Comparing confidence biases in decision about perception and general knowledge

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Introduction

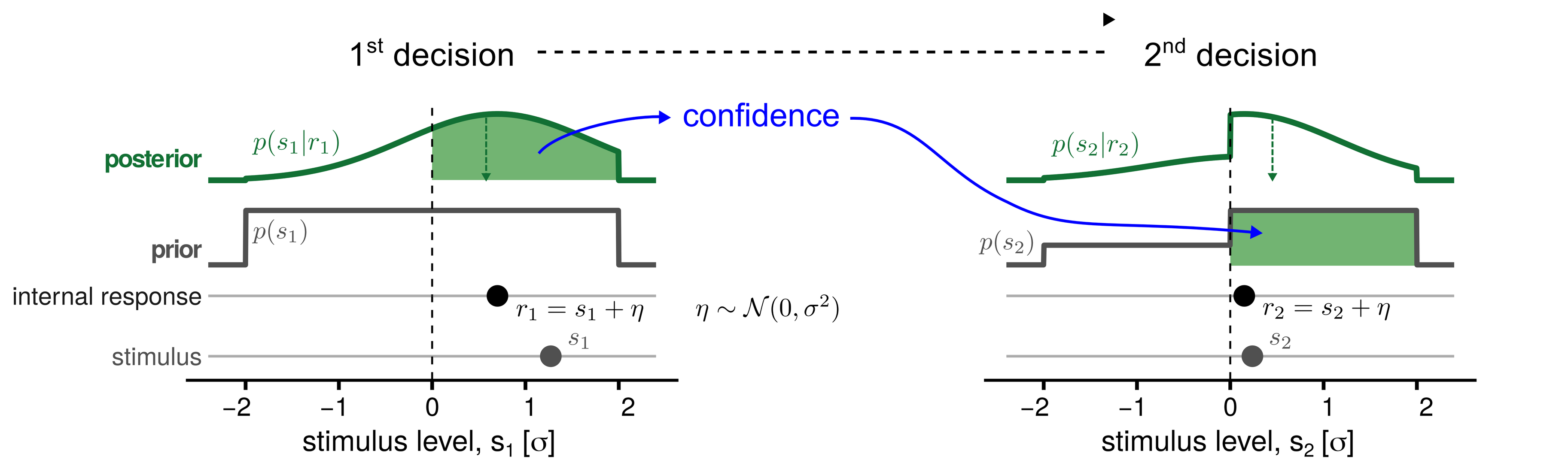
Confidence biases — over/under estimation of uncertainty — are a pervasive source of errors in decision-making.

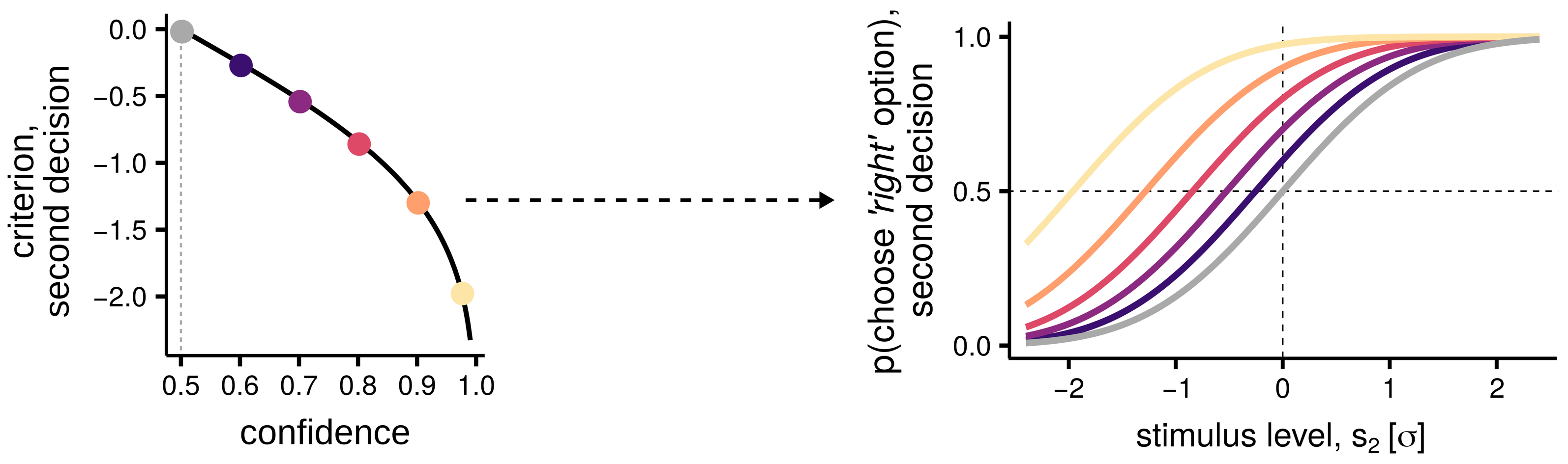
Previous studies suggest correlations in confidence ratings across decision domains, hinting at a *domain-general* mechanism.

However, self-reported confidence may mix genuine confidence biases with response biases.

To address this, we used a *dual-decision* method [1] to explore confidence biases across domains.

Computational modelling

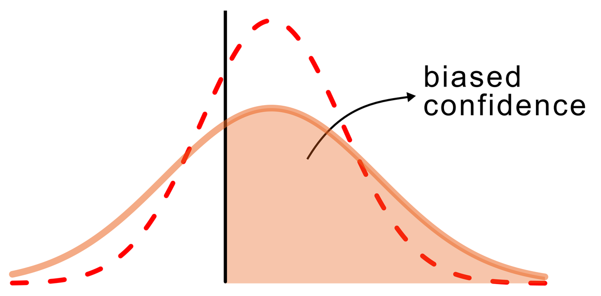




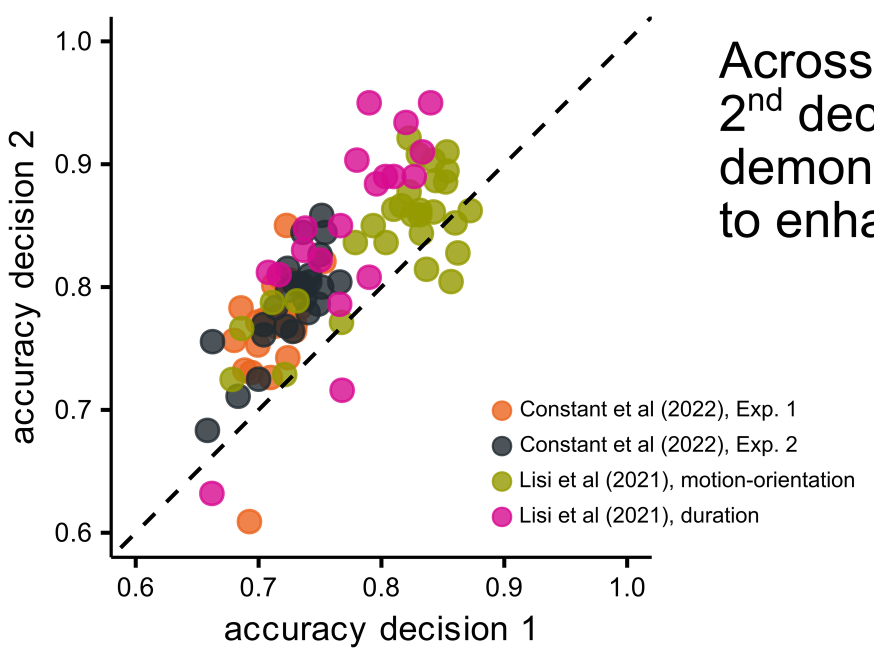
In the 'standard' Bayesian observer model, the only free parameter represents uncertainty, specifically the standard deviation of internal noise (σ).

The Bayesian observer can be modified to incorporate a confidence bias by assuming it uses an inaccurate estimate ($\hat{\sigma}$) of its own internal noise:

$$\text{Confidence bias} = \log \frac{\hat{\sigma}}{\sigma}$$

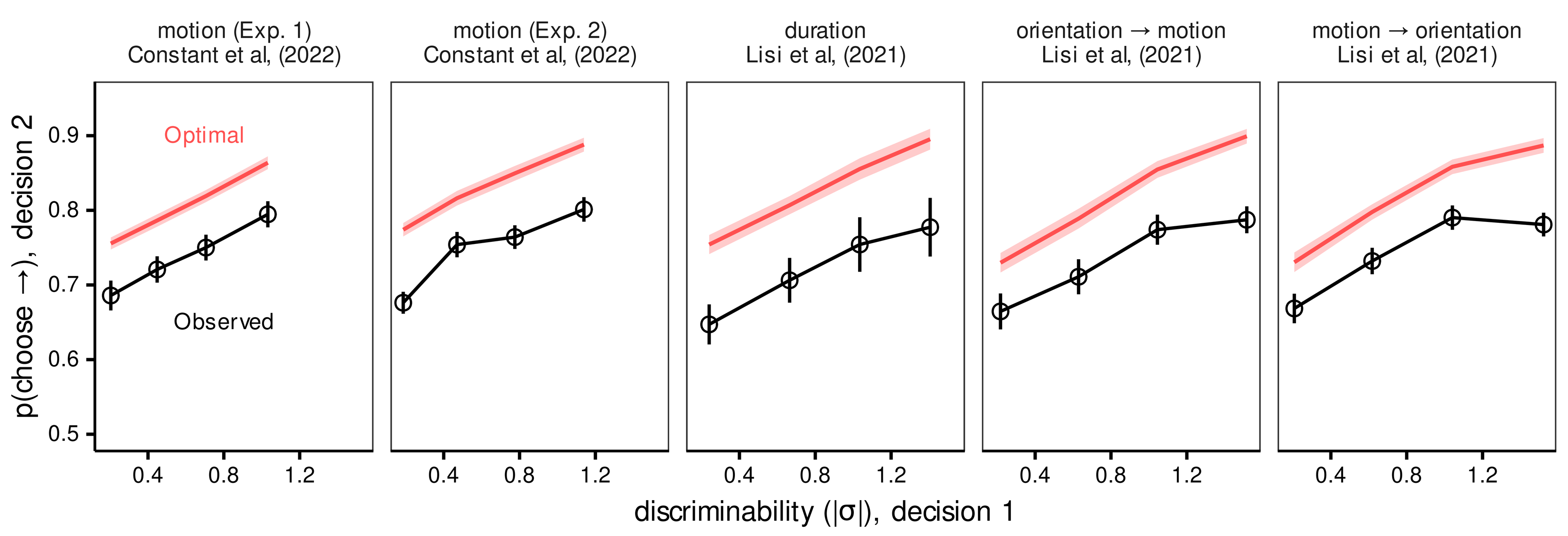


Previous studies — underconfidence in perception

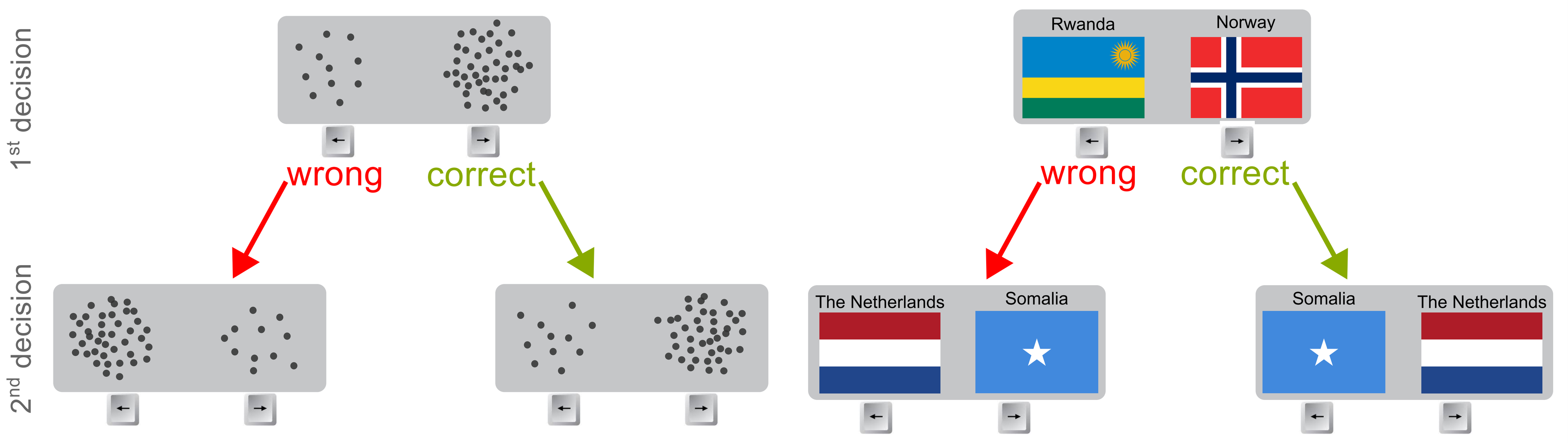


Across 4 experiments from previous studies,[1,2] 2nd decisions are more often correct than 1st, demonstrating effective use of confidence to enhance performance

Participants choose → less frequently than optimal across tasks, suggesting they underestimate the reliability of their perception (indicative of an underconfidence bias)



'Dual-decision' tasks



Two decisions per trial: the correct response in the 2nd decision (← vs →) is determined by accuracy in the 1st decision.

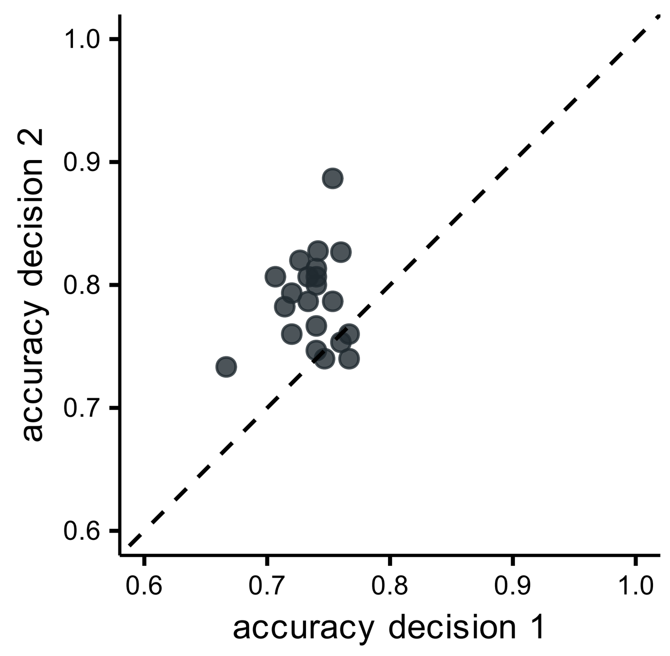
Confidence as a prior: confidence in the 1st decision serves as a prior to guide the 2nd decision.

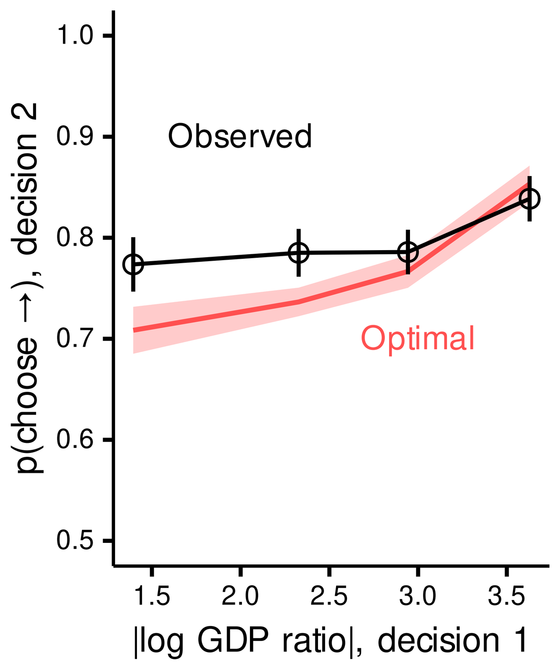
Assessing confidence biases: the frequency of → responses in the 2nd decision, compared to the optimal frequency, reveals participants' confidence biases.

Results

Experiment 1

Participants (N=21) completed 150 trials of the GDP task.





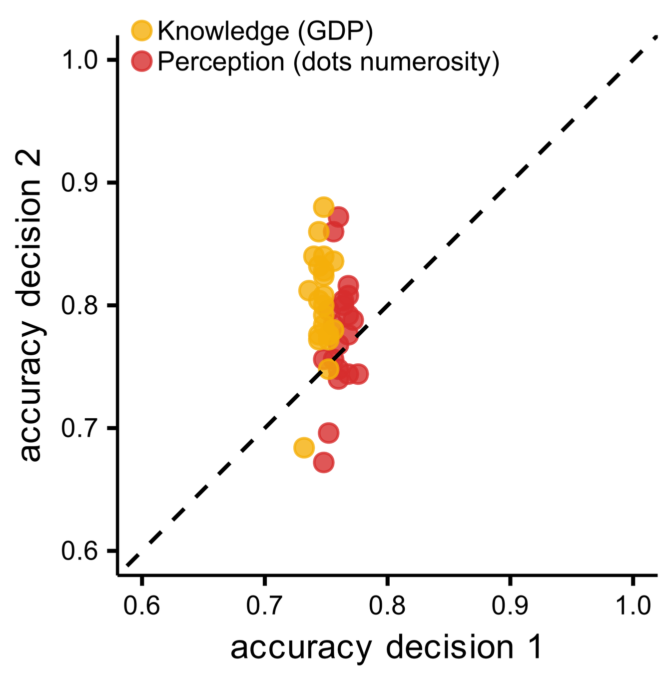
Differently from previous results, in the general knowledge (GDP) task participants responded → as frequently as the optimal Bayesian model.

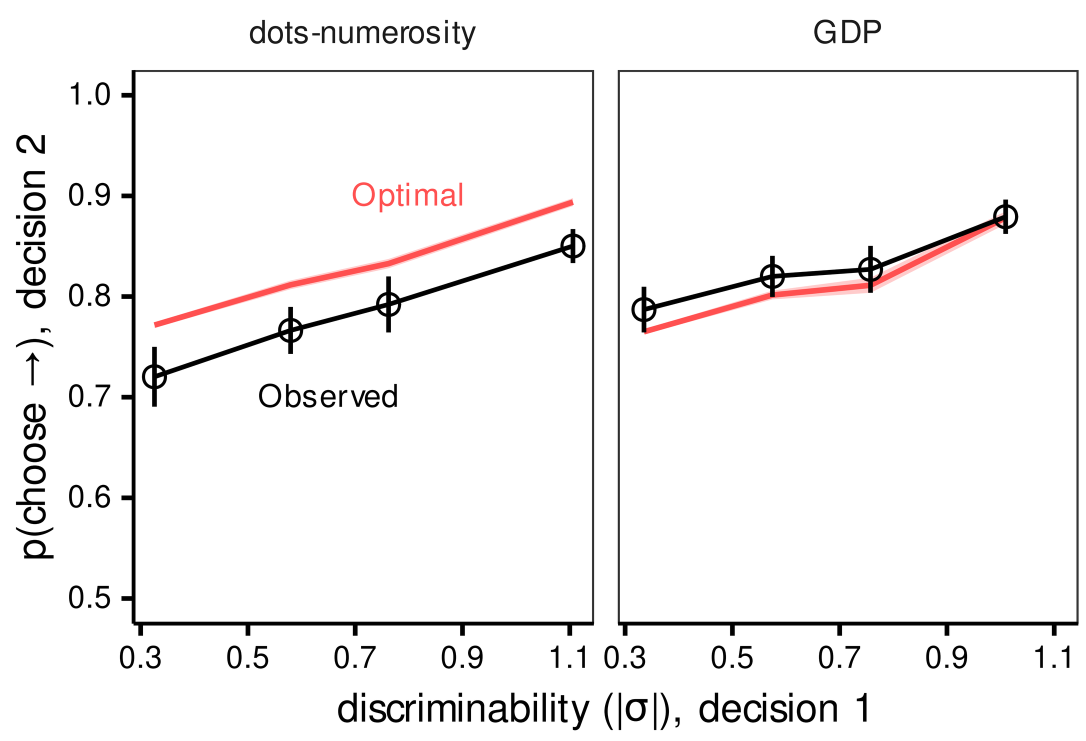
Experiment 2

Within-subject comparison:
Participants (N=23) completed 250 trials each of the GDP and dots numerosity tasks in a randomized order.

Difficulty adjusted with a 3-up-1-down staircase, based on performance in Decision 1.

Accuracy in decision 2 exceeded decision 1 in both tasks, with a larger effect size in knowledge tasks (odds ratios: 1.1 for perception, 1.4 for knowledge).

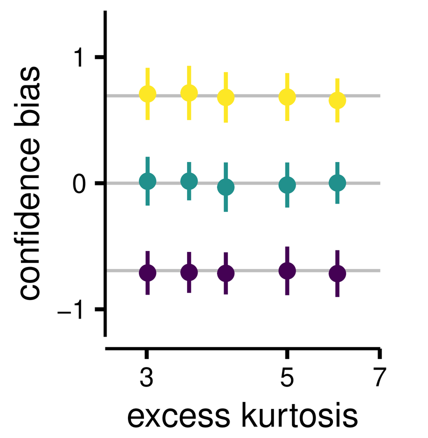




Participants responded → less frequently than the optimal Bayesian model in the perceptual task, suggesting under-confidence, but showed well-calibrated confidence in the knowledge task

Fat-tailed internal noise distribution?

Simulations show that excess kurtosis does not influence the estimated confidence bias.



The optimal strategy — using internal response from decision 1 as criterion shift for decision 2 — holds for any symmetric, unimodal distribution

(scan QR code for a proof).

Data simulated using Pearson Type VII distributions with varying excess kurtosis, refitted with a biased Bayesian model assuming Gaussian noise

Discussion

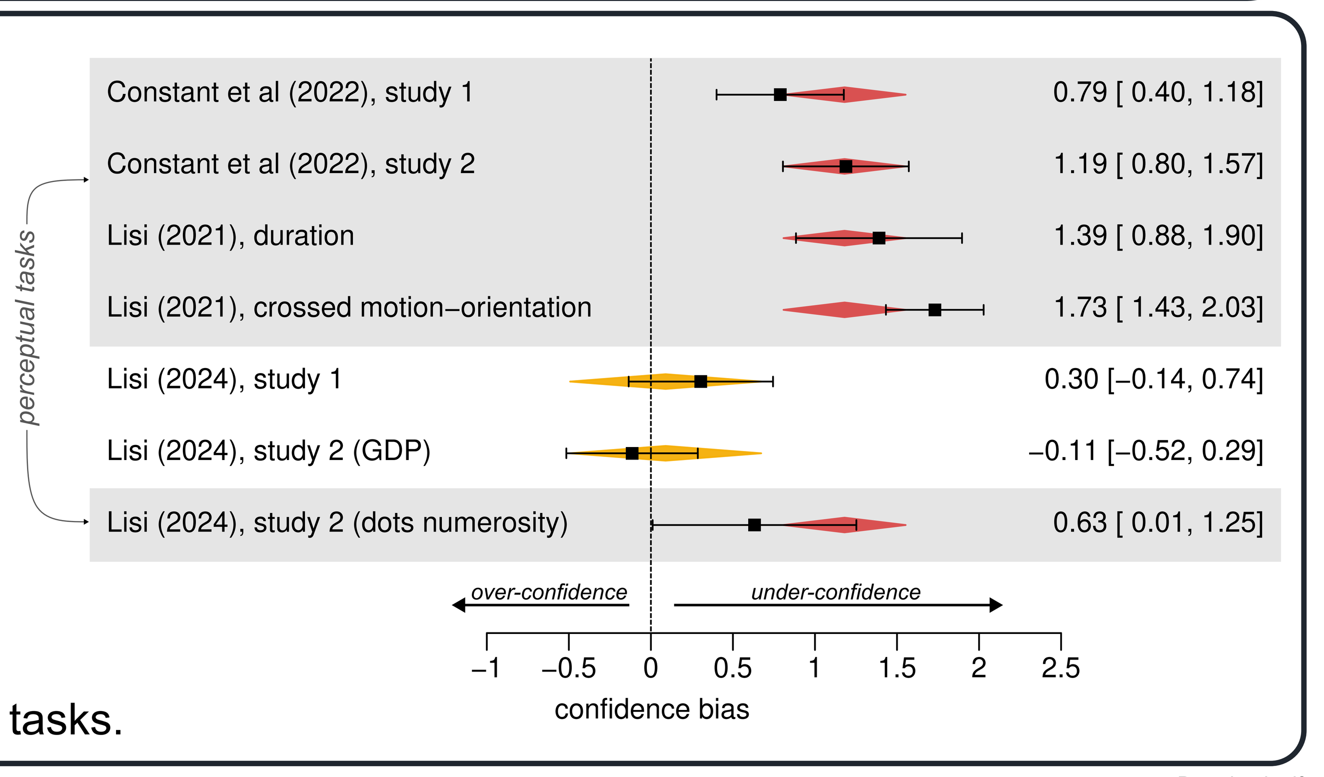
Across all studies, participants effectively used the dual-decision task structure to improve decision 2 performance.

Modeling indicated an under-confidence bias in perceptual tasks, but no bias in the general knowledge task.

Within-participant comparison in Exp. 2 showed a significant difference in confidence bias. A meta-analysis found no bias in the GDP task and a greater bias in perceptual tasks — 95% CI [0.30, 1.59] In units increase.

These results may reflect over-confidence in knowledge tasks [3], combined with a cautious strategy to mitigate errors due to confidence "noise."

A limitation is that only a GDP-based knowledge task was tested, leaving open the question of whether this pattern extends to other knowledge-based tasks.



References
[1] Lisi, M., Mongillo, G., Milne, G. et al. (2021) Discrete confidence levels revealed by sequential decisions. Nat Hum Behav 5, 273–280.
[2] Constant, M., Pereira, M., Faivre, N. et al. (2022) Prior information differentially affects discrimination decisions and subjective confidence reports. Nat Commun 14, 5473
[3] Fischhoff, B., Slovic, P., & Lichtenstein, S. (1977). Knowing with certainty: The appropriateness of extreme confidence. J Exp Psychol Hum Percept Perform, 3(4), 552–564.

Acknowledgments
*Big thanks to **Lottie Wood** and **Marc Pabst** from UCL Child Vision Lab for useful feedback and assisting with data collection.*
The study was funded by Research Initiative Funds (RIF) from Royal Holloway, University of London

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