

A Comprehensive Comparison of Signal Detection Theory-based Models of Perceptual Confidence and Metacognition

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Background

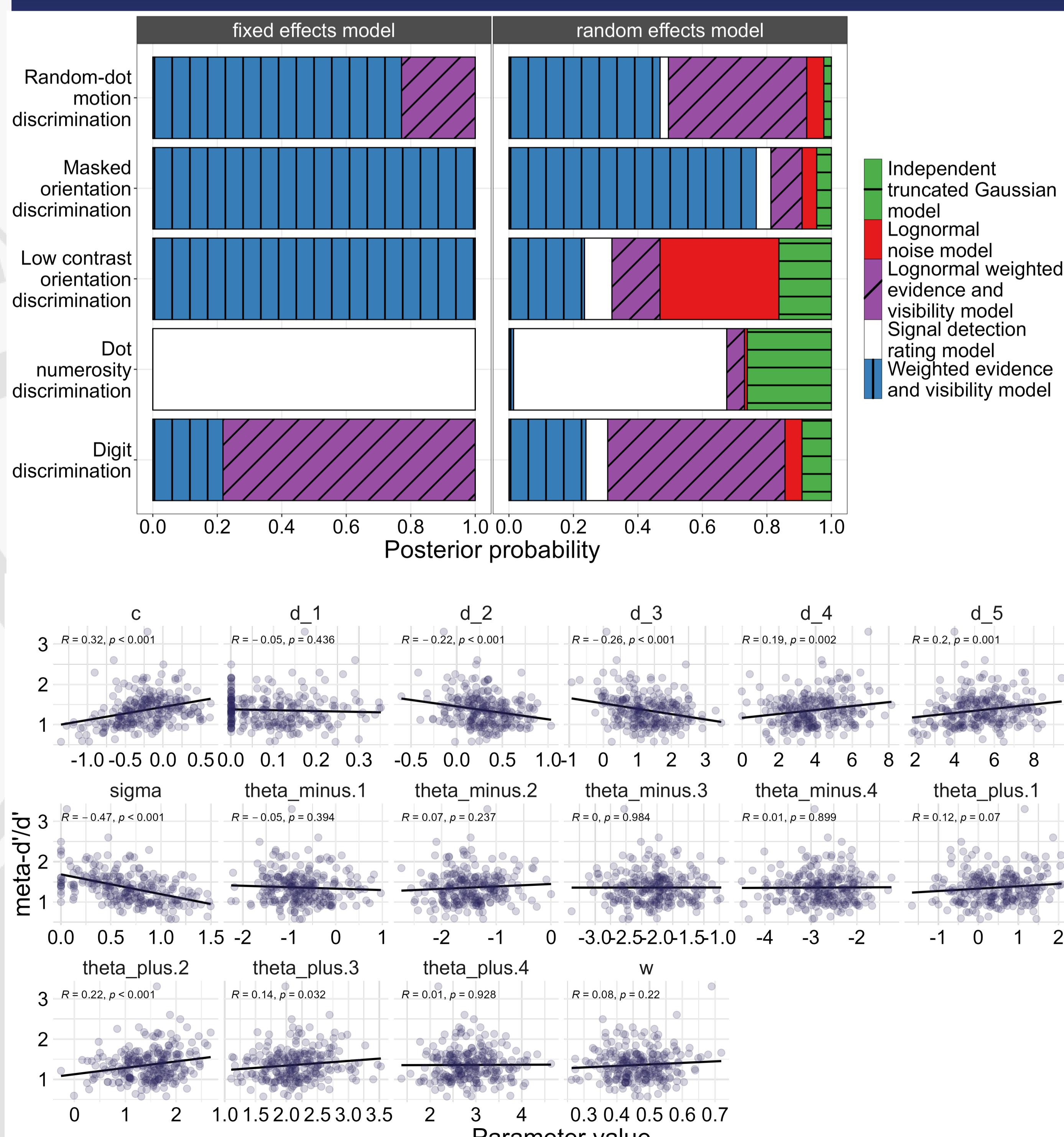
- Metacognition researchers quantify metacognitive ability with meta-d'/d' (Maniscalco & Lau, 2012, *Consc Cog*) and Hmetad (Fleming, 2017, *Neurosci Consc*), which rely implicitly on the independent truncated Gaussian model (Rausch et al., 2023, *Psychol Methods*).
- Do alternative signal detection theory-based models of perceptual confidence provide a better account of the data?
- Is meta-d'/d' biased if an alternative model is the generative model of the data?

Model

Conceptual idea how confidence is generated

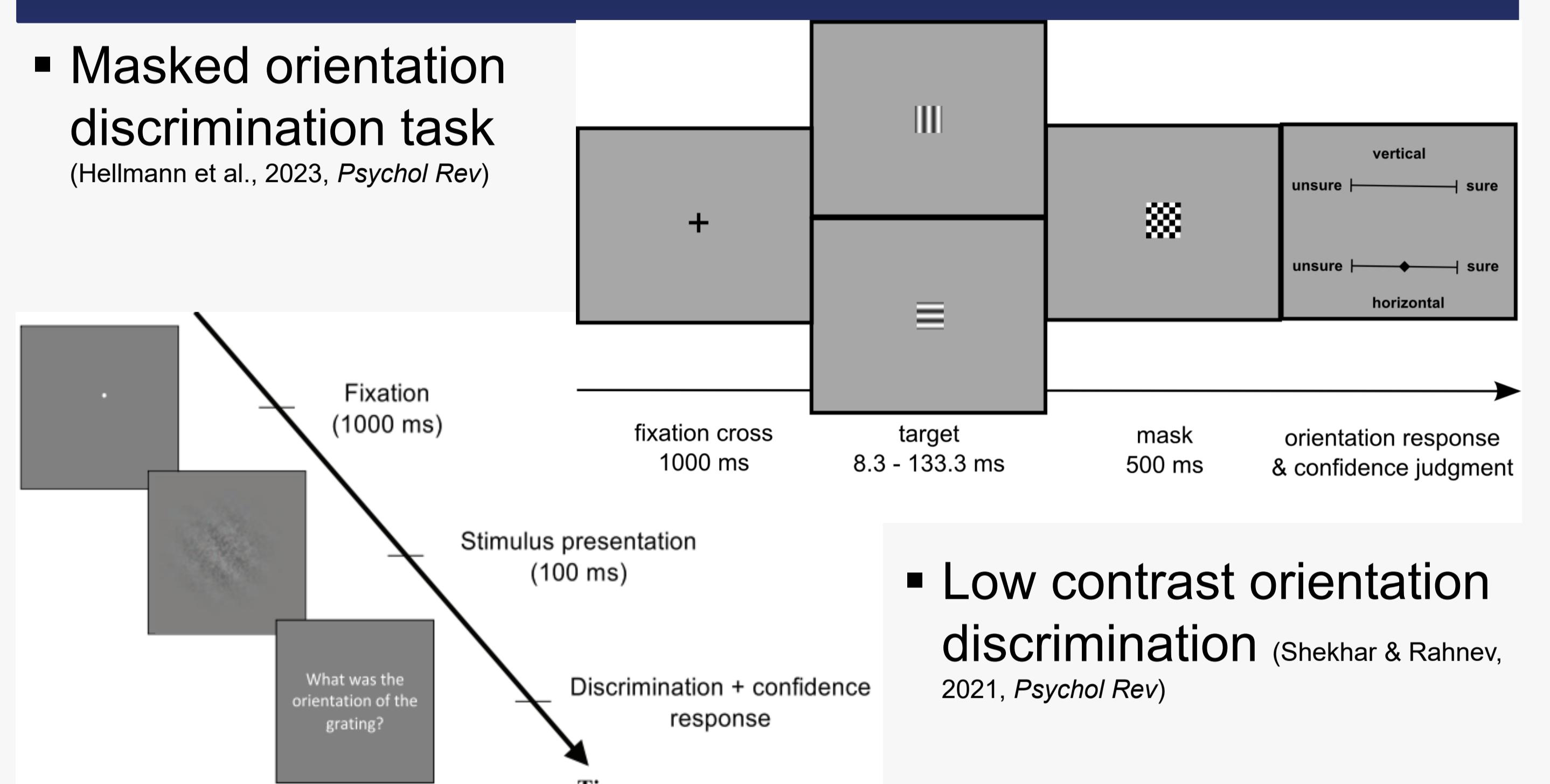
Signal detection rating model (Green & Swets, 1966; Egan et al., 1959, <i>J Acoust. Soc Am</i>)	<ul style="list-style-type: none"> The same evidence is used for making the decision and for making the confidence judgments
Independent truncated Gaussian model (Rausch et al., 2023, <i>Psychol Methods</i>)	<ul style="list-style-type: none"> Evidence used for confidence is sampled independently from decision evidence, from truncated gaussian distributions
Weighted evidence and visibility model (Rausch et al., 2018, <i>Attent Percept Psychophys</i>)	<ul style="list-style-type: none"> Decision evidence Trial-to-trial estimate of the reliability of the percept Independent Gaussian noise on confidence ratings
Lognormal noise model (Shekhar & Rahnev, 2021, <i>Psychol Rev</i>)	<ul style="list-style-type: none"> Decision evidence Lognormally distributed noise on confidence criteria
Lognormal weighted evidence and visibility model (Shekhar & Rahnev, 2024, <i>JEP:Gen</i>)	<ul style="list-style-type: none"> Same as weighted evidence and visibility model, but with lognormal noise on confidence ratings

Results

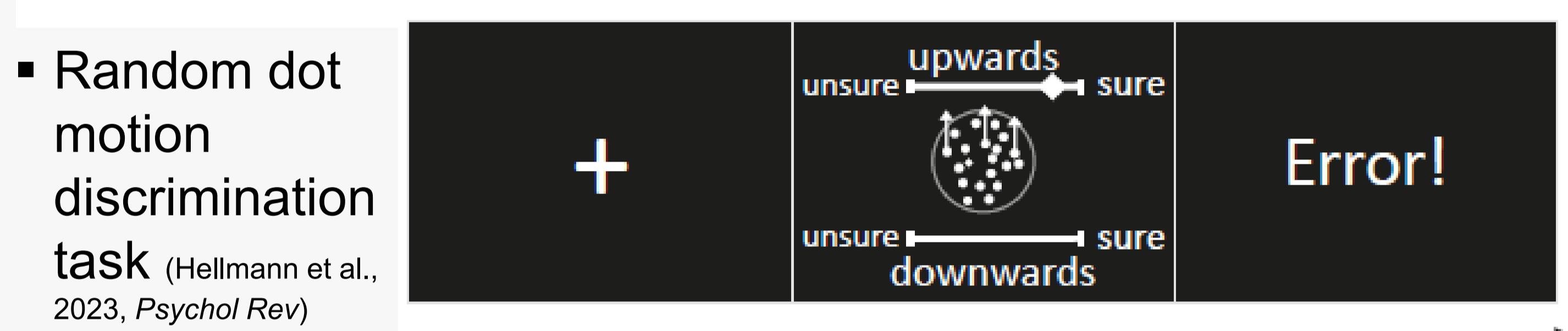


Reanalyzed experiments

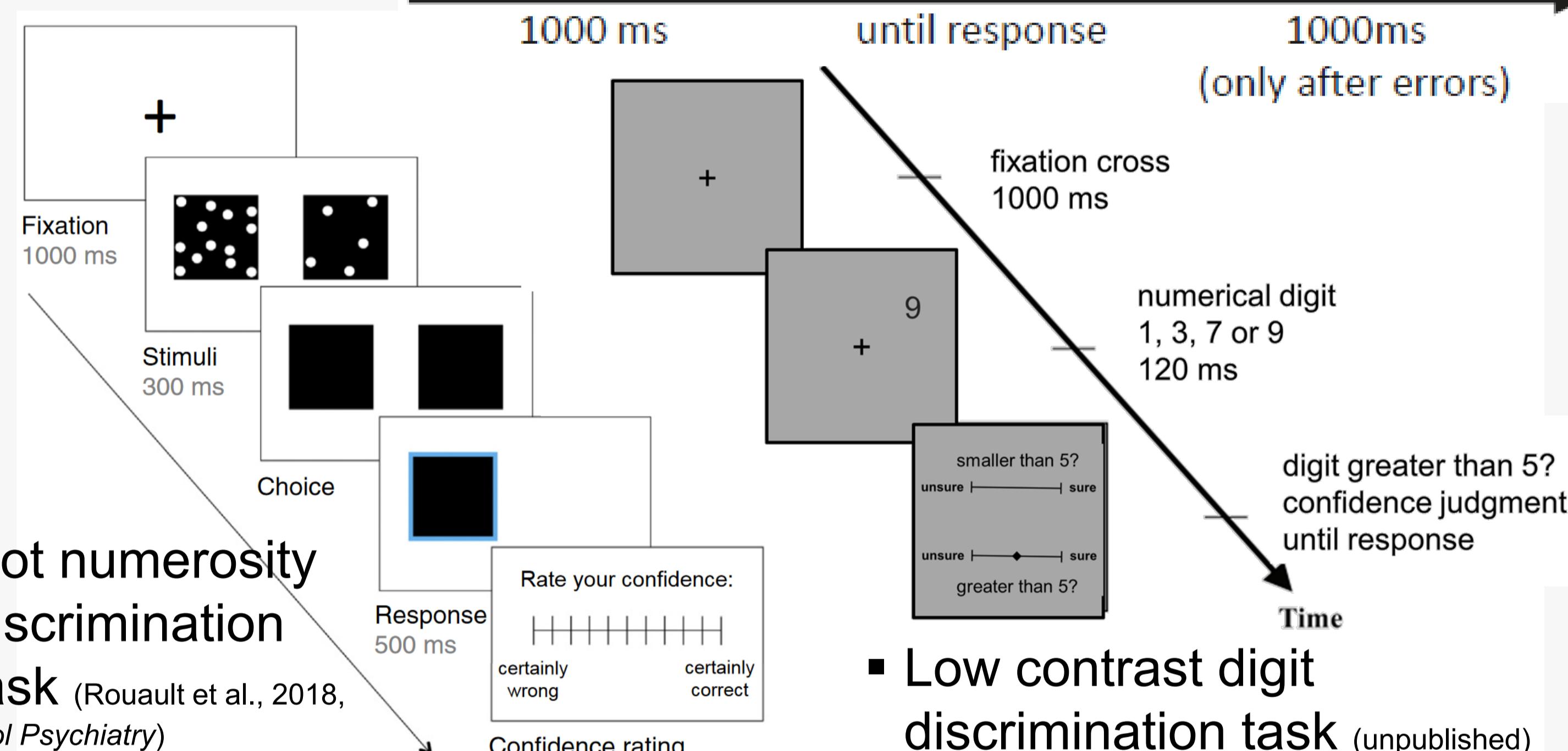
- Masked orientation discrimination task (Hellmann et al., 2023, *Psychol Rev*)



- Low contrast orientation discrimination (Shekhar & Rahnev, 2021, *Psychol Rev*)



- Random dot motion discrimination task (Hellmann et al., 2023, *Psychol Rev*)



- Dot numerosity discrimination task (Rouault et al., 2018, *Biol Psychiatry*)

Time

Discussion

- Weighted evidence and visibility model, lognormal weighted evidence and visibility model → best static accounts for the statistical properties underlying confidence judgments in 4 out of 5 tasks
- Implication: Confidence = Decision evidence + parallel evidence about reliability of the percept + noise (Gaussian or lognormal?)
- Meta-d'/d' : Although standard approach to measure metacognition not necessarily a decent account of the statistical properties of the data.
- Meta-d'/d' used on WEV-data does not control for sensitivity, decision bias
- Dataset exist where the signal detection rating model wins: not always evidence for varying metacognitive ability
- Metacognition researchers need to start checking the assumptions underlying their data before using meta-d'/d' , e.g. statConfR package for R (Rausch et al., 2025, *JOSS*)