Where's Waldo, Ohio?
Improving Wisdom of the Crowd Aggregates for Spatial Knowledge

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Main Finding

Participants were asked for their best guess of where a particular US city was located and to draw a circle centered at that estimate such that they were confident the circle's area would contain the city's true location. Simple and radius-weighted arithmetic averages of the individuals' point estimates demonstrated a **wisdom of the crowd effect**. Model-based estimates generally outperformed these statistical averages, especially when the models allowed for **individual differences in expertise** that could vary city by city.

Experimental Design

Example Response

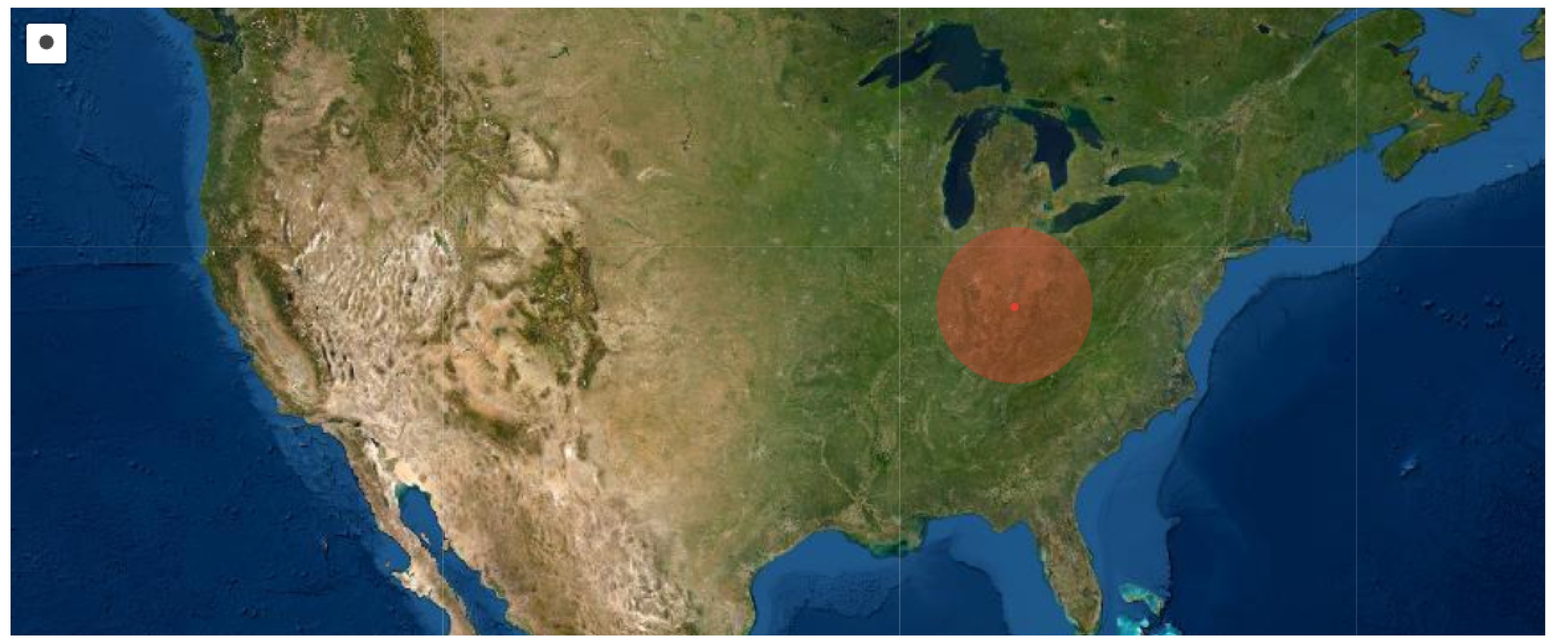

Figure 1: *An example of a participant's response with their point estimate of where the city is located represented as a dark orange dot and their selected radius represented as the larger orange circle surrounding it.*

Participant Responses

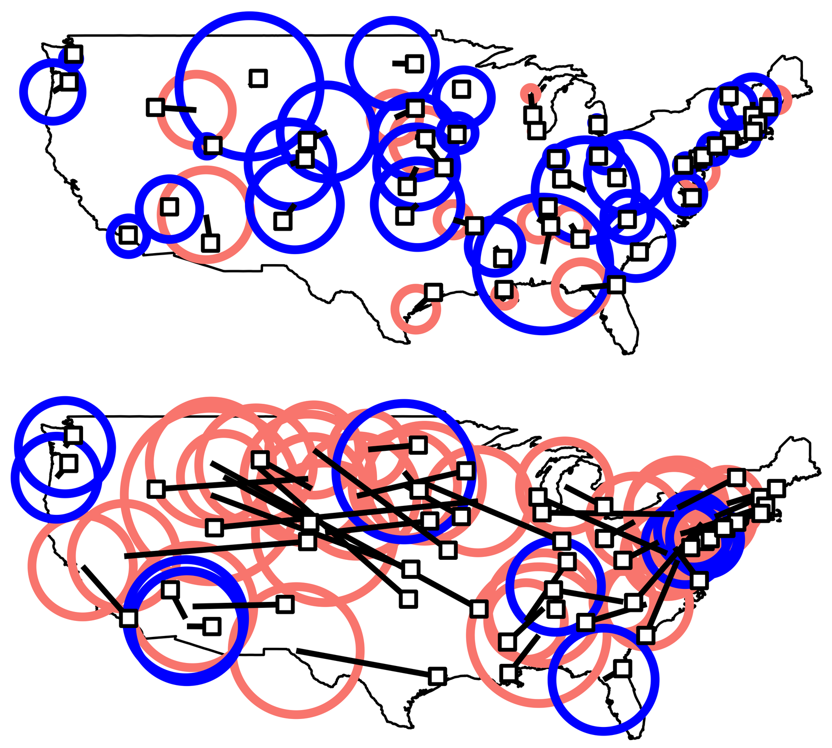

Figure 2: *The true locations of the 48 city locations (as squares) compared with the estimated locations (the centers of the blue and red circles) for a relatively accurate participant (top panel) and for a less accurate participant (bottom panel). Correct responses for which the circles participants drew contained the true location are in blue, while incorrect responses are in red.*

Crowd Performance

Four Selected Cities

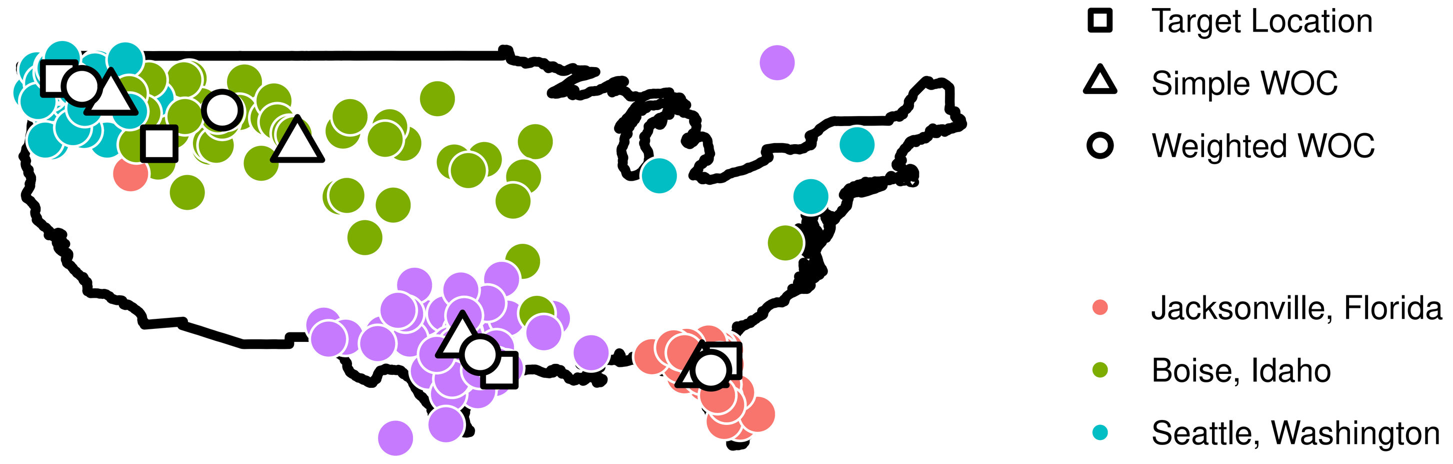

Figure 3: *The 50 participants' estimates for four cities: Jacksonville (coral), Boise (green) Idaho, Seattle (teal), and Washington (lilac). The target city's true location is shown as squares, the simple wisdom of the crowd estimate is shown as a triangle, and the weighted wisdom of the crowd estimate is shown as a circle.*

Cognitive Models for Aggregating Estimates

Model of Point Estimates

$$\boldsymbol{y}_{ij} \sim \text{Multivariate Gaussian}(\boldsymbol{\mu}_j, \boldsymbol{\Sigma}_{ij}) \tag{1}$$

$$\boldsymbol{\Sigma_{ij}} = \begin{bmatrix} \lambda_{j1}^2 + \sigma_i^2 + \beta_{ij}^2 & \rho_j \sqrt{\lambda_{j1}^2 + \sigma_i^2 + \beta_{ij}^2}\sqrt{\lambda_{j2}^2 + \sigma_i^2 + \beta_{ij}^2} \\ \rho_j \sqrt{\lambda_{j1}^2 + \sigma_i^2 + \beta_{ij}^2}\sqrt{\lambda_{j2}^2 + \sigma_i^2 + \beta_{ij}^2} & \lambda_{j2}^2 + \sigma_i^2 + \beta_{ij}^2 \end{bmatrix} \tag{2}$$

Model of Radius Information

$$y_{ij}^r \sim \text{Gaussian}\left(\alpha_i \sqrt{\max(\boldsymbol{\lambda}_j)^2 + \sigma_i^2 + \beta_{ij}^2}, 1/\tau^2\right) \tag{3}$$

Key Parameters

City Location	$\boldsymbol{\mu_j}$
Individual Expertise	σ_i
Individual-by-City Expertise	β_{ij}
City Difficulty	$\lambda_{j1}, \lambda_{j2}$
Individual Uncertainty	α_i

References

Mayer, M., & Heck, D. W. (2023). Cultural consensus theory for two-dimensional location judgments. *Journal of Mathematical Psychology*, *113*, 102742. doi: 10.1016/j.jmp.2022.102742

See the project OSF at `osf.io/ve8t9/` or QR code above

Results

US Cities Data Set

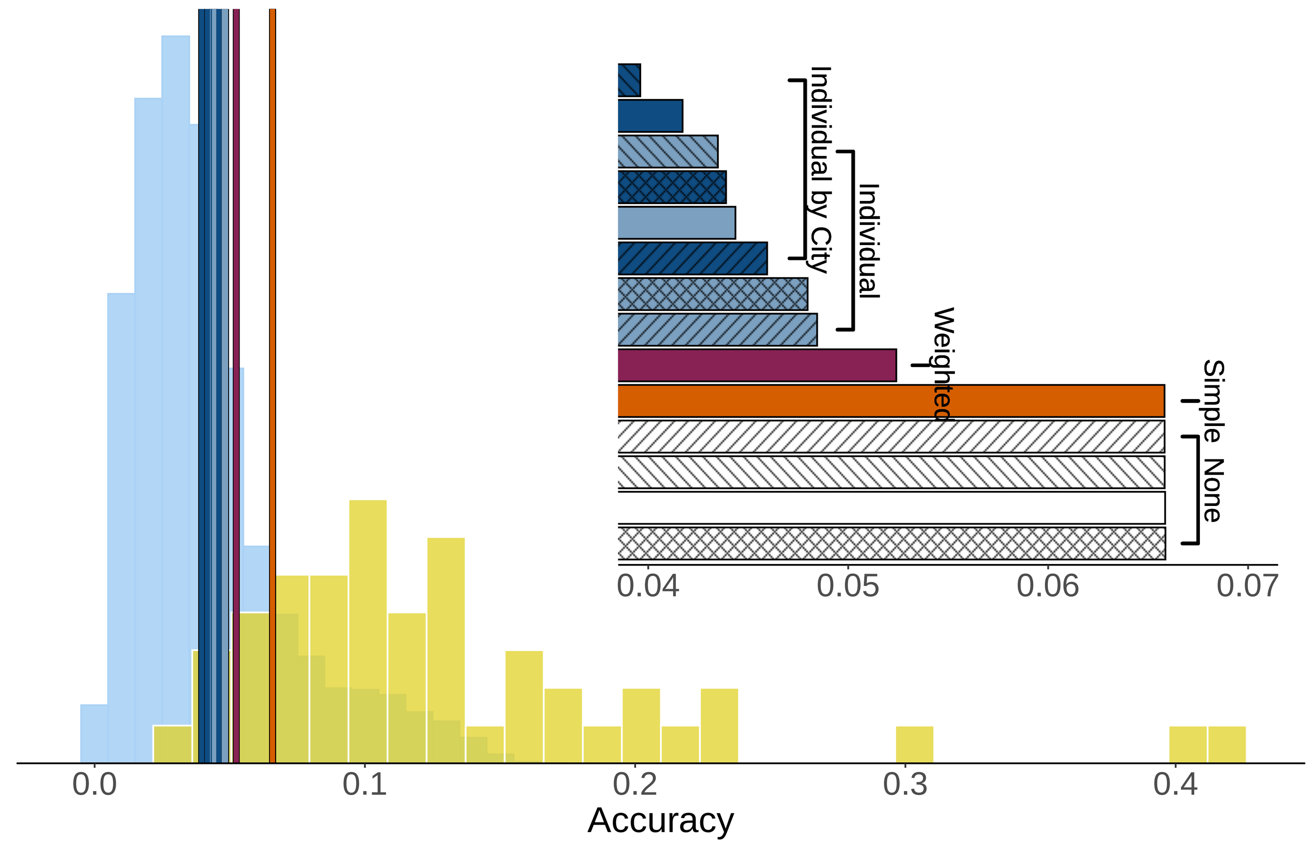

Figure 4: *The main panel shows the distribution of individual accuracy in yellow and the accuracy of statistical and model-based estimates by vertical lines. The posterior distribution of accuracy for the best-performing model is shown in blue. The horizontal bars in the inset panel provide a magnified view of the performance of model-based and statistical estimates.*

Mayer & Heck Data Set

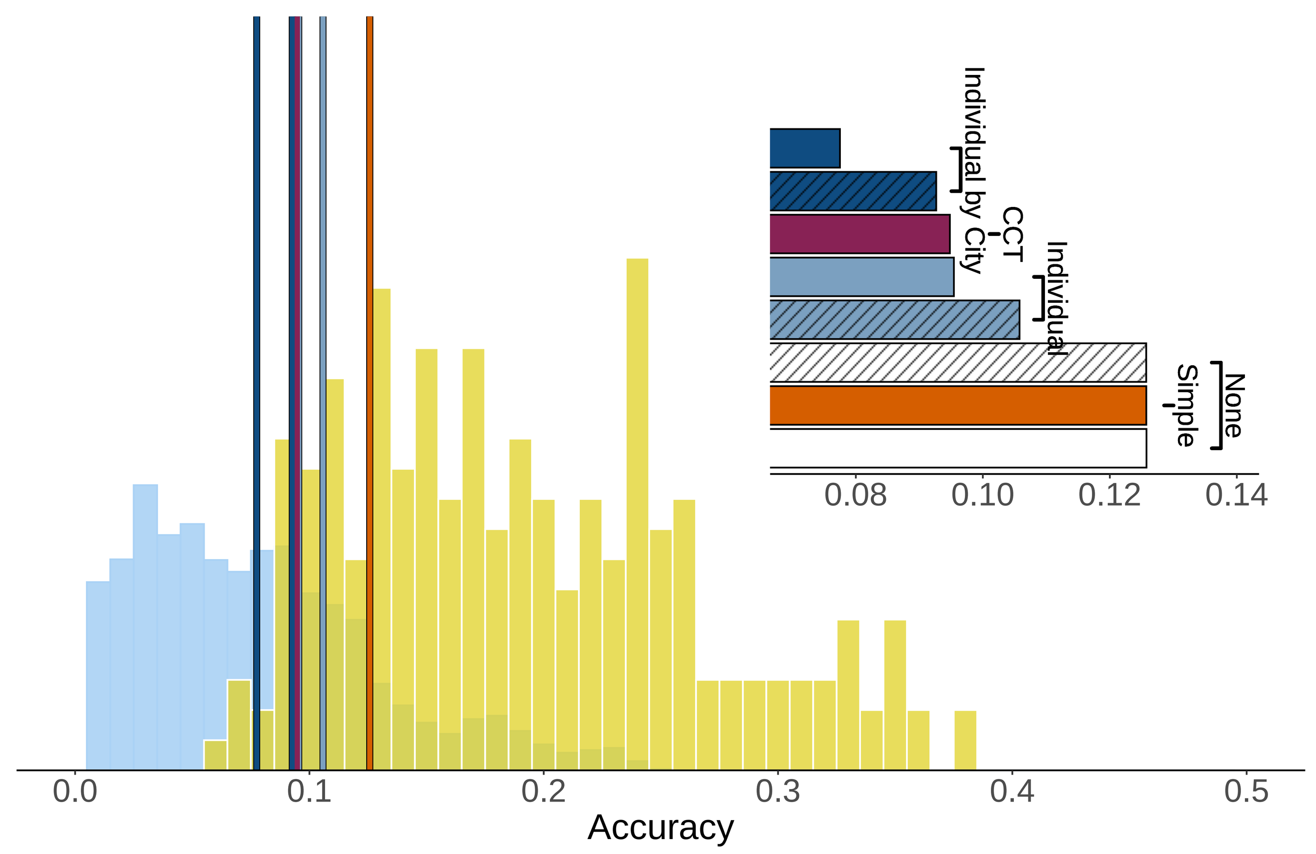

Figure 5: *Same structure as Figure 4*

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