.6883219	0.0304	TRUE
## X-squared50	o3-Pro vs GPT-5-Medium	-0.055	2.0901458	0.1483	FALSE
## X-squared51	o3-Pro vs GPT-5-Low	0.092	3.7318677	0.0534	FALSE
## X-squared52	o3-Pro vs GPT-5-Minimal	0.167	12.7541485	0.0004	TRUE
## X-squared53	o3-Pro vs o4-mini-High	0.053	1.6374358	0.2007	FALSE
## X-squared54	o3-Pro vs o4-mini-Medium	0.090	4.8198083	0.0281	TRUE
## X-squared55	o3-Pro vs o3-GPT-Image-High	0.033	0.7286695	0.3933	FALSE
## X-squared56	o3-Pro vs o3-GPT-Image-Medium	0.026	0.2282248	0.6328	FALSE
## X-squared57	GPT-5-Medium vs GPT-5-Low	0.147	15.6387810	0.0001	TRUE
## X-squared58	GPT-5-Medium vs GPT-5-Minimal	0.222	35.6439923	0.0000	TRUE
## X-squared59	GPT-5-Medium vs o4-mini-High	0.108	13.6072593	0.0002	TRUE
## X-squared60	GPT-5-Medium vs o4-mini-Medium	0.145	24.1996546	0.0000	TRUE
## X-squared61	GPT-5-Medium vs o3-GPT-Image-High	0.088	12.8378194	0.0003	TRUE
## X-squared62	GPT-5-Medium vs o3-GPT-Image-Medium	0.081	4.6326164	0.0314	TRUE
## X-squared63	GPT-5-Low vs GPT-5-Minimal	0.075	2.4345048	0.1187	FALSE
## X-squared64	GPT-5-Low vs o4-mini-High	-0.039	0.8071628	0.3690	FALSE
## X-squared65	GPT-5-Low vs o4-mini-Medium	-0.002	0.0000000	1.0000	FALSE
## X-squared66	GPT-5-Low vs o3-GPT-Image-High	-0.059	2.4476967	0.1177	FALSE
## X-squared67	GPT-5-Low vs o3-GPT-Image-Medium	-0.066	1.8598675	0.1726	FALSE
## X-squared68	GPT-5-Minimal vs o4-mini-High	-0.114	7.8282651	0.0051	TRUE
## X-squared69	GPT-5-Minimal vs o4-mini-Medium	-0.077	3.5417399	0.0598	FALSE
## X-squared70	GPT-5-Minimal vs o3-GPT-Image-High	-0.134	13.2879128	0.0003	TRUE
## X-squared71	GPT-5-Minimal vs o3-GPT-Image-Medium	-0.141	9.0483795	0.0026	TRUE
## X-squared72	o4-mini-High vs o4-mini-Medium	0.036	1.1271703	0.2884	FALSE
## X-squared73	o4-mini-High vs o3-GPT-Image-High	-0.020	0.4513398	0.5017	FALSE
## X-squared74	o4-mini-High vs o3-GPT-Image-Medium	-0.028	0.3895990	0.5325	FALSE
## X-squared75	o4-mini-Medium vs o3-GPT-Image-High	-0.057	3.8942781	0.0485	TRUE
## X-squared76	o4-mini-Medium vs o3-GPT-Image-Medium	-0.064	2.3783849	0.1230	FALSE
## X-squared77	o3-GPT-Image-High vs o3-GPT-Image-Medium	-0.007	0.0182536	0.8925	FALSE

Heatmap for 48 Novel Reasoning Variations

```

# Create matrix of p-values for 48 Novel reasoning variations
novel_48_reasoning_models <- novel_reasoning_data$model
novel_48_reasoning_pval_matrix <- matrix(NA, nrow = length(novel_48_reasoning_models), ncol = length(novel_48_reasoning_models),
rownames(novel_48_reasoning_pval_matrix) <- novel_48_reasoning_models
colnames(novel_48_reasoning_pval_matrix) <- novel_48_reasoning_models

for (i in 1:nrow(novel_48_reasoning_results)) {
  row_idx <- which(novel_48_reasoning_models == novel_48_reasoning_results$model1[i])
  col_idx <- which(novel_48_reasoning_models == novel_48_reasoning_results$model2[i])
  novel_48_reasoning_pval_matrix[row_idx, col_idx] <- novel_48_reasoning_results$p_value[i]
  novel_48_reasoning_pval_matrix[col_idx, row_idx] <- novel_48_reasoning_results$p_value[i]
}

# Set diagonal to NA
diag(novel_48_reasoning_pval_matrix) <- NA

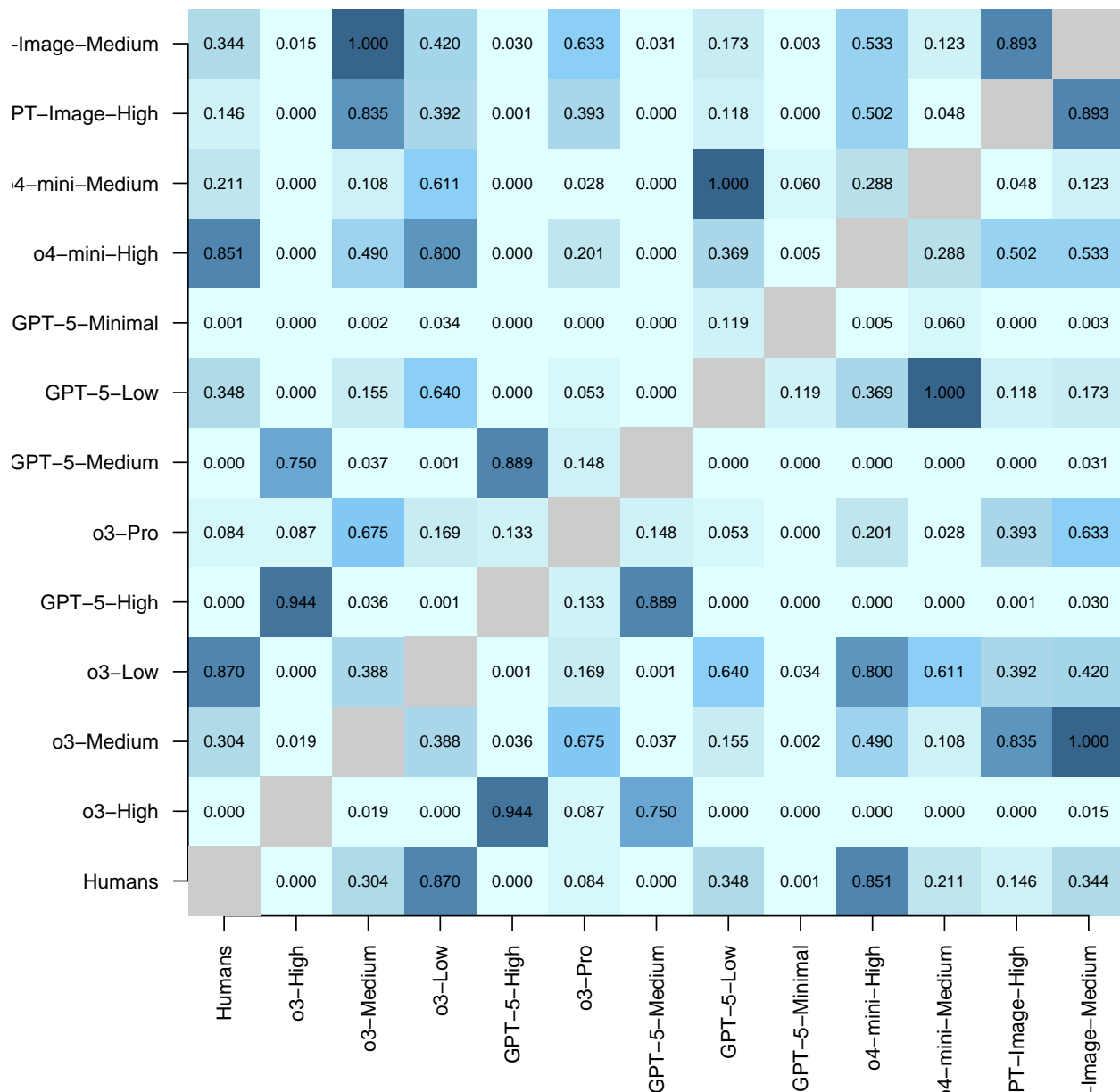
```

```

# Set margins for better label display
par(mar = c(6, 6, 3, 2))
# Plot heatmap with same color palette
image(novel_48_reasoning_pval_matrix, axes = FALSE, col = col_palette,
      main = "P-values Heatmap - 48 Novel Reasoning Variations")
axis(1, at = seq(0, 1, length.out = length(novel_48_reasoning_models)), labels = novel_48_reasoning_models,
      las = 2, cex.axis = 0.8) # las= 2 makes labels perpendicular, cex.axis makes them smaller
axis(2, at = seq(0, 1, length.out = length(novel_48_reasoning_models)), labels = novel_48_reasoning_models,
      las = 2, cex.axis = 0.8)
# Add gray color for diagonal
for (i in 1:length(novel_48_reasoning_models)) {
  x_pos <- (i - 1) / (length(novel_48_reasoning_models) - 1)
  y_pos <- (i - 1) / (length(novel_48_reasoning_models) - 1)
  rect(x_pos - 0.5 / (length(novel_48_reasoning_models) - 1), y_pos - 0.5 / (length(novel_48_reasoning_models) - 1),
        x_pos + 0.5 / (length(novel_48_reasoning_models) - 1), y_pos + 0.5 / (length(novel_48_reasoning_models) - 1),
        col = "gray80", border = NA)
}
# Add p-values to the plot
for (i in 1:nrow(novel_48_reasoning_pval_matrix)) {
  for (j in 1:ncol(novel_48_reasoning_pval_matrix)) {
    if (!is.na(novel_48_reasoning_pval_matrix[i, j])) {
      x_pos <- (j - 1) / (ncol(novel_48_reasoning_pval_matrix) - 1)
      y_pos <- (i - 1) / (nrow(novel_48_reasoning_pval_matrix) - 1)
      text(x_pos, y_pos, sprintf("%.3f", novel_48_reasoning_pval_matrix[i, j]), cex = 0.7)
    }
  }
}

```

P-values Heatmap – 48 Novel Reasoning Variations



Summary of Significant Differences - 48 Novel Reasoning Variations

```
# Count significant differences for 48 Novel reasoning variations
novel_48_reasoning_sig_count <- sum(novel_48_reasoning_results$significant)
cat("Summary of Significant Differences - 48 Novel Reasoning Variations:\n")
```

```
## Summary of Significant Differences - 48 Novel Reasoning Variations:
```

```
cat(paste(rep("=", 50), collapse = ""), "\n")
```

```
## =====
```

```
cat(" Total comparisons:", nrow(novel_48_reasoning_results), "\n")
```

```

## Total comparisons: 78
cat(" Significant differences:", novel_48_reasoning_sig_count, "\n")

## Significant differences: 36
cat(" Percentage significant:", round(novel_48_reasoning_sig_count / nrow(novel_48_reasoning_results))

## Percentage significant: 46.2 %
# Show which comparisons are significant
cat("Significant Comparisons in 48 Novel Reasoning Variations:\n")

## Significant Comparisons in 48 Novel Reasoning Variations:
novel_48_reasoning_sig <- novel_48_reasoning_results[novel_48_reasoning_results$significant, c("compari
if (nrow(novel_48_reasoning_sig) > 0) {
  print(kable(novel_48_reasoning_sig, format = "simple", digits = 4))
} else {
  cat(" None\n")
}

##
##
## comparison diff p_value
## -----
## X-squared Humans vs o3-High -0.1234 0.0000
## X-squared3 Humans vs GPT-5-High -0.1196 0.0000
## X-squared5 Humans vs GPT-5-Medium -0.1140 0.0000
## X-squared7 Humans vs GPT-5-Minimal 0.1081 0.0013
## X-squared12 o3-High vs o3-Medium 0.0874 0.0188
## X-squared13 o3-High vs o3-Low 0.1309 0.0004
## X-squared17 o3-High vs GPT-5-Low 0.1564 0.0000
## X-squared18 o3-High vs GPT-5-Minimal 0.2315 0.0000
## X-squared19 o3-High vs o4-mini-High 0.1178 0.0001
## X-squared20 o3-High vs o4-mini-Medium 0.1541 0.0000
## X-squared21 o3-High vs o3-GPT-Image-High 0.0975 0.0001
## X-squared22 o3-High vs o3-GPT-Image-Medium 0.0901 0.0155
## X-squared24 o3-Medium vs GPT-5-High -0.0837 0.0359
## X-squared26 o3-Medium vs GPT-5-Medium -0.0780 0.0375
## X-squared28 o3-Medium vs GPT-5-Minimal 0.1441 0.0022
## X-squared33 o3-Low vs GPT-5-High -0.1272 0.0013
## X-squared35 o3-Low vs GPT-5-Medium -0.1215 0.0011
## X-squared37 o3-Low vs GPT-5-Minimal 0.1006 0.0343
## X-squared44 GPT-5-High vs GPT-5-Low 0.1527 0.0001
## X-squared45 GPT-5-High vs GPT-5-Minimal 0.2278 0.0000
## X-squared46 GPT-5-High vs o4-mini-High 0.1141 0.0004
## X-squared47 GPT-5-High vs o4-mini-Medium 0.1504 0.0000
## X-squared48 GPT-5-High vs o3-GPT-Image-High 0.0938 0.0008
## X-squared49 GPT-5-High vs o3-GPT-Image-Medium 0.0863 0.0304
## X-squared52 o3-Pro vs GPT-5-Minimal 0.1672 0.0004
## X-squared54 o3-Pro vs o4-mini-Medium 0.0898 0.0281
## X-squared57 GPT-5-Medium vs GPT-5-Low 0.1470 0.0001
## X-squared58 GPT-5-Medium vs GPT-5-Minimal 0.2221 0.0000
## X-squared59 GPT-5-Medium vs o4-mini-High 0.1084 0.0002
## X-squared60 GPT-5-Medium vs o4-mini-Medium 0.1447 0.0000
## X-squared61 GPT-5-Medium vs o3-GPT-Image-High 0.0881 0.0003

```

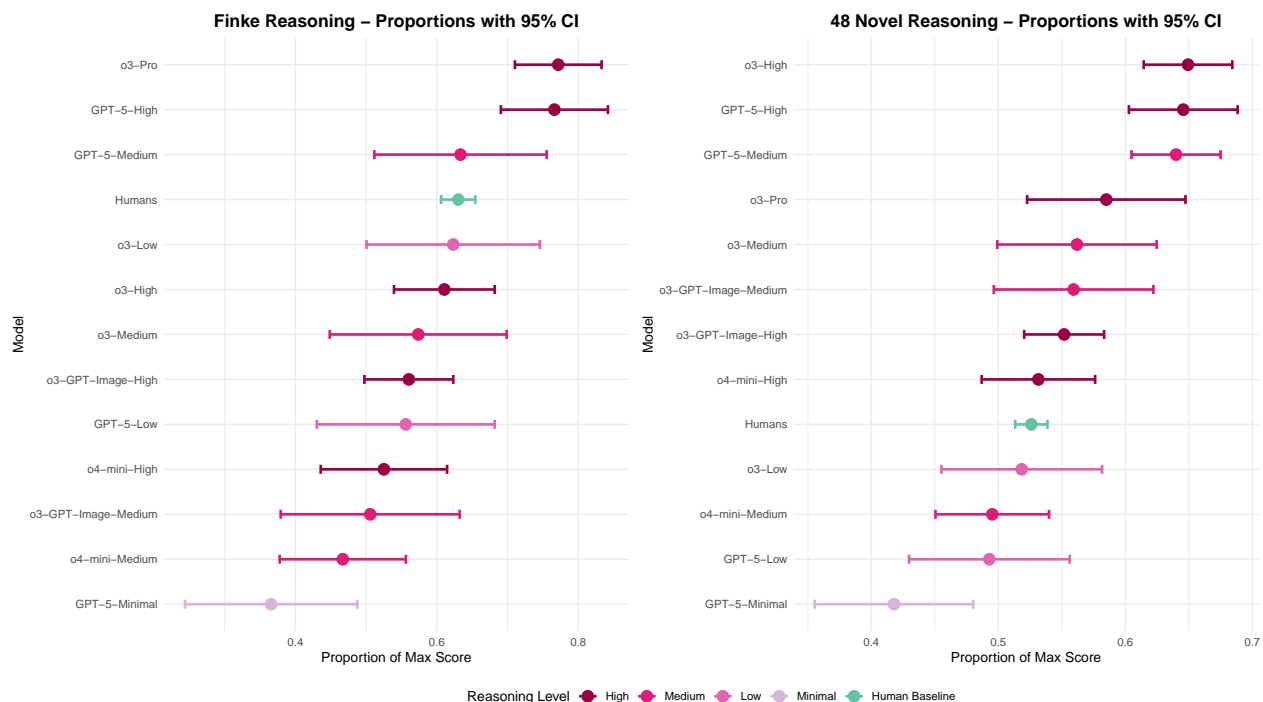
## X-squared62	GPT-5-Medium vs o3-GPT-Image-Medium	0.0807	0.0314
## X-squared68	GPT-5-Minimal vs o4-mini-High	-0.1137	0.0051
## X-squared70	GPT-5-Minimal vs o3-GPT-Image-High	-0.1340	0.0003
## X-squared71	GPT-5-Minimal vs o3-GPT-Image-Medium	-0.1414	0.0026
## X-squared75	o4-mini-Medium vs o3-GPT-Image-High	-0.0566	0.0485

Visualization of Finke and Novel Reasoning Variations

```
# Plot proportions with confidence intervals for Finke reasoning variations
finke_reasoning_plot <- ggplot(finke_reasoning_data, aes(x = reorder(model, proportion), y = proportion)) +
  geom_point(size = 4, aes(color = color)) +
  geom_errorbar(aes(ymin = proportion - 1.96 * sqrt(proportion * (1 - proportion) / max_score),
                    ymax = proportion + 1.96 * sqrt(proportion * (1 - proportion) / max_score),
                    color = color),
                width = 0.2, size = 1) +
  coord_flip() +
  theme_minimal() +
  labs(title = "Finke Reasoning - Proportions with 95% CI",
       x = "Model",
       y = "Proportion of Max Score") +
  theme(plot.title = element_text(hjust = 0.5, size = 14, face = "bold")) +
  scale_color_manual(
    values = c("#980043", "#dd1c77", "#df65b0", "#d7b5d8", "#66c2a5"),
    name = "Reasoning Level",
    breaks = c("#980043", "#dd1c77", "#df65b0", "#d7b5d8", "#66c2a5"),
    labels = c("High", "Medium", "Low", "Minimal", "Human Baseline")
  )

# Plot proportions with confidence intervals for 48 Novel reasoning variations
novel_48_reasoning_plot <- ggplot(novel_reasoning_data, aes(x = reorder(model, proportion), y = proportion)) +
  geom_point(size = 4, aes(color = color)) +
  geom_errorbar(aes(ymin = proportion - 1.96 * sqrt(proportion * (1 - proportion) / max_score),
                    ymax = proportion + 1.96 * sqrt(proportion * (1 - proportion) / max_score),
                    color = color),
                width = 0.2, size = 1) +
  coord_flip() +
  theme_minimal() +
  labs(title = "48 Novel Reasoning - Proportions with 95% CI",
       x = "Model",
       y = "Proportion of Max Score") +
  theme(plot.title = element_text(hjust = 0.5, size = 14, face = "bold")) +
  scale_color_manual(
    values = c("#980043", "#dd1c77", "#df65b0", "#d7b5d8", "#66c2a5"),
    name = "Reasoning Level",
    breaks = c("#980043", "#dd1c77", "#df65b0", "#d7b5d8", "#66c2a5"),
    labels = c("High", "Medium", "Low", "Minimal", "Human Baseline")
  )

combined_reasoning_plot <- (finke_reasoning_plot + novel_48_reasoning_plot & theme(legend.position = "bottom"))
print(combined_reasoning_plot)
```



Combined Summary of Reasoning Variations

```
combined_reasoning_results <- test_all_combinations(collapsed_reasoning_data, "Combined Reasoning Variations")
# Display results
cat("All Pairwise Comparisons for Combined Reasoning Variations:\n")
```

```
## All Pairwise Comparisons for Combined Reasoning Variations:
```

```
cat(paste(rep("=", 80), collapse = ""), "\n")
```

```
## =====
```

```
for (i in 1:nrow(combined_reasoning_results)) {
  cat("\n", combined_reasoning_results$comparison[i], "\n")
  cat(paste(rep("-", 40), collapse = ""), "\n")
  cat("Proportions: ", round(combined_reasoning_results$prop1[i], 3), " vs ",
      round(combined_reasoning_results$prop2[i], 3), "\n")
  cat("Difference: ", round(combined_reasoning_results$diff[i], 3), "\n")
  cat("Chi-squared: ", round(combined_reasoning_results$chi_squared[i], 3), "\n")
  cat("Degrees of freedom: ", round(combined_reasoning_results$df[i], 3), "\n")
  cat("P-value: ", format(combined_reasoning_results$p_value[i], scientific = FALSE, digits = 4), "\n")
  cat("95% CI: [", round(combined_reasoning_results$ci_lower[i], 3), ", ",
      round(combined_reasoning_results$ci_upper[i], 3), "]\n")
  cat("Significant: ", ifelse(combined_reasoning_results$significant[i], "YES (p < 0.05)", "NO"), "\n")
}
```

```
##
```

```
## Humans vs o3-High
```

```
## -----
```

```
## Proportions: 0.547 vs 0.642
```

```
## Difference: -0.094
```

```
## Chi-squared: 28.631
```

```
## Degrees of freedom: 1
```

```

## P-value: 0.00000008757
## 95% CI: [ -0.128 , -0.06 ]
## Significant: YES (p < 0.05)
##
## Humans vs o3-Medium
## -----
## Proportions: 0.547 vs 0.564
## Difference: -0.017
## Chi-squared: 0.273
## Degrees of freedom: 1
## P-value: 0.6014
## 95% CI: [ -0.076 , 0.042 ]
## Significant: NO
##
## Humans vs o3-Low
## -----
## Proportions: 0.547 vs 0.539
## Difference: 0.008
## Chi-squared: 0.043
## Degrees of freedom: 1
## P-value: 0.8349
## 95% CI: [ -0.051 , 0.067 ]
## Significant: NO
##
## Humans vs GPT-5-High
## -----
## Proportions: 0.547 vs 0.67
## Difference: -0.123
## Chi-squared: 33.302
## Degrees of freedom: 1
## P-value: 0.00000000789
## 95% CI: [ -0.163 , -0.082 ]
## Significant: YES (p < 0.05)
##
## Humans vs o3-Pro
## -----
## Proportions: 0.547 vs 0.666
## Difference: -0.119
## Chi-squared: 45.76
## Degrees of freedom: 1
## P-value: 0.0000000001336
## 95% CI: [ -0.153 , -0.086 ]
## Significant: YES (p < 0.05)
##
## Humans vs GPT-5-Medium
## -----
## Proportions: 0.547 vs 0.595
## Difference: -0.048
## Chi-squared: 2.441
## Degrees of freedom: 1
## P-value: 0.1182
## 95% CI: [ -0.106 , 0.011 ]
## Significant: NO
##

```



```

## Humans vs GPT-5-Low
## -----
## Proportions: 0.547 vs 0.506
## Difference: 0.042
## Chi-squared: 1.854
## Degrees of freedom: 1
## P-value: 0.1733
## 95% CI: [ -0.018 , 0.101 ]
## Significant: NO
##
## Humans vs GPT-5-Minimal
## -----
## Proportions: 0.547 vs 0.407
## Difference: 0.14
## Chi-squared: 22.151
## Degrees of freedom: 1
## P-value: 0.00000252
## 95% CI: [ 0.081 , 0.198 ]
## Significant: YES (p < 0.05)
##
## Humans vs o4-mini-High
## -----
## Proportions: 0.547 vs 0.53
## Difference: 0.017
## Chi-squared: 0.577
## Degrees of freedom: 1
## P-value: 0.4477
## 95% CI: [ -0.025 , 0.059 ]
## Significant: NO
##
## Humans vs o4-mini-Medium
## -----
## Proportions: 0.547 vs 0.49
## Difference: 0.058
## Chi-squared: 7.209
## Degrees of freedom: 1
## P-value: 0.007255
## 95% CI: [ 0.015 , 0.1 ]
## Significant: YES (p < 0.05)
##
## Humans vs o3-GPT-Image-High
## -----
## Proportions: 0.547 vs 0.553
## Difference: -0.006
## Chi-squared: 0.143
## Degrees of freedom: 1
## P-value: 0.7057
## 95% CI: [ -0.037 , 0.024 ]
## Significant: NO
##
## Humans vs o3-GPT-Image-Medium
## -----
## Proportions: 0.547 vs 0.549
## Difference: -0.001

```

```

## Chi-squared: 0
## Degrees of freedom: 1
## P-value: 1
## 95% CI: [ -0.06 , 0.057 ]
## Significant: NO
##
## o3-High vs o3-Medium
## -----
## Proportions: 0.642 vs 0.564
## Difference: 0.077
## Chi-squared: 5.401
## Degrees of freedom: 1
## P-value: 0.02012
## 95% CI: [ 0.011 , 0.144 ]
## Significant: YES (p < 0.05)
##
## o3-High vs o3-Low
## -----
## Proportions: 0.642 vs 0.539
## Difference: 0.102
## Chi-squared: 9.513
## Degrees of freedom: 1
## P-value: 0.00204
## 95% CI: [ 0.035 , 0.169 ]
## Significant: YES (p < 0.05)
##
## o3-High vs GPT-5-High
## -----
## Proportions: 0.642 vs 0.67
## Difference: -0.028
## Chi-squared: 1.138
## Degrees of freedom: 1
## P-value: 0.286
## 95% CI: [ -0.079 , 0.022 ]
## Significant: NO
##
## o3-High vs o3-Pro
## -----
## Proportions: 0.642 vs 0.666
## Difference: -0.025
## Chi-squared: 1.106
## Degrees of freedom: 1
## P-value: 0.2928
## 95% CI: [ -0.07 , 0.02 ]
## Significant: NO
##
## o3-High vs GPT-5-Medium
## -----
## Proportions: 0.642 vs 0.595
## Difference: 0.047
## Chi-squared: 1.924
## Degrees of freedom: 1
## P-value: 0.1654
## 95% CI: [ -0.019 , 0.113 ]

```

```

## Significant:  NO
##
## o3-High vs GPT-5-Low
## -----
## Proportions:  0.642  vs  0.506
## Difference:   0.136
## Chi-squared:  16.897
## Degrees of freedom:  1
## P-value:      0.00003946
## 95% CI: [ 0.069 ,  0.203 ]
## Significant:  YES (p < 0.05)
##
## o3-High vs GPT-5-Minimal
## -----
## Proportions:  0.642  vs  0.407
## Difference:   0.234
## Chi-squared:  49.803
## Degrees of freedom:  1
## P-value:      0.00000000000017
## 95% CI: [ 0.168 ,  0.3 ]
## Significant:  YES (p < 0.05)
##
## o3-High vs o4-mini-High
## -----
## Proportions:  0.642  vs  0.53
## Difference:   0.111
## Chi-squared:  18.085
## Degrees of freedom:  1
## P-value:      0.00002112
## 95% CI: [ 0.059 ,  0.163 ]
## Significant:  YES (p < 0.05)
##
## o3-High vs o4-mini-Medium
## -----
## Proportions:  0.642  vs  0.49
## Difference:   0.152
## Chi-squared:  33.555
## Degrees of freedom:  1
## P-value:      0.000000006929
## 95% CI: [ 0.1 ,  0.204 ]
## Significant:  YES (p < 0.05)
##
## o3-High vs o3-GPT-Image-High
## -----
## Proportions:  0.642  vs  0.553
## Difference:   0.088
## Chi-squared:  16.139
## Degrees of freedom:  1
## P-value:      0.00005886
## 95% CI: [ 0.045 ,  0.131 ]
## Significant:  YES (p < 0.05)
##
## o3-High vs o3-GPT-Image-Medium
## -----

```

```

## Proportions: 0.642 vs 0.549
## Difference: 0.093
## Chi-squared: 7.863
## Degrees of freedom: 1
## P-value: 0.005045
## 95% CI: [ 0.026 , 0.16 ]
## Significant: YES (p < 0.05)
##
## o3-Medium vs o3-Low
## -----
## Proportions: 0.564 vs 0.539
## Difference: 0.025
## Chi-squared: 0.282
## Degrees of freedom: 1
## P-value: 0.5956
## 95% CI: [ -0.058 , 0.108 ]
## Significant: NO
##
## o3-Medium vs GPT-5-High
## -----
## Proportions: 0.564 vs 0.67
## Difference: -0.106
## Chi-squared: 9.15
## Degrees of freedom: 1
## P-value: 0.002487
## 95% CI: [ -0.176 , -0.035 ]
## Significant: YES (p < 0.05)
##
## o3-Medium vs o3-Pro
## -----
## Proportions: 0.564 vs 0.666
## Difference: -0.102
## Chi-squared: 9.74
## Degrees of freedom: 1
## P-value: 0.001803
## 95% CI: [ -0.168 , -0.036 ]
## Significant: YES (p < 0.05)
##
## o3-Medium vs GPT-5-Medium
## -----
## Proportions: 0.564 vs 0.595
## Difference: -0.03
## Chi-squared: 0.453
## Degrees of freedom: 1
## P-value: 0.5009
## 95% CI: [ -0.113 , 0.052 ]
## Significant: NO
##
## o3-Medium vs GPT-5-Low
## -----
## Proportions: 0.564 vs 0.506
## Difference: 0.059
## Chi-squared: 1.848
## Degrees of freedom: 1

```

```

## P-value: 0.174
## 95% CI: [ -0.024 , 0.142 ]
## Significant: NO
##
## o3-Medium vs GPT-5-Minimal
## -----
## Proportions: 0.564 vs 0.407
## Difference: 0.157
## Chi-squared: 14.152
## Degrees of freedom: 1
## P-value: 0.0001686
## 95% CI: [ 0.075 , 0.239 ]
## Significant: YES (p < 0.05)
##
## o3-Medium vs o4-mini-High
## -----
## Proportions: 0.564 vs 0.53
## Difference: 0.034
## Chi-squared: 0.799
## Degrees of freedom: 1
## P-value: 0.3715
## 95% CI: [ -0.037 , 0.105 ]
## Significant: NO
##
## o3-Medium vs o4-mini-Medium
## -----
## Proportions: 0.564 vs 0.49
## Difference: 0.075
## Chi-squared: 4.173
## Degrees of freedom: 1
## P-value: 0.04108
## 95% CI: [ 0.003 , 0.146 ]
## Significant: YES (p < 0.05)
##
## o3-Medium vs o3-GPT-Image-High
## -----
## Proportions: 0.564 vs 0.553
## Difference: 0.011
## Chi-squared: 0.072
## Degrees of freedom: 1
## P-value: 0.7878
## 95% CI: [ -0.054 , 0.076 ]
## Significant: NO
##
## o3-Medium vs o3-GPT-Image-Medium
## -----
## Proportions: 0.564 vs 0.549
## Difference: 0.016
## Chi-squared: 0.093
## Degrees of freedom: 1
## P-value: 0.7605
## 95% CI: [ -0.067 , 0.099 ]
## Significant: NO
##

```

```

## o3-Low vs GPT-5-High
## -----
## Proportions: 0.539 vs 0.67
## Difference: -0.13
## Chi-squared: 13.975
## Degrees of freedom: 1
## P-value: 0.0001853
## 95% CI: [ -0.201 , -0.06 ]
## Significant: YES (p < 0.05)
##
## o3-Low vs o3-Pro
## -----
## Proportions: 0.539 vs 0.666
## Difference: -0.127
## Chi-squared: 15.089
## Degrees of freedom: 1
## P-value: 0.0001026
## 95% CI: [ -0.193 , -0.06 ]
## Significant: YES (p < 0.05)
##
## o3-Low vs GPT-5-Medium
## -----
## Proportions: 0.539 vs 0.595
## Difference: -0.055
## Chi-squared: 1.653
## Degrees of freedom: 1
## P-value: 0.1985
## 95% CI: [ -0.138 , 0.027 ]
## Significant: NO
##
## o3-Low vs GPT-5-Low
## -----
## Proportions: 0.539 vs 0.506
## Difference: 0.034
## Chi-squared: 0.558
## Degrees of freedom: 1
## P-value: 0.4549
## 95% CI: [ -0.049 , 0.117 ]
## Significant: NO
##
## o3-Low vs GPT-5-Minimal
## -----
## Proportions: 0.539 vs 0.407
## Difference: 0.132
## Chi-squared: 9.956
## Degrees of freedom: 1
## P-value: 0.001603
## 95% CI: [ 0.049 , 0.215 ]
## Significant: YES (p < 0.05)
##
## o3-Low vs o4-mini-High
## -----
## Proportions: 0.539 vs 0.53
## Difference: 0.009

```

```

## Chi-squared: 0.035
## Degrees of freedom: 1
## P-value: 0.8516
## 95% CI: [ -0.063 , 0.081 ]
## Significant: NO
##
## o3-Low vs o4-mini-Medium
## -----
## Proportions: 0.539 vs 0.49
## Difference: 0.05
## Chi-squared: 1.791
## Degrees of freedom: 1
## P-value: 0.1808
## 95% CI: [ -0.022 , 0.121 ]
## Significant: NO
##
## o3-Low vs o3-GPT-Image-High
## -----
## Proportions: 0.539 vs 0.553
## Difference: -0.014
## Chi-squared: 0.142
## Degrees of freedom: 1
## P-value: 0.7067
## 95% CI: [ -0.079 , 0.051 ]
## Significant: NO
##
## o3-Low vs o3-GPT-Image-Medium
## -----
## Proportions: 0.539 vs 0.549
## Difference: -0.009
## Chi-squared: 0.021
## Degrees of freedom: 1
## P-value: 0.8856
## 95% CI: [ -0.092 , 0.074 ]
## Significant: NO
##
## GPT-5-High vs o3-Pro
## -----
## Proportions: 0.67 vs 0.666
## Difference: 0.003
## Chi-squared: 0.007
## Degrees of freedom: 1
## P-value: 0.9336
## 95% CI: [ -0.047 , 0.053 ]
## Significant: NO
##
## GPT-5-High vs GPT-5-Medium
## -----
## Proportions: 0.67 vs 0.595
## Difference: 0.075
## Chi-squared: 4.594
## Degrees of freedom: 1
## P-value: 0.03208
## 95% CI: [ 0.005 , 0.145 ]

```

```

## Significant: YES (p < 0.05)
##
## GPT-5-High vs GPT-5-Low
## -----
## Proportions: 0.67 vs 0.506
## Difference: 0.164
## Chi-squared: 22.084
## Degrees of freedom: 1
## P-value: 0.000002609
## 95% CI: [ 0.094 , 0.235 ]
## Significant: YES (p < 0.05)
##
## GPT-5-High vs GPT-5-Minimal
## -----
## Proportions: 0.67 vs 0.407
## Difference: 0.262
## Chi-squared: 55.522
## Degrees of freedom: 1
## P-value: 0.0000000000000924
## 95% CI: [ 0.193 , 0.332 ]
## Significant: YES (p < 0.05)
##
## GPT-5-High vs o4-mini-High
## -----
## Proportions: 0.67 vs 0.53
## Difference: 0.139
## Chi-squared: 23.742
## Degrees of freedom: 1
## P-value: 0.000001102
## 95% CI: [ 0.083 , 0.196 ]
## Significant: YES (p < 0.05)
##
## GPT-5-High vs o4-mini-Medium
## -----
## Proportions: 0.67 vs 0.49
## Difference: 0.18
## Chi-squared: 39.241
## Degrees of freedom: 1
## P-value: 0.0000000003745
## 95% CI: [ 0.124 , 0.237 ]
## Significant: YES (p < 0.05)
##
## GPT-5-High vs o3-GPT-Image-High
## -----
## Proportions: 0.67 vs 0.553
## Difference: 0.116
## Chi-squared: 21.894
## Degrees of freedom: 1
## P-value: 0.000002882
## 95% CI: [ 0.068 , 0.164 ]
## Significant: YES (p < 0.05)
##
## GPT-5-High vs o3-GPT-Image-Medium
## -----

```



```

## Proportions: 0.67 vs 0.549
## Difference: 0.121
## Chi-squared: 12.08
## Degrees of freedom: 1
## P-value: 0.0005097
## 95% CI: [ 0.051 , 0.191 ]
## Significant: YES (p < 0.05)
##
## o3-Pro vs GPT-5-Medium
## -----
## Proportions: 0.666 vs 0.595
## Difference: 0.072
## Chi-squared: 4.747
## Degrees of freedom: 1
## P-value: 0.02934
## 95% CI: [ 0.006 , 0.137 ]
## Significant: YES (p < 0.05)
##
## o3-Pro vs GPT-5-Low
## -----
## Proportions: 0.666 vs 0.506
## Difference: 0.161
## Chi-squared: 24.15
## Degrees of freedom: 1
## P-value: 0.0000008913
## 95% CI: [ 0.094 , 0.227 ]
## Significant: YES (p < 0.05)
##
## o3-Pro vs GPT-5-Minimal
## -----
## Proportions: 0.666 vs 0.407
## Difference: 0.259
## Chi-squared: 61.843
## Degrees of freedom: 1
## P-value: 0.000000000000003719
## 95% CI: [ 0.193 , 0.325 ]
## Significant: YES (p < 0.05)
##
## o3-Pro vs o4-mini-High
## -----
## Proportions: 0.666 vs 0.53
## Difference: 0.136
## Chi-squared: 27.478
## Degrees of freedom: 1
## P-value: 0.0000001589
## 95% CI: [ 0.084 , 0.188 ]
## Significant: YES (p < 0.05)
##
## o3-Pro vs o4-mini-Medium
## -----
## Proportions: 0.666 vs 0.49
## Difference: 0.177
## Chi-squared: 45.953
## Degrees of freedom: 1

```

```

## P-value: 0.00000000001211
## 95% CI: [ 0.125 , 0.229 ]
## Significant: YES (p < 0.05)
##
## o3-Pro vs o3-GPT-Image-High
## -----
## Proportions: 0.666 vs 0.553
## Difference: 0.113
## Chi-squared: 26.82
## Degrees of freedom: 1
## P-value: 0.0000002234
## 95% CI: [ 0.07 , 0.155 ]
## Significant: YES (p < 0.05)
##
## o3-Pro vs o3-GPT-Image-Medium
## -----
## Proportions: 0.666 vs 0.549
## Difference: 0.118
## Chi-squared: 12.982
## Degrees of freedom: 1
## P-value: 0.0003144
## 95% CI: [ 0.051 , 0.184 ]
## Significant: YES (p < 0.05)
##
## GPT-5-Medium vs GPT-5-Low
## -----
## Proportions: 0.595 vs 0.506
## Difference: 0.089
## Chi-squared: 4.464
## Degrees of freedom: 1
## P-value: 0.03461
## 95% CI: [ 0.007 , 0.172 ]
## Significant: YES (p < 0.05)
##
## GPT-5-Medium vs GPT-5-Minimal
## -----
## Proportions: 0.595 vs 0.407
## Difference: 0.187
## Chi-squared: 20.31
## Degrees of freedom: 1
## P-value: 0.000006585
## 95% CI: [ 0.105 , 0.269 ]
## Significant: YES (p < 0.05)
##
## GPT-5-Medium vs o4-mini-High
## -----
## Proportions: 0.595 vs 0.53
## Difference: 0.064
## Chi-squared: 3.103
## Degrees of freedom: 1
## P-value: 0.07814
## 95% CI: [ -0.006 , 0.135 ]
## Significant: NO
##

```

```

## GPT-5-Medium vs o4-mini-Medium
## -----
## Proportions: 0.595 vs 0.49
## Difference: 0.105
## Chi-squared: 8.451
## Degrees of freedom: 1
## P-value: 0.003648
## 95% CI: [ 0.034 , 0.176 ]
## Significant: YES (p < 0.05)
##
## GPT-5-Medium vs o3-GPT-Image-High
## -----
## Proportions: 0.595 vs 0.553
## Difference: 0.041
## Chi-squared: 1.49
## Degrees of freedom: 1
## P-value: 0.2222
## 95% CI: [ -0.023 , 0.106 ]
## Significant: NO
##
## GPT-5-Medium vs o3-GPT-Image-Medium
## -----
## Proportions: 0.595 vs 0.549
## Difference: 0.046
## Chi-squared: 1.124
## Degrees of freedom: 1
## P-value: 0.2891
## 95% CI: [ -0.036 , 0.129 ]
## Significant: NO
##
## GPT-5-Low vs GPT-5-Minimal
## -----
## Proportions: 0.506 vs 0.407
## Difference: 0.098
## Chi-squared: 5.436
## Degrees of freedom: 1
## P-value: 0.01972
## 95% CI: [ 0.016 , 0.181 ]
## Significant: YES (p < 0.05)
##
## GPT-5-Low vs o4-mini-High
## -----
## Proportions: 0.506 vs 0.53
## Difference: -0.025
## Chi-squared: 0.395
## Degrees of freedom: 1
## P-value: 0.5295
## 95% CI: [ -0.096 , 0.047 ]
## Significant: NO
##
## GPT-5-Low vs o4-mini-Medium
## -----
## Proportions: 0.506 vs 0.49
## Difference: 0.016

```

```

## Chi-squared: 0.146
## Degrees of freedom: 1
## P-value: 0.7026
## 95% CI: [ -0.056 , 0.088 ]
## Significant: NO
##
## GPT-5-Low vs o3-GPT-Image-High
## -----
## Proportions: 0.506 vs 0.553
## Difference: -0.048
## Chi-squared: 2.038
## Degrees of freedom: 1
## P-value: 0.1534
## 95% CI: [ -0.113 , 0.017 ]
## Significant: NO
##
## GPT-5-Low vs o3-GPT-Image-Medium
## -----
## Proportions: 0.506 vs 0.549
## Difference: -0.043
## Chi-squared: 0.947
## Degrees of freedom: 1
## P-value: 0.3306
## 95% CI: [ -0.126 , 0.04 ]
## Significant: NO
##
## GPT-5-Minimal vs o4-mini-High
## -----
## Proportions: 0.407 vs 0.53
## Difference: -0.123
## Chi-squared: 11.596
## Degrees of freedom: 1
## P-value: 0.0006608
## 95% CI: [ -0.194 , -0.052 ]
## Significant: YES (p < 0.05)
##
## GPT-5-Minimal vs o4-mini-Medium
## -----
## Proportions: 0.407 vs 0.49
## Difference: -0.082
## Chi-squared: 5.106
## Degrees of freedom: 1
## P-value: 0.02384
## 95% CI: [ -0.153 , -0.011 ]
## Significant: YES (p < 0.05)
##
## GPT-5-Minimal vs o3-GPT-Image-High
## -----
## Proportions: 0.407 vs 0.553
## Difference: -0.146
## Chi-squared: 19.968
## Degrees of freedom: 1
## P-value: 0.000007874
## 95% CI: [ -0.211 , -0.082 ]

```

```

## Significant: YES (p < 0.05)
##
## GPT-5-Minimal vs o3-GPT-Image-Medium
## -----
## Proportions: 0.407 vs 0.549
## Difference: -0.141
## Chi-squared: 11.419
## Degrees of freedom: 1
## P-value: 0.0007269
## 95% CI: [ -0.224 , -0.059 ]
## Significant: YES (p < 0.05)
##
## o4-mini-High vs o4-mini-Medium
## -----
## Proportions: 0.53 vs 0.49
## Difference: 0.041
## Chi-squared: 1.83
## Degrees of freedom: 1
## P-value: 0.1761
## 95% CI: [ -0.017 , 0.099 ]
## Significant: NO
##
## o4-mini-High vs o3-GPT-Image-High
## -----
## Proportions: 0.53 vs 0.553
## Difference: -0.023
## Chi-squared: 0.782
## Degrees of freedom: 1
## P-value: 0.3765
## 95% CI: [ -0.073 , 0.027 ]
## Significant: NO
##
## o4-mini-High vs o3-GPT-Image-Medium
## -----
## Proportions: 0.53 vs 0.549
## Difference: -0.018
## Chi-squared: 0.2
## Degrees of freedom: 1
## P-value: 0.6544
## 95% CI: [ -0.09 , 0.053 ]
## Significant: NO
##
## o4-mini-Medium vs o3-GPT-Image-High
## -----
## Proportions: 0.49 vs 0.553
## Difference: -0.064
## Chi-squared: 6.321
## Degrees of freedom: 1
## P-value: 0.01193
## 95% CI: [ -0.114 , -0.014 ]
## Significant: YES (p < 0.05)
##
## o4-mini-Medium vs o3-GPT-Image-Medium
## -----

```

```
## Proportions: 0.49 vs 0.549
## Difference: -0.059
## Chi-squared: 2.554
## Degrees of freedom: 1
## P-value: 0.11
## 95% CI: [ -0.131 , 0.013 ]
## Significant: NO
##
## o3-GPT-Image-High vs o3-GPT-Image-Medium
## -----
## Proportions: 0.553 vs 0.549
## Difference: 0.005
## Chi-squared: 0.008
## Degrees of freedom: 1
## P-value: 0.9281
## 95% CI: [ -0.06 , 0.07 ]
## Significant: NO
# Summary table
combined_reasoning_summary <- combined_reasoning_results %>%
  select(comparison, diff, chi_squared, p_value, significant) %>%
  mutate(diff = round(diff, 3),
         p_value = round(p_value, 4))
cat("\n\nSummary Table - Combined Reasoning Variations:\n")
```

```
##
##
## Summary Table - Combined Reasoning Variations:
print(kable(combined_reasoning_summary, format = "simple"))
```

```
##
##
## comparison diff chi_squared p_value significant
## -----
```

## X-squared	Humans vs o3-High	-0.094	28.6308876	0.0000	TRUE
## X-squared1	Humans vs o3-Medium	-0.017	0.2729579	0.6014	FALSE
## X-squared2	Humans vs o3-Low	0.008	0.0434201	0.8349	FALSE
## X-squared3	Humans vs GPT-5-High	-0.123	33.3019857	0.0000	TRUE
## X-squared4	Humans vs o3-Pro	-0.119	45.7603911	0.0000	TRUE
## X-squared5	Humans vs GPT-5-Medium	-0.048	2.4410000	0.1182	FALSE
## X-squared6	Humans vs GPT-5-Low	0.042	1.8538008	0.1733	FALSE
## X-squared7	Humans vs GPT-5-Minimal	0.140	22.1514893	0.0000	TRUE
## X-squared8	Humans vs o4-mini-High	0.017	0.5765459	0.4477	FALSE
## X-squared9	Humans vs o4-mini-Medium	0.058	7.2087261	0.0073	TRUE
## X-squared10	Humans vs o3-GPT-Image-High	-0.006	0.1425741	0.7057	FALSE
## X-squared11	Humans vs o3-GPT-Image-Medium	-0.001	0.0000000	1.0000	FALSE
## X-squared12	o3-High vs o3-Medium	0.077	5.4014481	0.0201	TRUE
## X-squared13	o3-High vs o3-Low	0.102	9.5128679	0.0020	TRUE
## X-squared14	o3-High vs GPT-5-High	-0.028	1.1383107	0.2860	FALSE
## X-squared15	o3-High vs o3-Pro	-0.025	1.1064986	0.2928	FALSE
## X-squared16	o3-High vs GPT-5-Medium	0.047	1.9244960	0.1654	FALSE
## X-squared17	o3-High vs GPT-5-Low	0.136	16.8973639	0.0000	TRUE
## X-squared18	o3-High vs GPT-5-Minimal	0.234	49.8027874	0.0000	TRUE
## X-squared19	o3-High vs o4-mini-High	0.111	18.0851641	0.0000	TRUE

## X-squared20	o3-High vs o4-mini-Medium	0.152	33.5545083	0.0000	TRUE
## X-squared21	o3-High vs o3-GPT-Image-High	0.088	16.1391378	0.0001	TRUE
## X-squared22	o3-High vs o3-GPT-Image-Medium	0.093	7.8633176	0.0050	TRUE
## X-squared23	o3-Medium vs o3-Low	0.025	0.2817014	0.5956	FALSE
## X-squared24	o3-Medium vs GPT-5-High	-0.106	9.1499944	0.0025	TRUE
## X-squared25	o3-Medium vs o3-Pro	-0.102	9.7395028	0.0018	TRUE
## X-squared26	o3-Medium vs GPT-5-Medium	-0.030	0.4530888	0.5009	FALSE
## X-squared27	o3-Medium vs GPT-5-Low	0.059	1.8478915	0.1740	FALSE
## X-squared28	o3-Medium vs GPT-5-Minimal	0.157	14.1524588	0.0002	TRUE
## X-squared29	o3-Medium vs o4-mini-High	0.034	0.7985134	0.3715	FALSE
## X-squared30	o3-Medium vs o4-mini-Medium	0.075	4.1728658	0.0411	TRUE
## X-squared31	o3-Medium vs o3-GPT-Image-High	0.011	0.0724599	0.7878	FALSE
## X-squared32	o3-Medium vs o3-GPT-Image-Medium	0.016	0.0929174	0.7605	FALSE
## X-squared33	o3-Low vs GPT-5-High	-0.130	13.9749251	0.0002	TRUE
## X-squared34	o3-Low vs o3-Pro	-0.127	15.0885546	0.0001	TRUE
## X-squared35	o3-Low vs GPT-5-Medium	-0.055	1.6530660	0.1985	FALSE
## X-squared36	o3-Low vs GPT-5-Low	0.034	0.5584009	0.4549	FALSE
## X-squared37	o3-Low vs GPT-5-Minimal	0.132	9.9564864	0.0016	TRUE
## X-squared38	o3-Low vs o4-mini-High	0.009	0.0349944	0.8516	FALSE
## X-squared39	o3-Low vs o4-mini-Medium	0.050	1.7906703	0.1808	FALSE
## X-squared40	o3-Low vs o3-GPT-Image-High	-0.014	0.1416433	0.7067	FALSE
## X-squared41	o3-Low vs o3-GPT-Image-Medium	-0.009	0.0207156	0.8856	FALSE
## X-squared42	GPT-5-High vs o3-Pro	0.003	0.0069479	0.9336	FALSE
## X-squared43	GPT-5-High vs GPT-5-Medium	0.075	4.5940970	0.0321	TRUE
## X-squared44	GPT-5-High vs GPT-5-Low	0.164	22.0842822	0.0000	TRUE
## X-squared45	GPT-5-High vs GPT-5-Minimal	0.262	55.5223070	0.0000	TRUE
## X-squared46	GPT-5-High vs o4-mini-High	0.139	23.7419837	0.0000	TRUE
## X-squared47	GPT-5-High vs o4-mini-Medium	0.180	39.2413370	0.0000	TRUE
## X-squared48	GPT-5-High vs o3-GPT-Image-High	0.116	21.8935396	0.0000	TRUE
## X-squared49	GPT-5-High vs o3-GPT-Image-Medium	0.121	12.0796975	0.0005	TRUE
## X-squared50	o3-Pro vs GPT-5-Medium	0.072	4.7472865	0.0293	TRUE
## X-squared51	o3-Pro vs GPT-5-Low	0.161	24.1496509	0.0000	TRUE
## X-squared52	o3-Pro vs GPT-5-Minimal	0.259	61.8432618	0.0000	TRUE
## X-squared53	o3-Pro vs o4-mini-High	0.136	27.4784870	0.0000	TRUE
## X-squared54	o3-Pro vs o4-mini-Medium	0.177	45.9534117	0.0000	TRUE
## X-squared55	o3-Pro vs o3-GPT-Image-High	0.113	26.8195138	0.0000	TRUE
## X-squared56	o3-Pro vs o3-GPT-Image-Medium	0.118	12.9823165	0.0003	TRUE
## X-squared57	GPT-5-Medium vs GPT-5-Low	0.089	4.4643993	0.0346	TRUE
## X-squared58	GPT-5-Medium vs GPT-5-Minimal	0.187	20.3101779	0.0000	TRUE
## X-squared59	GPT-5-Medium vs o4-mini-High	0.064	3.1032648	0.0781	FALSE
## X-squared60	GPT-5-Medium vs o4-mini-Medium	0.105	8.4511203	0.0036	TRUE
## X-squared61	GPT-5-Medium vs o3-GPT-Image-High	0.041	1.4902319	0.2222	FALSE
## X-squared62	GPT-5-Medium vs o3-GPT-Image-Medium	0.046	1.1236450	0.2891	FALSE
## X-squared63	GPT-5-Low vs GPT-5-Minimal	0.098	5.4363969	0.0197	TRUE
## X-squared64	GPT-5-Low vs o4-mini-High	-0.025	0.3954028	0.5295	FALSE
## X-squared65	GPT-5-Low vs o4-mini-Medium	0.016	0.1457727	0.7026	FALSE
## X-squared66	GPT-5-Low vs o3-GPT-Image-High	-0.048	2.0376965	0.1534	FALSE
## X-squared67	GPT-5-Low vs o3-GPT-Image-Medium	-0.043	0.9466394	0.3306	FALSE
## X-squared68	GPT-5-Minimal vs o4-mini-High	-0.123	11.5963146	0.0007	TRUE
## X-squared69	GPT-5-Minimal vs o4-mini-Medium	-0.082	5.1059649	0.0238	TRUE
## X-squared70	GPT-5-Minimal vs o3-GPT-Image-High	-0.146	19.9681005	0.0000	TRUE
## X-squared71	GPT-5-Minimal vs o3-GPT-Image-Medium	-0.141	11.4191029	0.0007	TRUE
## X-squared72	o4-mini-High vs o4-mini-Medium	0.041	1.8298142	0.1761	FALSE
## X-squared73	o4-mini-High vs o3-GPT-Image-High	-0.023	0.7821301	0.3765	FALSE

```

## X-squared74    o4-mini-High vs o3-GPT-Image-Medium        -0.018      0.2004081      0.6544 FALSE
## X-squared75    o4-mini-Medium vs o3-GPT-Image-High        -0.064      6.3212724      0.0119 TRUE
## X-squared76    o4-mini-Medium vs o3-GPT-Image-Medium      -0.059      2.5541219      0.1100 FALSE
## X-squared77    o3-GPT-Image-High vs o3-GPT-Image-Medium    0.005      0.0081513      0.9281 FALSE

# Count significant differences
combined_reasoning_sig_count <- sum(combined_reasoning_results$significant)
cat("\n\nCombined Reasoning Variations Summary:\n")

##
##
## Combined Reasoning Variations Summary:

cat("  Total comparisons:", nrow(combined_reasoning_results), "\n")

##  Total comparisons: 78

cat("  Significant differences:", combined_reasoning_sig_count, "\n")

##  Significant differences: 43

cat("  Percentage significant:", round(combined_reasoning_sig_count / nrow(combined_reasoning_results) * 100, 1), "%\n")

##  Percentage significant: 55.1 %

# Show significant comparisons
cat("Significant Comparisons in Combined Reasoning Variations:\n")

## Significant Comparisons in Combined Reasoning Variations:

combined_reasoning_sig <- combined_reasoning_results[combined_reasoning_results$significant, c("comparison", "diff", "p_value")]
if (nrow(combined_reasoning_sig) > 0) {
  print(kable(combined_reasoning_sig, format = "simple", digits = 4))
} else {
  cat("  None\n")
}

##
##
## ----- comparison ----- diff ----- p_value -----
## X-squared    Humans vs o3-High        -0.0944    0.0000
## X-squared3    Humans vs GPT-5-High      -0.1225    0.0000
## X-squared4    Humans vs o3-Pro         -0.1191    0.0000
## X-squared7    Humans vs GPT-5-Minimal   0.1398    0.0000
## X-squared9    Humans vs o4-mini-Medium  0.0576    0.0073
## X-squared12   o3-High vs o3-Medium      0.0773    0.0201
## X-squared13   o3-High vs o3-Low        0.1022    0.0020
## X-squared17   o3-High vs GPT-5-Low     0.1360    0.0000
## X-squared18   o3-High vs GPT-5-Minimal 0.2342    0.0000
## X-squared19   o3-High vs o4-mini-High  0.1113    0.0000
## X-squared20   o3-High vs o4-mini-Medium 0.1520    0.0000
## X-squared21   o3-High vs o3-GPT-Image-High 0.0881    0.0001
## X-squared22   o3-High vs o3-GPT-Image-Medium 0.0930    0.0050
## X-squared24   o3-Medium vs GPT-5-High  -0.1055    0.0025
## X-squared25   o3-Medium vs o3-Pro      -0.1020    0.0018
## X-squared28   o3-Medium vs GPT-5-Minimal 0.1569    0.0002
## X-squared30   o3-Medium vs o4-mini-Medium 0.0747    0.0411
## X-squared33   o3-Low vs GPT-5-High     -0.1304    0.0002

```

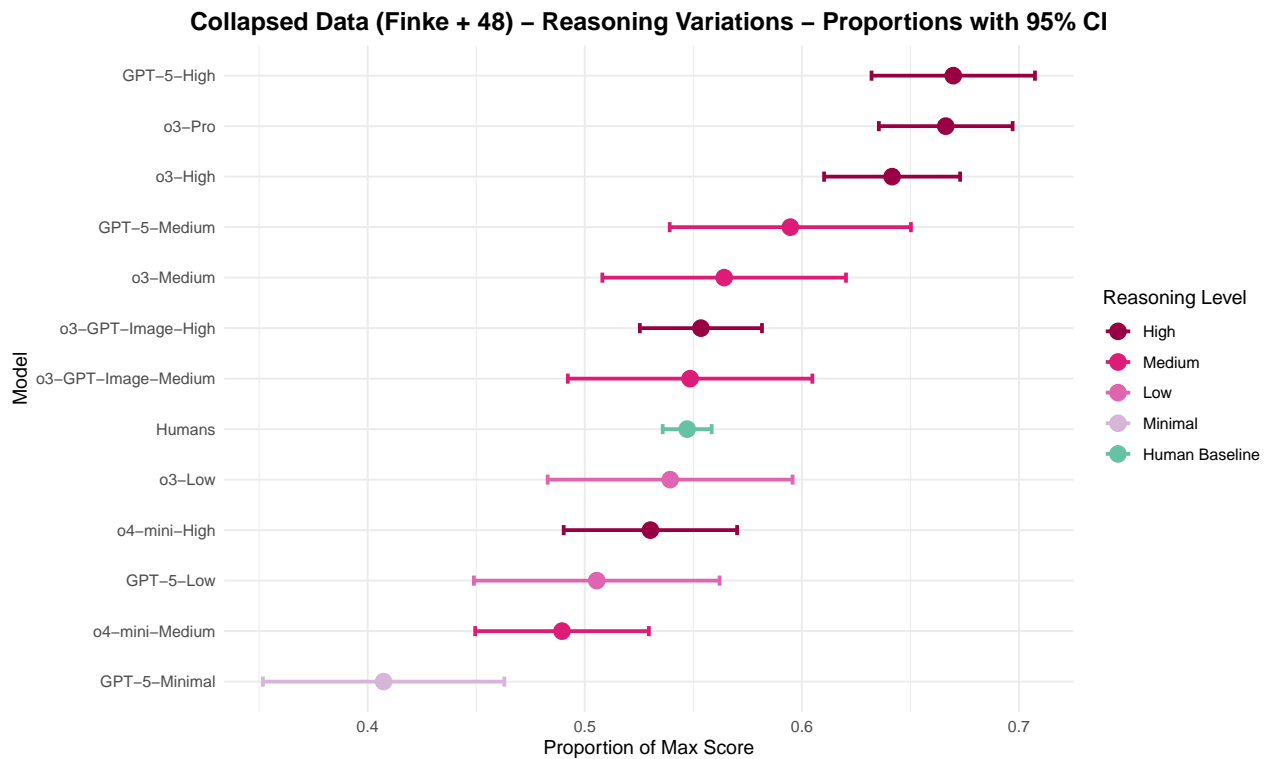

## X-squared34	o3-Low vs o3-Pro	-0.1269	0.0001
## X-squared37	o3-Low vs GPT-5-Minimal	0.1320	0.0016
## X-squared43	GPT-5-High vs GPT-5-Medium	0.0750	0.0321
## X-squared44	GPT-5-High vs GPT-5-Low	0.1642	0.0000
## X-squared45	GPT-5-High vs GPT-5-Minimal	0.2624	0.0000
## X-squared46	GPT-5-High vs o4-mini-High	0.1395	0.0000
## X-squared47	GPT-5-High vs o4-mini-Medium	0.1802	0.0000
## X-squared48	GPT-5-High vs o3-GPT-Image-High	0.1162	0.0000
## X-squared49	GPT-5-High vs o3-GPT-Image-Medium	0.1212	0.0005
## X-squared50	o3-Pro vs GPT-5-Medium	0.0716	0.0293
## X-squared51	o3-Pro vs GPT-5-Low	0.1607	0.0000
## X-squared52	o3-Pro vs GPT-5-Minimal	0.2589	0.0000
## X-squared53	o3-Pro vs o4-mini-High	0.1360	0.0000
## X-squared54	o3-Pro vs o4-mini-Medium	0.1767	0.0000
## X-squared55	o3-Pro vs o3-GPT-Image-High	0.1128	0.0000
## X-squared56	o3-Pro vs o3-GPT-Image-Medium	0.1177	0.0003
## X-squared57	GPT-5-Medium vs GPT-5-Low	0.0892	0.0346
## X-squared58	GPT-5-Medium vs GPT-5-Minimal	0.1873	0.0000
## X-squared60	GPT-5-Medium vs o4-mini-Medium	0.1052	0.0036
## X-squared63	GPT-5-Low vs GPT-5-Minimal	0.0982	0.0197
## X-squared68	GPT-5-Minimal vs o4-mini-High	-0.1229	0.0007
## X-squared69	GPT-5-Minimal vs o4-mini-Medium	-0.0822	0.0238
## X-squared70	GPT-5-Minimal vs o3-GPT-Image-High	-0.1461	0.0000
## X-squared71	GPT-5-Minimal vs o3-GPT-Image-Medium	-0.1412	0.0007
## X-squared75	o4-mini-Medium vs o3-GPT-Image-High	-0.0640	0.0119

Visualization of Combined Reasoning Variations

```
# Plot proportions with confidence intervals for combined reasoning variations
combined_reasoning_plot <- ggplot(collapsed_reasoning_data, aes(x = reorder(model, proportion), y = proportion)) +
  geom_point(size = 4, aes(color = color)) +
  geom_errorbar(aes(ymin = proportion - 1.96 * sqrt(proportion * (1 - proportion) / max_score),
                    ymax = proportion + 1.96 * sqrt(proportion * (1 - proportion) / max_score),
                    color = color),
                width = 0.2, size = 1) +
  coord_flip() +
  theme_minimal() +
  labs(title = "Collapsed Data (Finke + 48) - Reasoning Variations - Proportions with 95% CI",
       x = "Model",
       y = "Proportion of Max Score") +
  theme(plot.title = element_text(hjust = 0.5, size = 14, face = "bold")) +
  scale_color_manual(
    values = c("#980043", "#dd1c77", "#df65b0", "#d7b5d8", "#66c2a5"),
    name = "Reasoning Level",
    breaks = c("#980043", "#dd1c77", "#df65b0", "#d7b5d8", "#66c2a5"),
    labels = c("High", "Medium", "Low", "Minimal", "Human Baseline")
  )

# minimal #d7b5d8
# low #df65b0
# medium #dd1c77
# high #980043
# human #66c2a5
```

```
print(combined_reasoning_plot)
```



Heatmap for Combined Reasoning Variations

```
# Create matrix of p-values for combined reasoning variations
combined_reasoning_models <- collapsed_reasoning_data$model
combined_reasoning_pval_matrix <- matrix(NA, nrow = length(combined_reasoning_models), ncol = length(combined_reasoning_models))
rownames(combined_reasoning_pval_matrix) <- combined_reasoning_models
colnames(combined_reasoning_pval_matrix) <- combined_reasoning_models

for (i in 1:nrow(combined_reasoning_results)) {
  row_idx <- which(combined_reasoning_models == combined_reasoning_results$model1[i])
  col_idx <- which(combined_reasoning_models == combined_reasoning_results$model2[i])
  combined_reasoning_pval_matrix[row_idx, col_idx] <- combined_reasoning_results$p_value[i]
  combined_reasoning_pval_matrix[col_idx, row_idx] <- combined_reasoning_results$p_value[i]
}

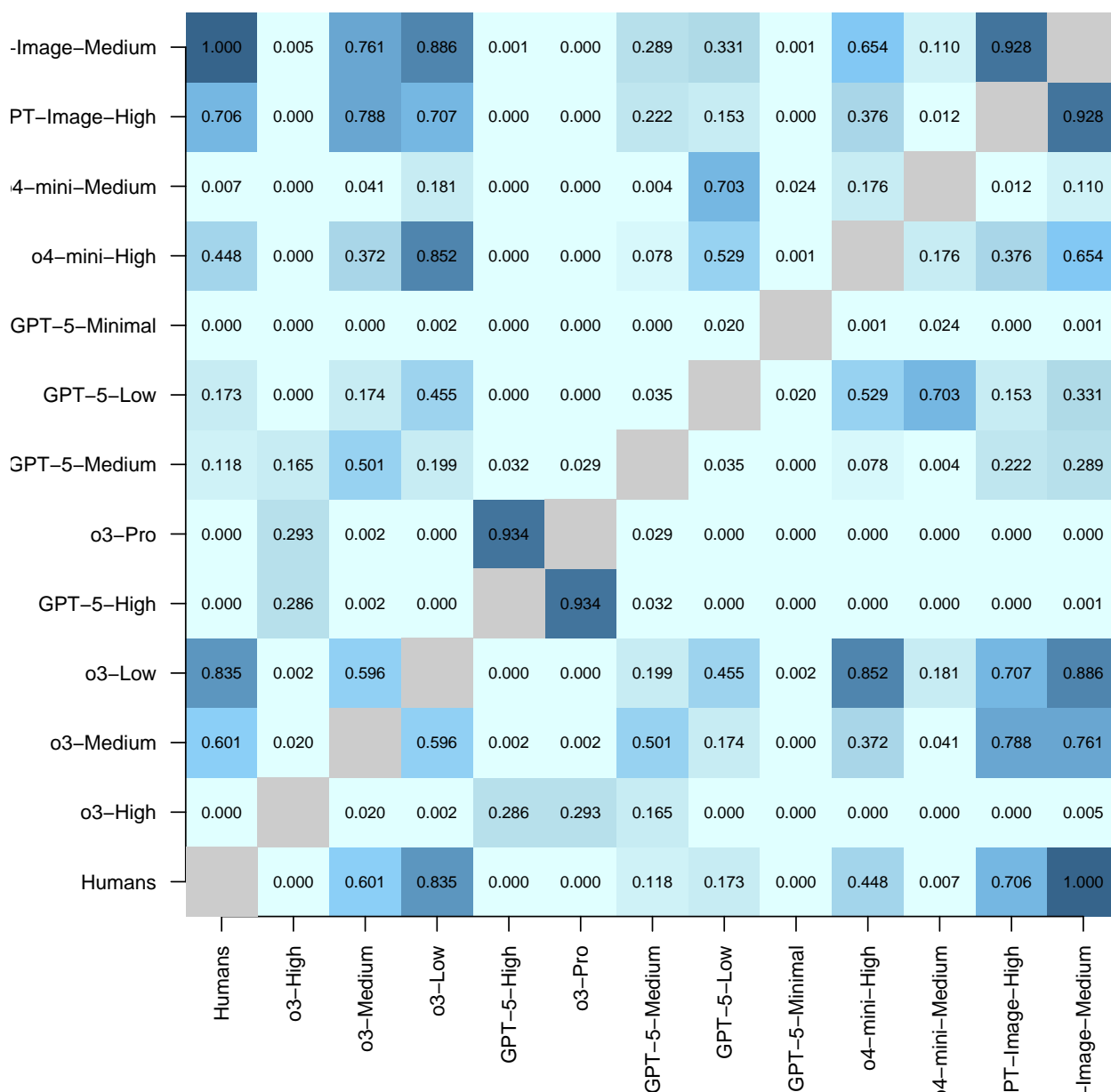
# Set diagonal to NA
diag(combined_reasoning_pval_matrix) <- NA
# Set margins for better label display
par(mar = c(6, 6, 3, 2))
# Plot heatmap with same color palette
image(combined_reasoning_pval_matrix, axes = FALSE, col = col_palette,
      main = "P-values Heatmap - Combined Reasoning Variations")
axis(1, at = seq(0, 1, length.out = length(combined_reasoning_models)), labels = combined_reasoning_models,
     las = 2, cex.axis = 0.8) # las= 2 makes labels perpendicular, cex.axis makes them smaller
axis(2, at = seq(0, 1, length.out = length(combined_reasoning_models)), labels = combined_reasoning_models,
     las = 2, cex.axis = 0.8)
# Add gray color for diagonal
for (i in 1:length(combined_reasoning_models)) {
```

```

x_pos <- (i - 1) / (length(combined_reasoning_models) - 1)
y_pos <- (i - 1) / (length(combined_reasoning_models) - 1)
rect(x_pos - 0.5 / (length(combined_reasoning_models) - 1), y_pos - 0.5 / (length(combined_reasoning_models) - 1),
      x_pos + 0.5 / (length(combined_reasoning_models) - 1), y_pos + 0.5 / (length(combined_reasoning_models) - 1),
      col = "gray80", border = NA)
}
# Add p-values to the plot
for (i in 1:nrow(combined_reasoning_pval_matrix)) {
  for (j in 1:ncol(combined_reasoning_pval_matrix)) {
    if (!is.na(combined_reasoning_pval_matrix[i, j])) {
      x_pos <- (j - 1) / (ncol(combined_reasoning_pval_matrix) - 1)
      y_pos <- (i - 1) / (nrow(combined_reasoning_pval_matrix) - 1)
      text(x_pos, y_pos, sprintf("%.3f", combined_reasoning_pval_matrix[i, j]), cex = 0.7)
    }
  }
}

```

P-values Heatmap – Combined Reasoning Variations



Summary of Significant Differences - Combined Reasoning Variations

```
# Count significant differences for combined reasoning variations
combined_reasoning_sig_count <- sum(combined_reasoning_results$significant)
cat("Summary of Significant Differences - Combined Reasoning Variations:\n")
```

```
## Summary of Significant Differences - Combined Reasoning Variations:
```

```
cat(paste(rep("=", 50), collapse = ""), "\n")
```

```
## =====
```

```
cat(" Total comparisons:", nrow(combined_reasoning_results), "\n")
```

```

## Total comparisons: 78
cat(" Significant differences:", combined_reasoning_sig_count, "\n")

## Significant differences: 43
cat(" Percentage significant:", round(combined_reasoning_sig_count / nrow(combined_reasoning_results))

## Percentage significant: 55.1 %
# Show which comparisons are significant
cat("Significant Comparisons in Combined Reasoning Variations:\n")

## Significant Comparisons in Combined Reasoning Variations:
combined_reasoning_sig <- combined_reasoning_results[combined_reasoning_results$significant, c("compari
if (nrow(combined_reasoning_sig) > 0) {
  print(kable(combined_reasoning_sig, format = "simple", digits = 4))
} else {
  cat(" None\n")
}

##
##
## comparison diff p_value
## -----
## X-squared Humans vs o3-High -0.0944 0.0000
## X-squared3 Humans vs GPT-5-High -0.1225 0.0000
## X-squared4 Humans vs o3-Pro -0.1191 0.0000
## X-squared7 Humans vs GPT-5-Minimal 0.1398 0.0000
## X-squared9 Humans vs o4-mini-Medium 0.0576 0.0073
## X-squared12 o3-High vs o3-Medium 0.0773 0.0201
## X-squared13 o3-High vs o3-Low 0.1022 0.0020
## X-squared17 o3-High vs GPT-5-Low 0.1360 0.0000
## X-squared18 o3-High vs GPT-5-Minimal 0.2342 0.0000
## X-squared19 o3-High vs o4-mini-High 0.1113 0.0000
## X-squared20 o3-High vs o4-mini-Medium 0.1520 0.0000
## X-squared21 o3-High vs o3-GPT-Image-High 0.0881 0.0001
## X-squared22 o3-High vs o3-GPT-Image-Medium 0.0930 0.0050
## X-squared24 o3-Medium vs GPT-5-High -0.1055 0.0025
## X-squared25 o3-Medium vs o3-Pro -0.1020 0.0018
## X-squared28 o3-Medium vs GPT-5-Minimal 0.1569 0.0002
## X-squared30 o3-Medium vs o4-mini-Medium 0.0747 0.0411
## X-squared33 o3-Low vs GPT-5-High -0.1304 0.0002
## X-squared34 o3-Low vs o3-Pro -0.1269 0.0001
## X-squared37 o3-Low vs GPT-5-Minimal 0.1320 0.0016
## X-squared43 GPT-5-High vs GPT-5-Medium 0.0750 0.0321
## X-squared44 GPT-5-High vs GPT-5-Low 0.1642 0.0000
## X-squared45 GPT-5-High vs GPT-5-Minimal 0.2624 0.0000
## X-squared46 GPT-5-High vs o4-mini-High 0.1395 0.0000
## X-squared47 GPT-5-High vs o4-mini-Medium 0.1802 0.0000
## X-squared48 GPT-5-High vs o3-GPT-Image-High 0.1162 0.0000
## X-squared49 GPT-5-High vs o3-GPT-Image-Medium 0.1212 0.0005
## X-squared50 o3-Pro vs GPT-5-Medium 0.0716 0.0293
## X-squared51 o3-Pro vs GPT-5-Low 0.1607 0.0000
## X-squared52 o3-Pro vs GPT-5-Minimal 0.2589 0.0000
## X-squared53 o3-Pro vs o4-mini-High 0.1360 0.0000

```

## X-squared54	o3-Pro vs o4-mini-Medium	0.1767	0.0000
## X-squared55	o3-Pro vs o3-GPT-Image-High	0.1128	0.0000
## X-squared56	o3-Pro vs o3-GPT-Image-Medium	0.1177	0.0003
## X-squared57	GPT-5-Medium vs GPT-5-Low	0.0892	0.0346
## X-squared58	GPT-5-Medium vs GPT-5-Minimal	0.1873	0.0000
## X-squared60	GPT-5-Medium vs o4-mini-Medium	0.1052	0.0036
## X-squared63	GPT-5-Low vs GPT-5-Minimal	0.0982	0.0197
## X-squared68	GPT-5-Minimal vs o4-mini-High	-0.1229	0.0007
## X-squared69	GPT-5-Minimal vs o4-mini-Medium	-0.0822	0.0238
## X-squared70	GPT-5-Minimal vs o3-GPT-Image-High	-0.1461	0.0000
## X-squared71	GPT-5-Minimal vs o3-GPT-Image-Medium	-0.1412	0.0007
## X-squared75	o4-mini-Medium vs o3-GPT-Image-High	-0.0640	0.0119

Export Results to CSV

```
# Combine all results
all_results <- rbind(finke_results, novel_48_results, collapsed_results,
                    finke_reasoning_results, novel_48_reasoning_results,
                    combined_reasoning_results)

# Export to CSV
write.csv(all_results, "statistical_results/proportion_test_results.csv", row.names = FALSE)
cat("\nResults exported to 'proportion_test_results.csv'\n")
```

```
##
```

```
## Results exported to 'proportion_test_results.csv'
```

```
# Create a more detailed summary for export
```

```
detailed_summary <- all_results %>%
  mutate(
    prop1_percent = paste0(round(prop1 * 100, 1), "%"),
    prop2_percent = paste0(round(prop2 * 100, 1), "%"),
    diff_percent = paste0(round(diff * 100, 1), "%"),
    ci_95 = paste0("[", round(ci_lower, 3), ", ", round(ci_upper, 3), "]"),
    interpretation = case_when(
      p_value < 0.001 ~ "Highly significant (p < 0.001)",
      p_value < 0.01 ~ "Very significant (p < 0.01)",
      p_value < 0.05 ~ "Significant (p < 0.05)",
      p_value < 0.10 ~ "Marginally significant (p < 0.10)",
      TRUE ~ "Not significant"
    )
  ) %>%
  select(task, comparison, prop1_percent, prop2_percent, diff_percent,
        chi_squared, p_value, ci_95, interpretation)
```

```
# Export detailed summary
```

```
write.csv(detailed_summary, "statistical_results/proportion_test_detailed_summary.csv", row.names = FALSE)
cat("Detailed summary exported to 'proportion_test_detailed_summary.csv'\n")
```

```
## Detailed summary exported to 'proportion_test_detailed_summary.csv'
```