UC San Diego

computational cognition lab

Mapping Visual Features Onto Numbers

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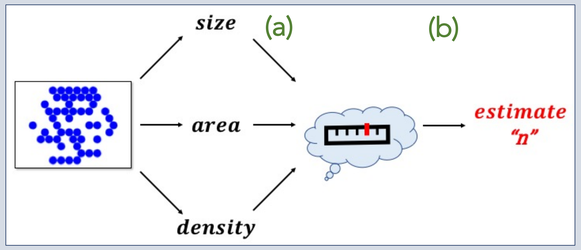
Question

What gets calibrated in number estimation?[1,2]

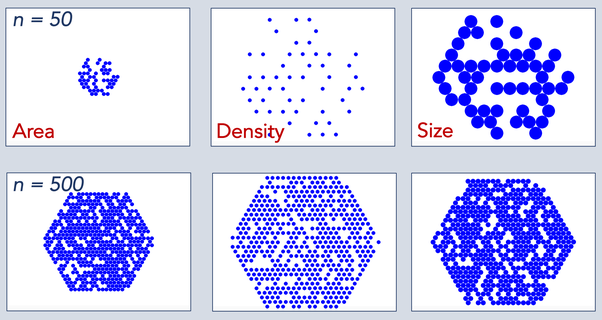
(a) visual cues to magnitude

(b) magnitude to verbal estimates



Methods

- Estimate number of dots
- Trials vary in *size*, *area*, or *density*



57 participants

1000 trials / participant

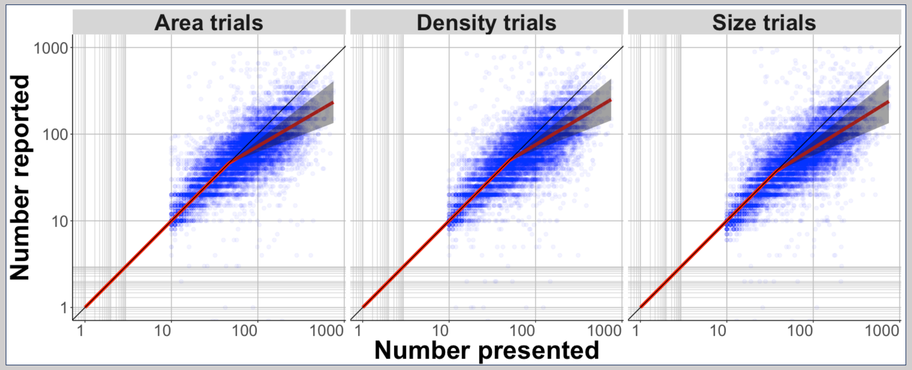
Are people's estimate calibrations stable across visual features?

References

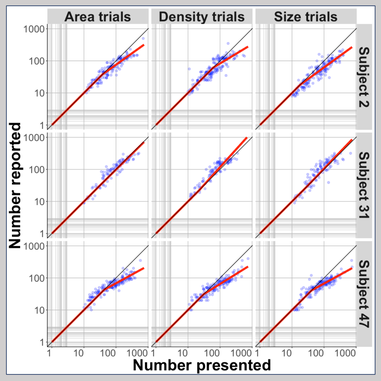
1. Izard & Dehaene, 2008
2. Leibovich, Katzin, Harel & Henik, 2017
3. Vul, Barner & Sullivan, 2013

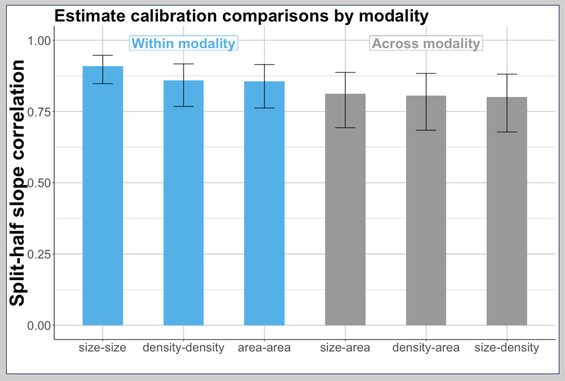
Results

Underestimation is consistent across modalities.

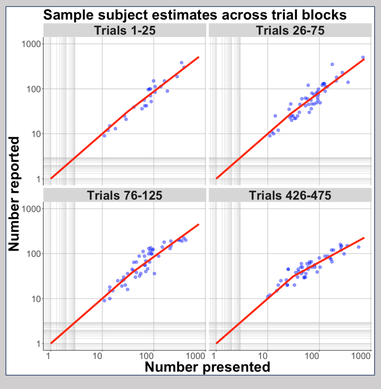


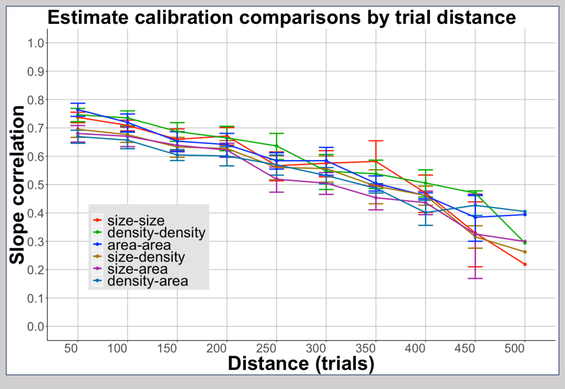
Individual variability is consistent across, within modalities.



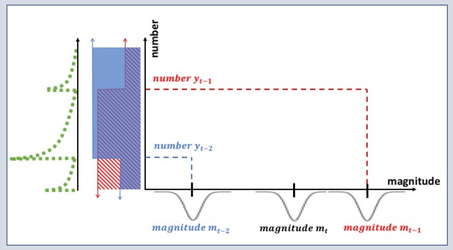


Calibration drift[3] is consistent across, within modalities.





Sample-Based Estimation Model

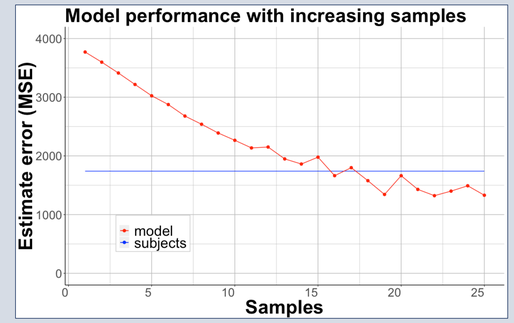


Model calculates most likely estimate for a given magnitude via ordinal comparison to sampled magnitudes from previous estimates.

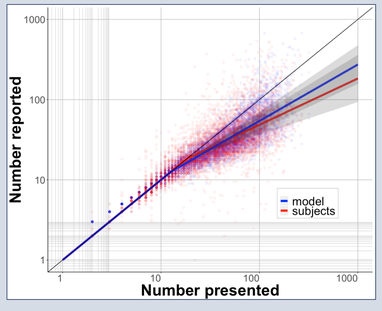
$$p(y \mid m, \boldsymbol{\mu}, \boldsymbol{\gamma}) \propto p(m \mid y, \boldsymbol{\mu}, \boldsymbol{\gamma})\, p(y)$$

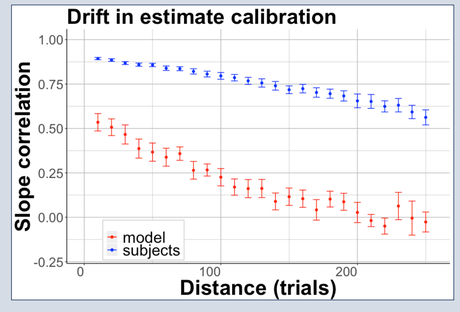
for estimate y, on magnitude m, and sampled magnitude, estimate pairs $\boldsymbol{\mu}$, $\boldsymbol{\gamma}$.

Model achieves human-level mean squared error with 15-20 samples of previous estimates.



Model produces characteristic underestimation and drift.





Conclusions

- Estimate calibration is mostly a feature of mapping from internal magnitude representations to verbal number.
- Modeling this process by sampling from prior estimates produces accurate and human-looking estimates.