How to Measure Legislative District Compactness If You Only Know it When You See it[1]

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[1] Based on joint work with Aaron Kaufman and Mayya Komisarchik

[2] GaryKing.org

Redistricting Defines Democracy — & Needs Fixing

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The Political Science Discipline & Redistricting

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    - Required in many other jurisdictions

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A simple single compactness dimension that you know when you see

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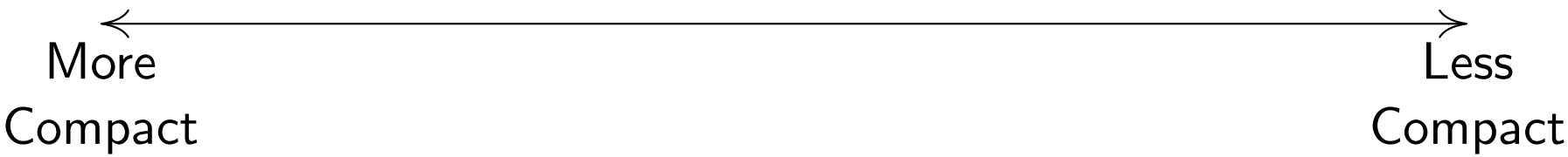

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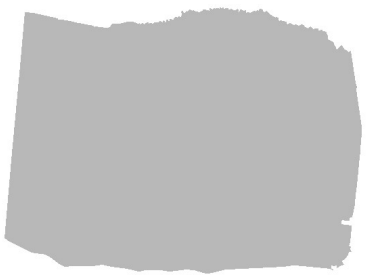

More Compact ⟵ ⟶ Less Compact

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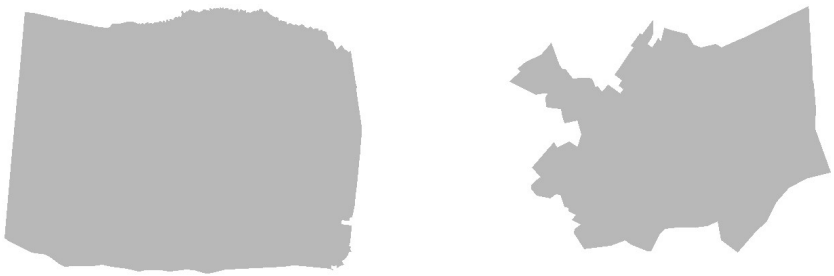

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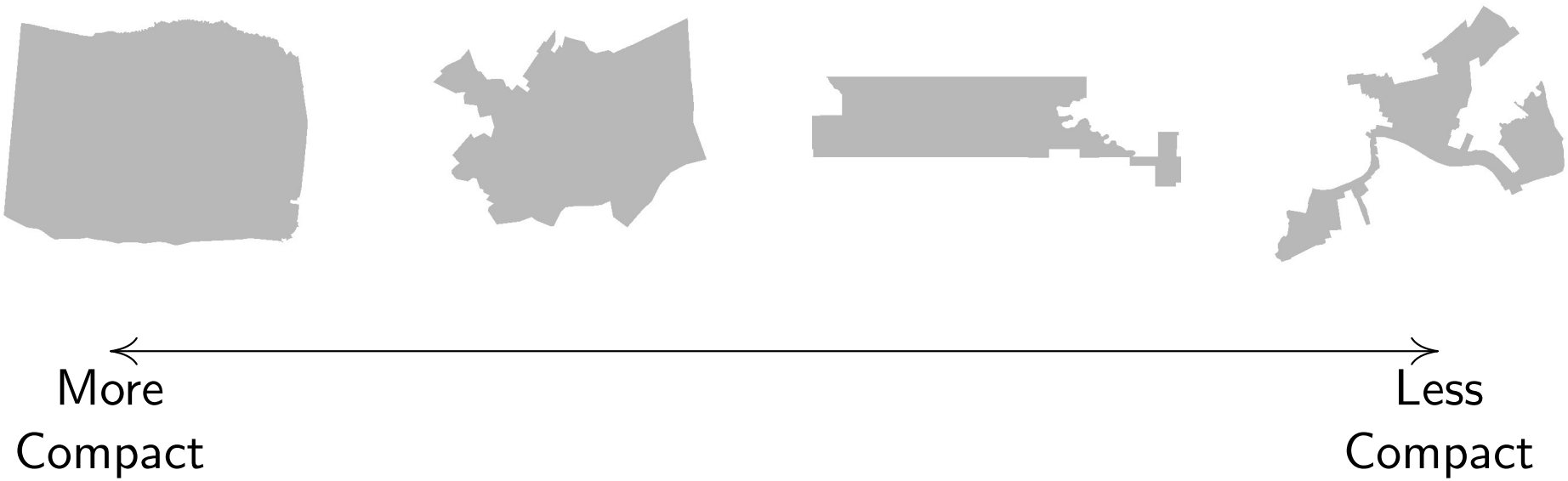

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- $\rightsquigarrow$ Let's start with existing measures by social scientists

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Squarish districts more compact than long thin ones

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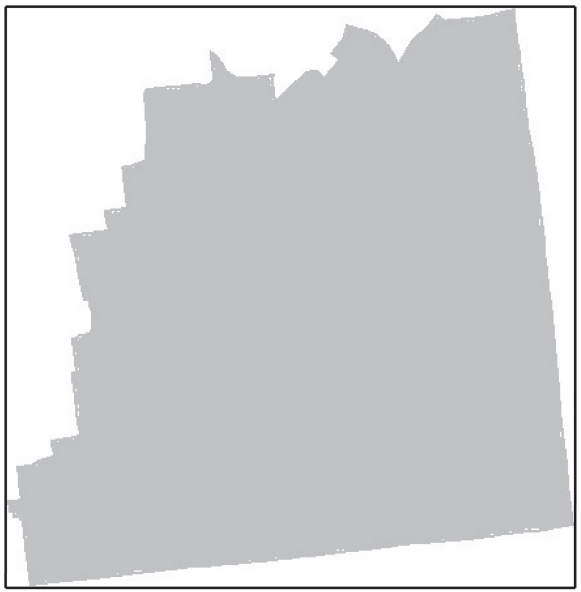

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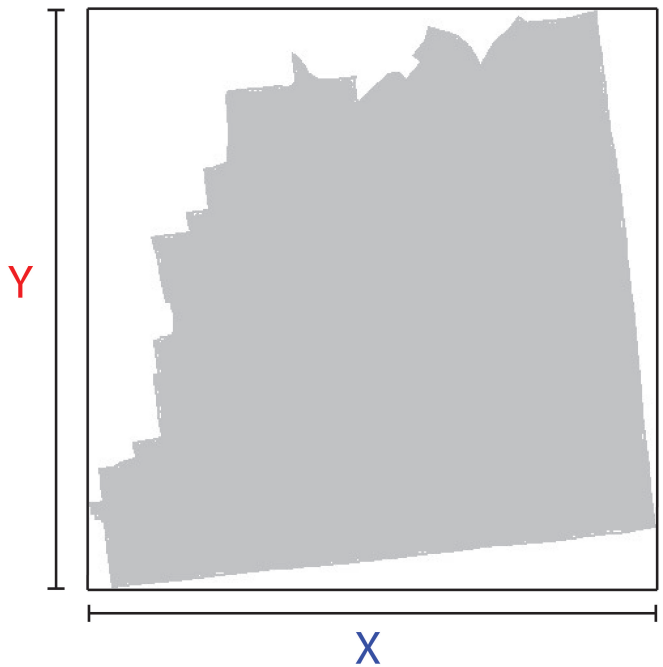

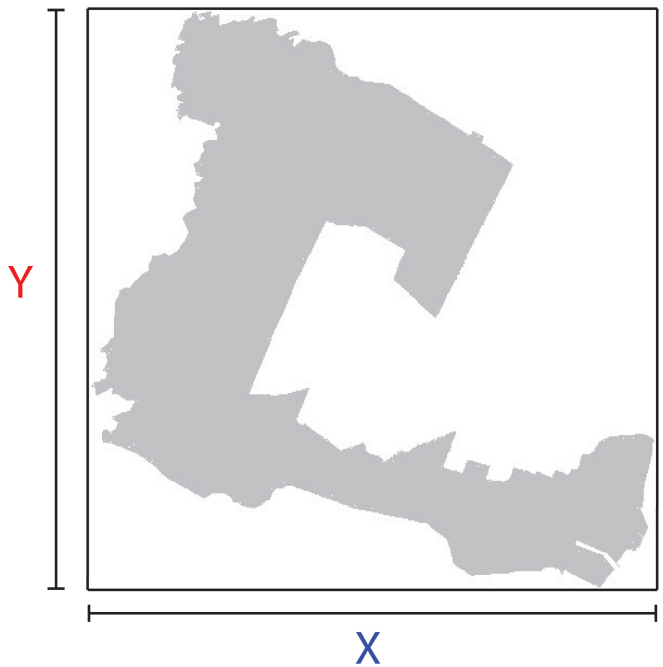

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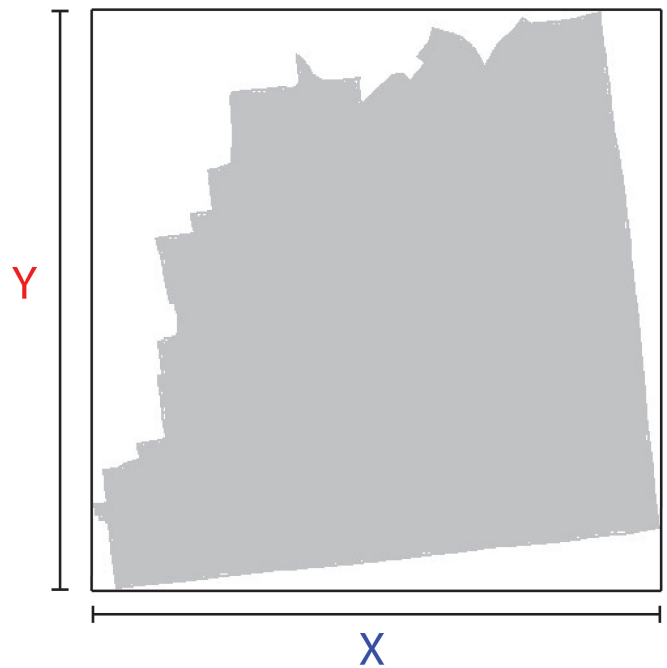

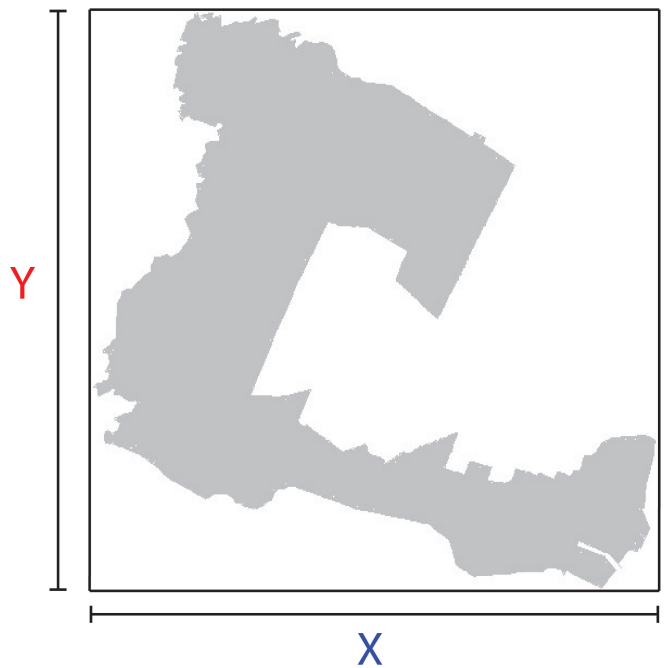

In both districts: $X/Y \approx 1.30$

Measure 2: Reock, District / Bounding Circle Areas

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Circular districts are most compact

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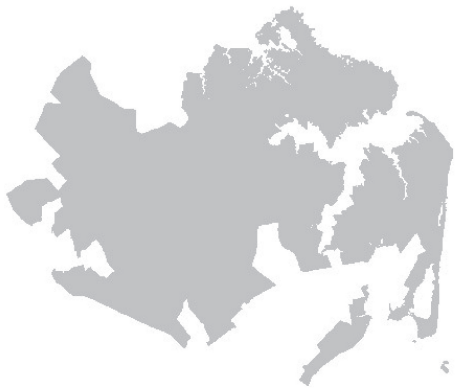

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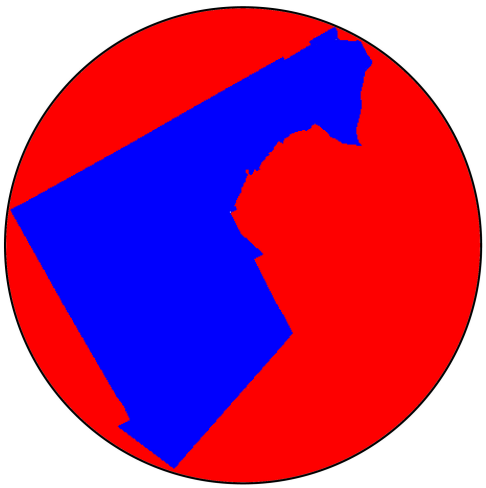

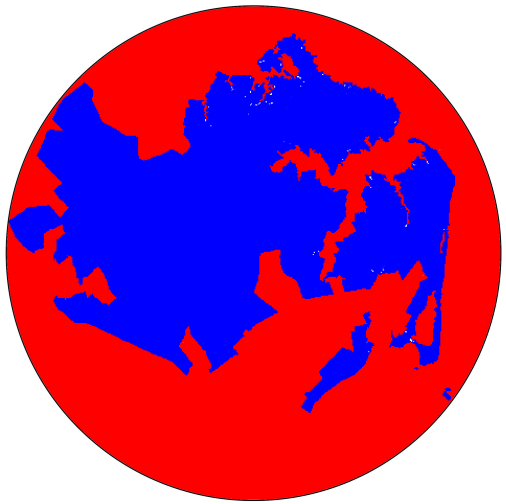

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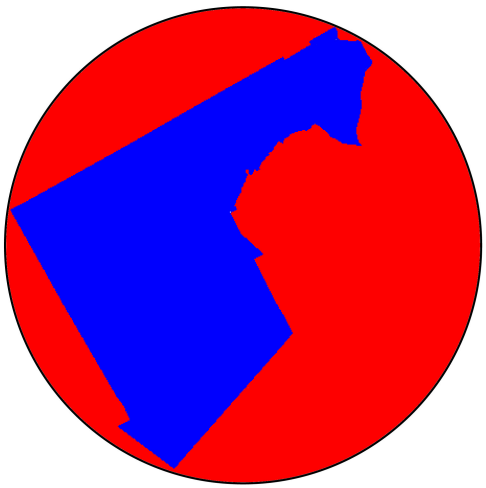

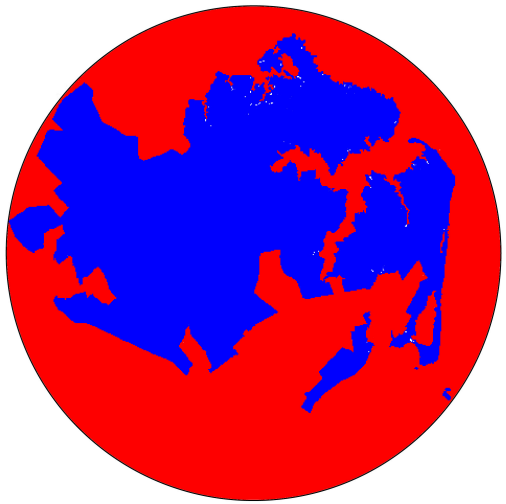

In both cases, $X/(Y + X) \approx 0.37$

Measure 3: Boyce-Clark, Variation in Centroid Deviations

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All travel distances from center should be similar

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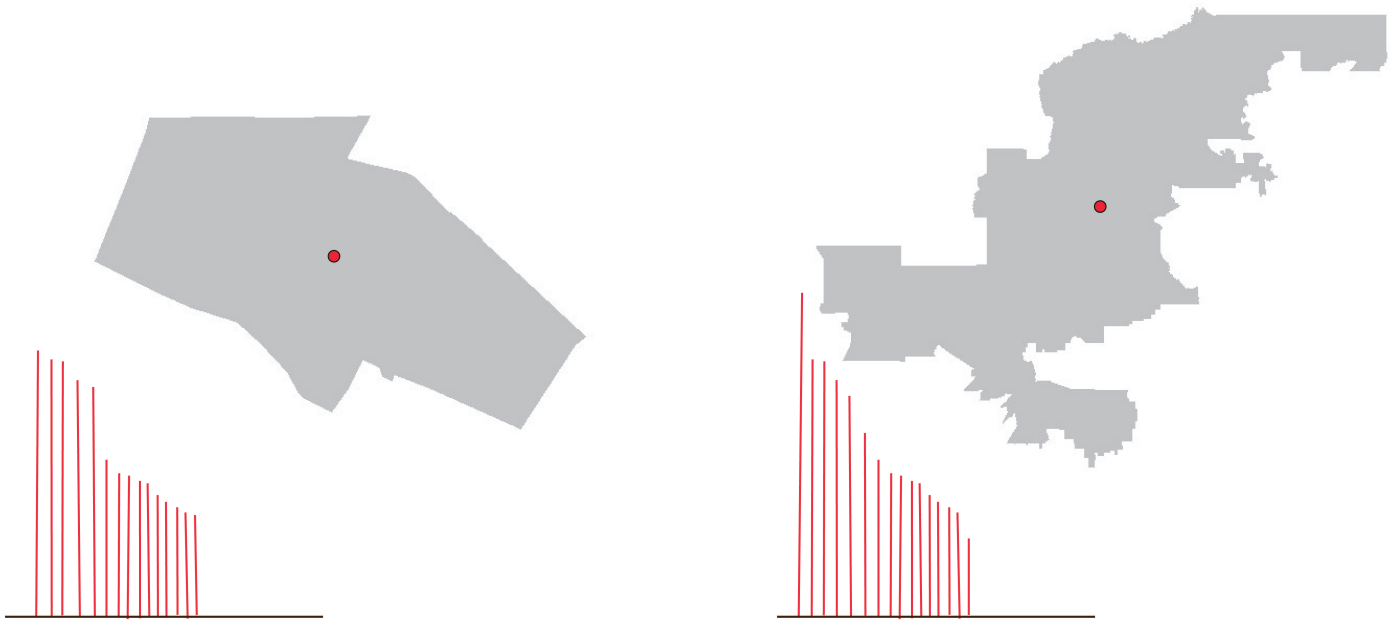

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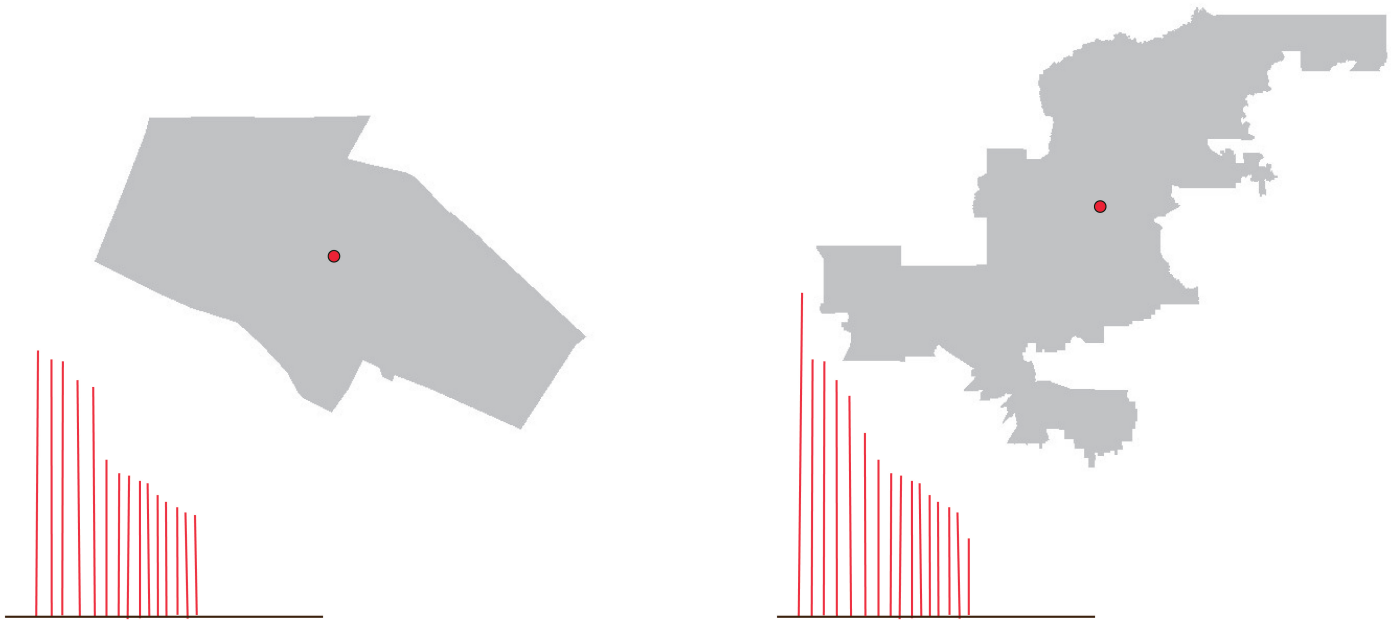

In both cases, $\text{MAD}(r)/\bar{r} \approx 0.31$

A Brief Rotational Invariance Interlude:

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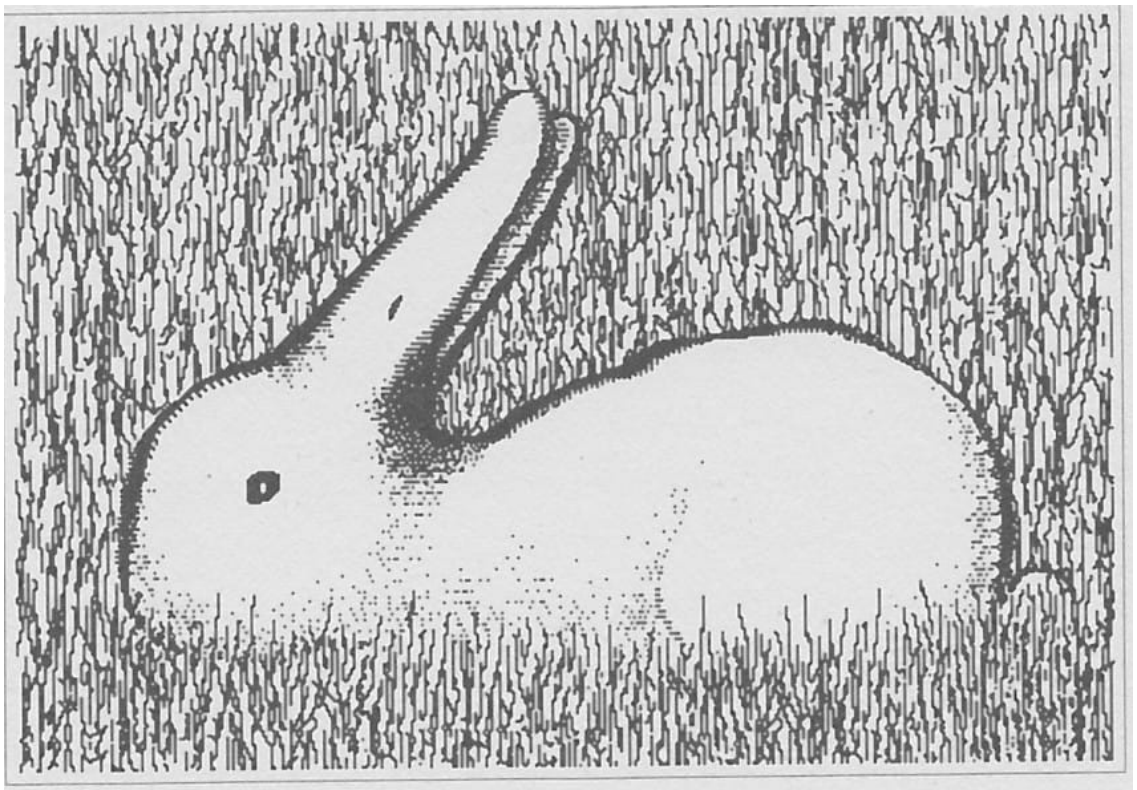
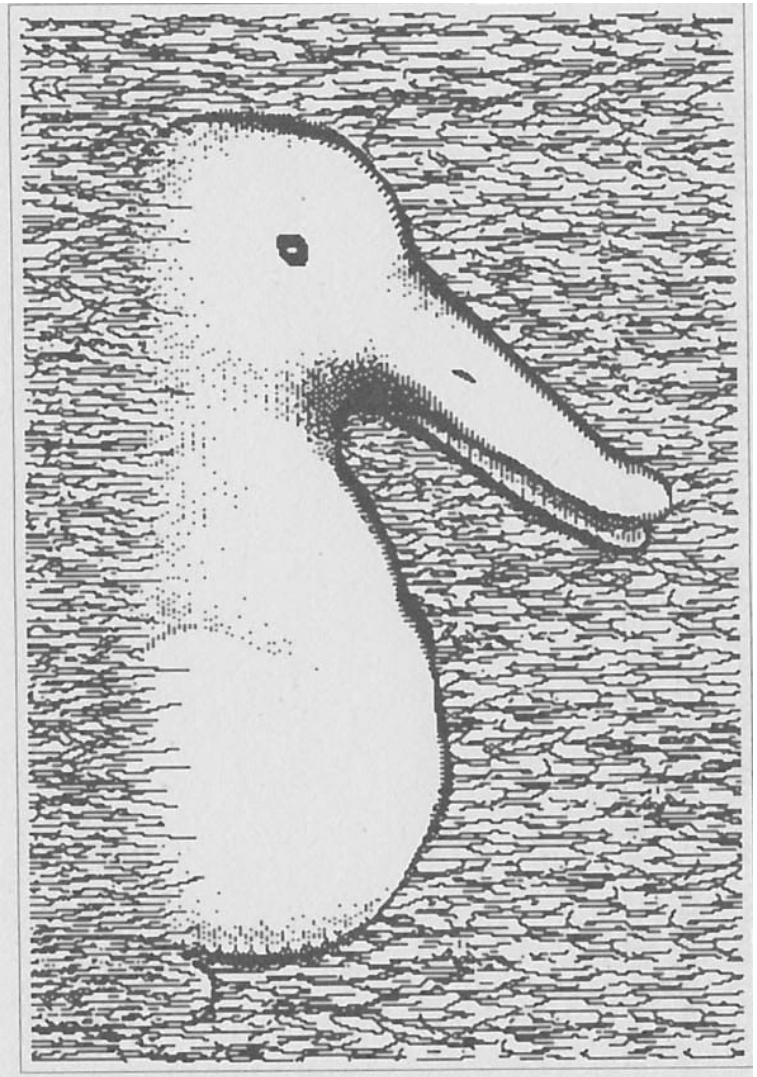
A Brief Rotational Invariance Interlude: Can you Name this Celebrity?

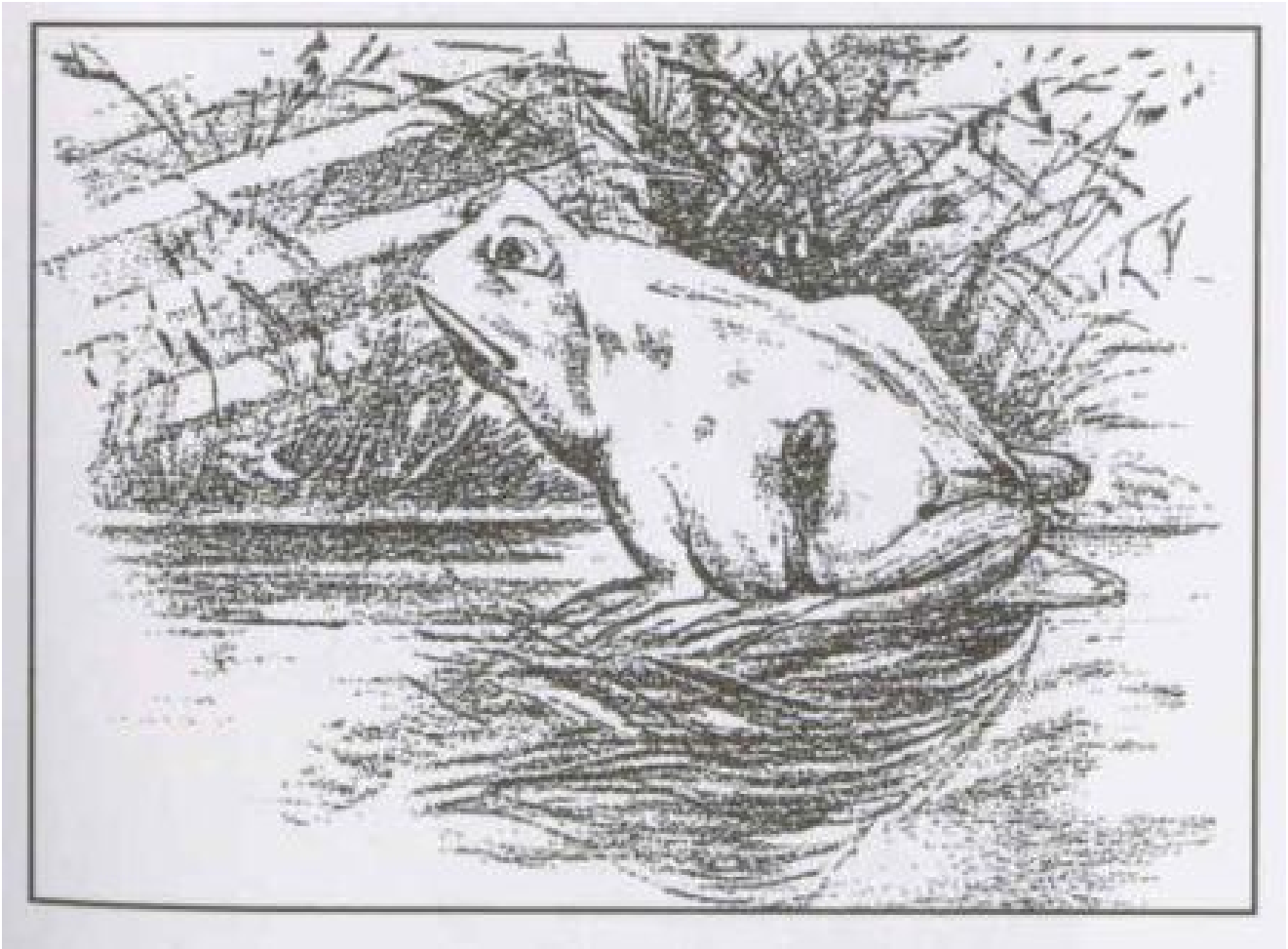
A Brief Interlude on Perception: See the Rabbit?



A Brief Interlude on Perception: See the ~~Rabbit~~ Duck?



A Brief Interlude on Perception: See the Frog?



A Brief Interlude on Perception: See the ~~Frog~~ Horse?

Human Perception: Not Rotationally Invariant

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- $\rightsquigarrow$ Measuring "you know it when you see it": No rotational invariance

New Measure: Y-Symmetry, area of symmetric reflection

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Symmetric figures (circles, squares) are more compact

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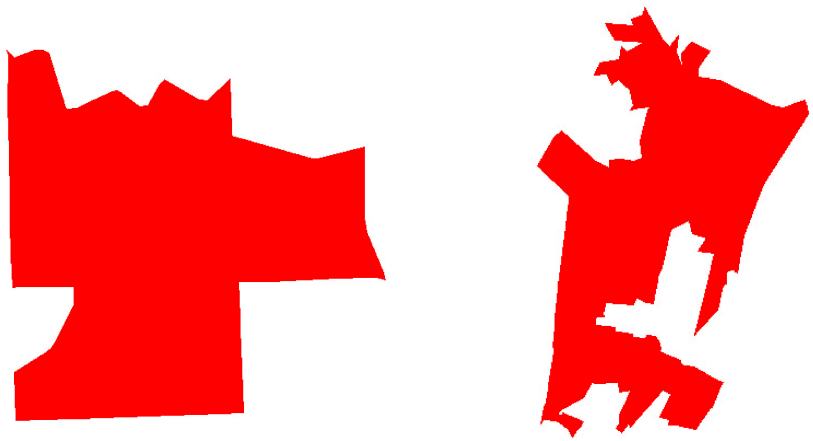

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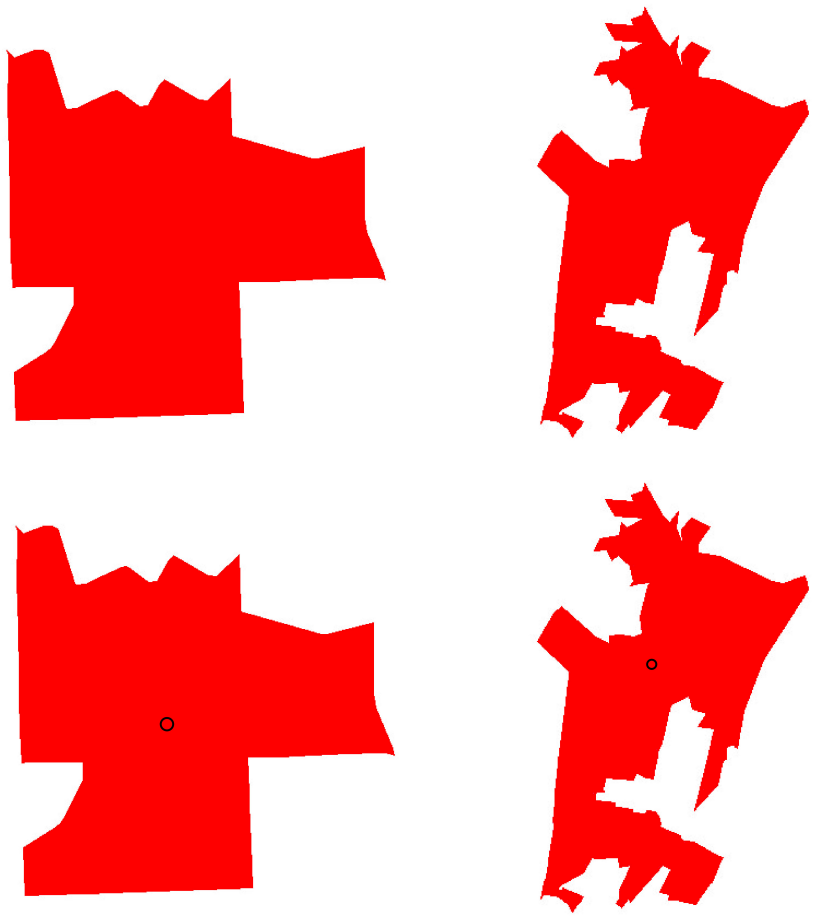

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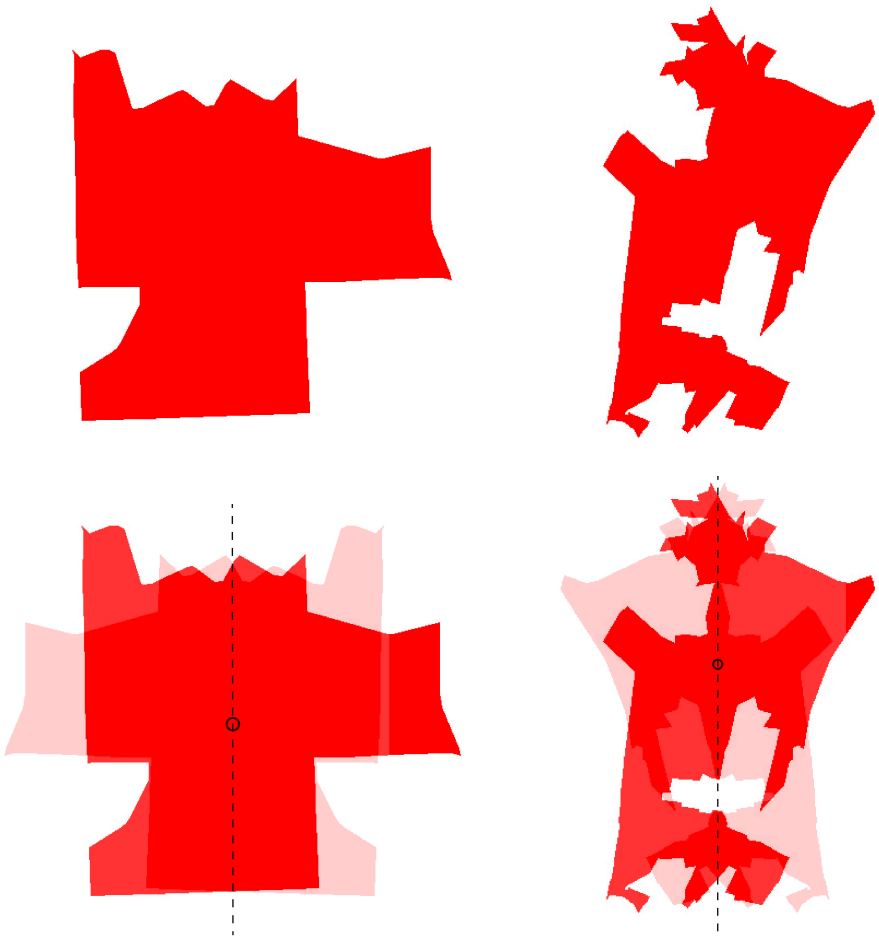

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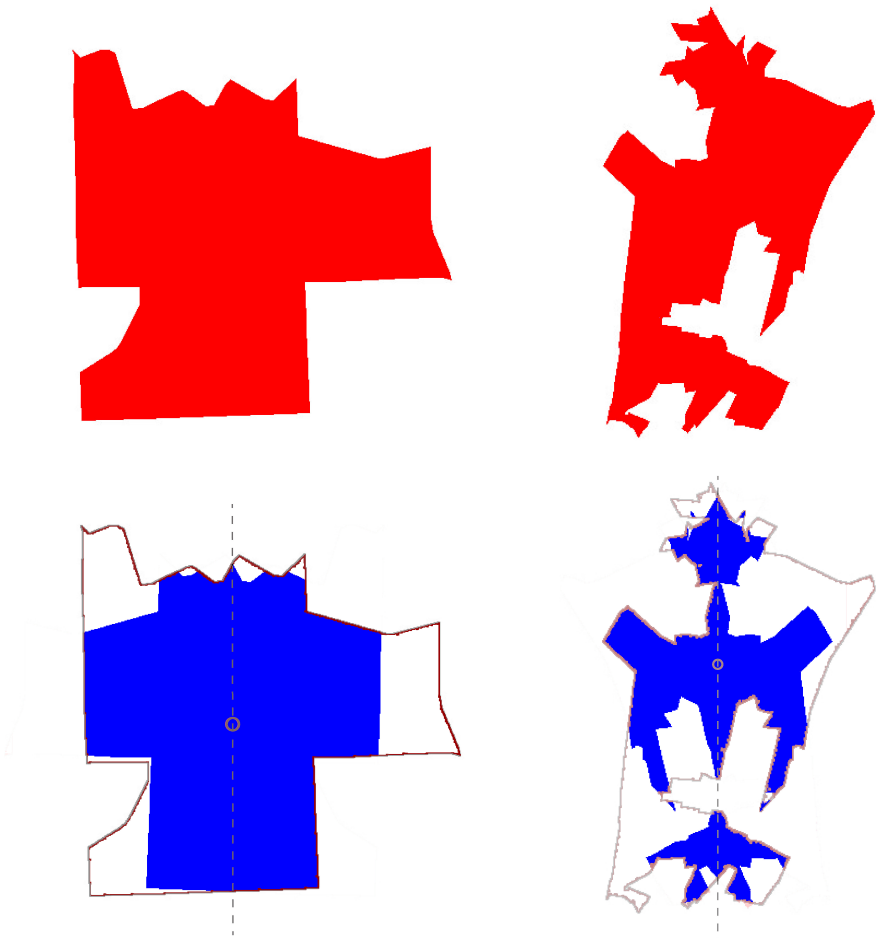

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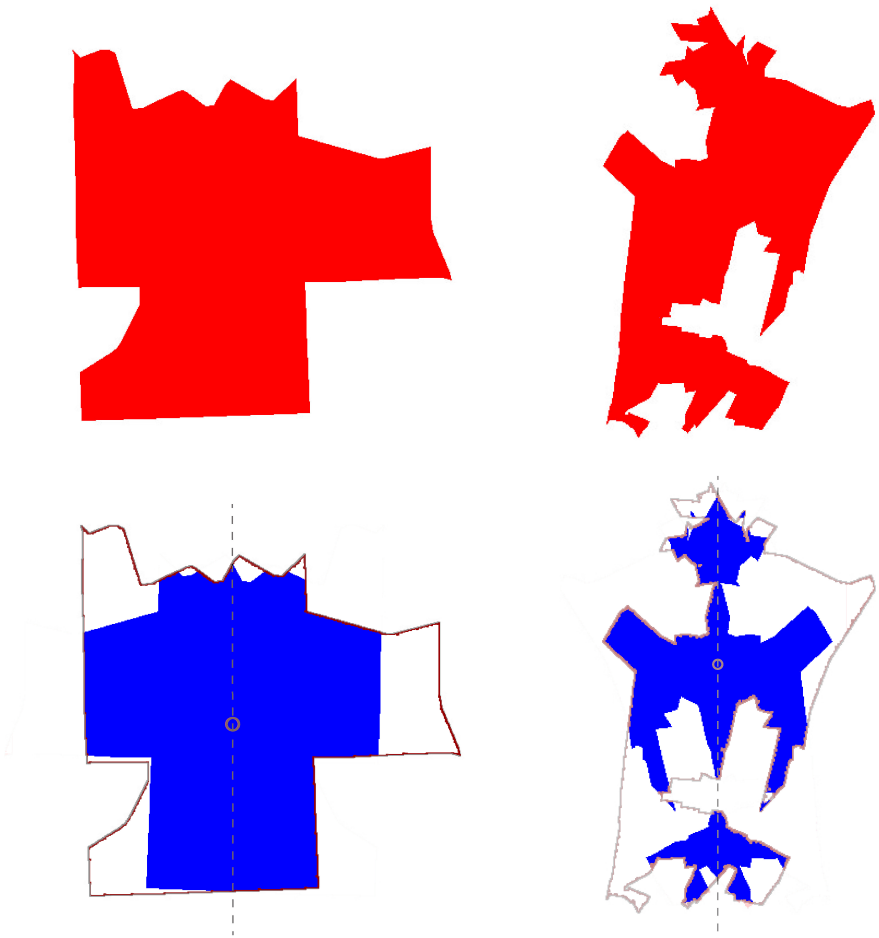

In both cases, Overlap/Original Area ≈ 0.34

New Measure 2: Number of Visually Significant Corners

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Computer vision algorithm identifies "objects" in photos

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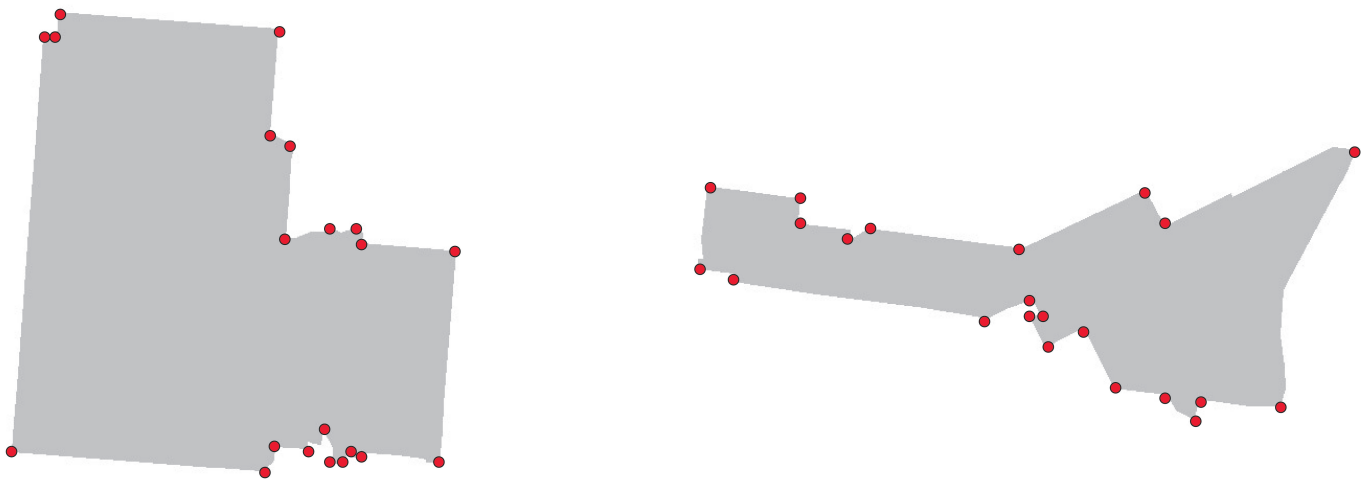

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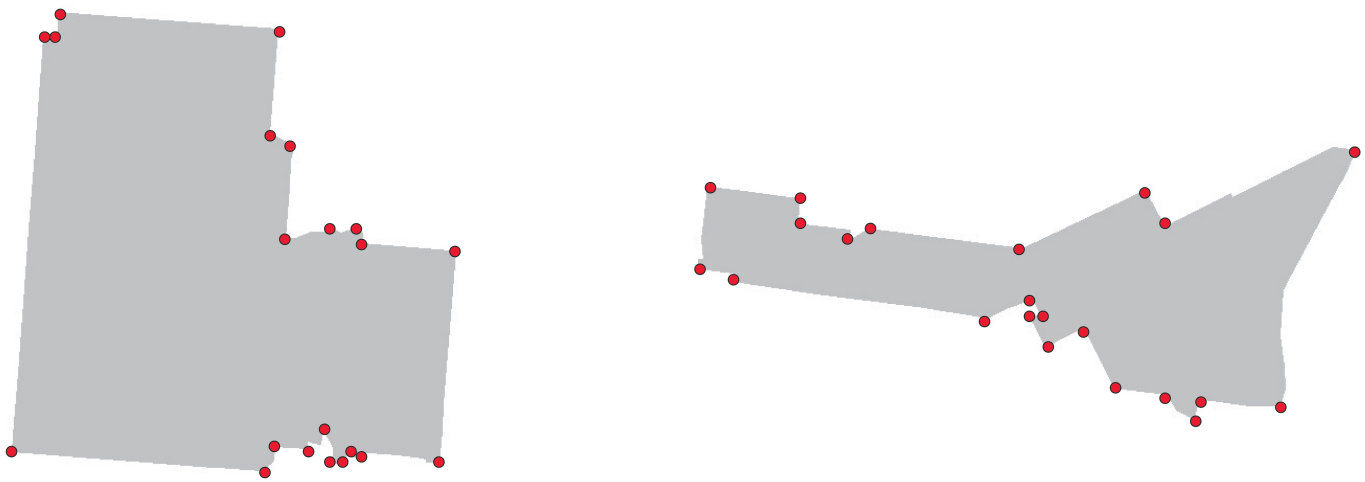
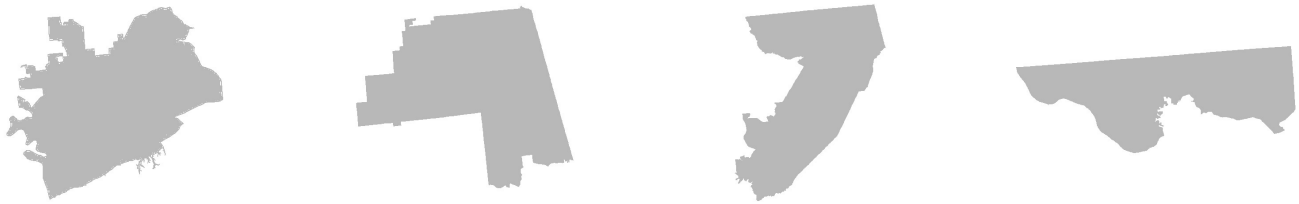


Both districts have 21 significant corners

Which is more compact?



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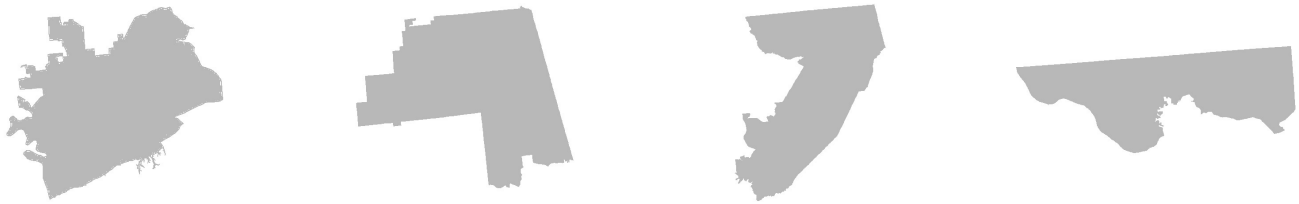

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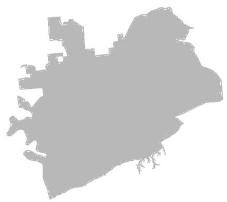
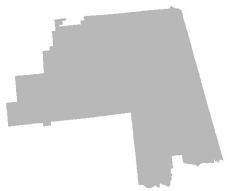

Convex Hull	4	3	2	1

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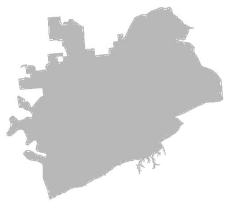
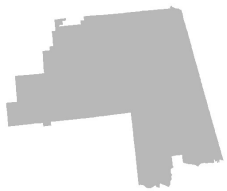

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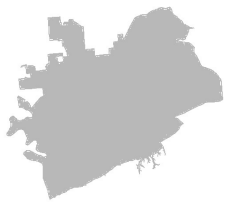
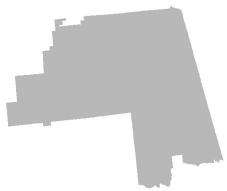

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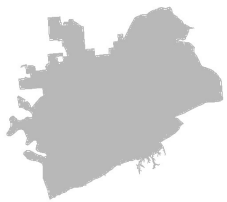
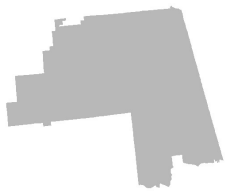

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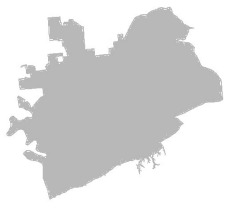
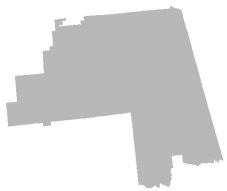

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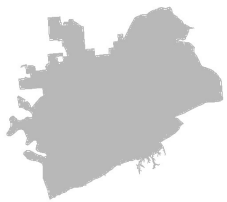
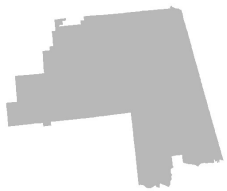

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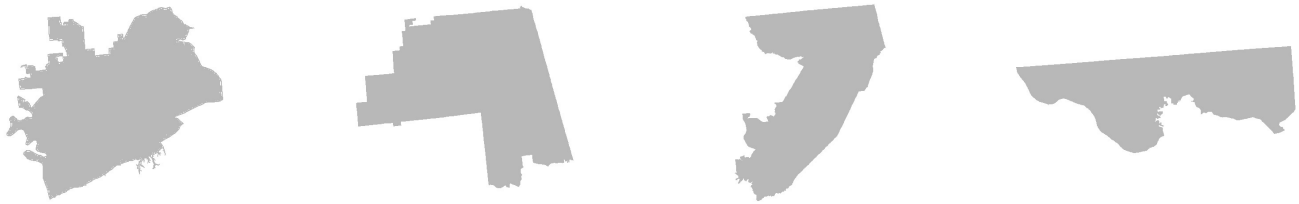

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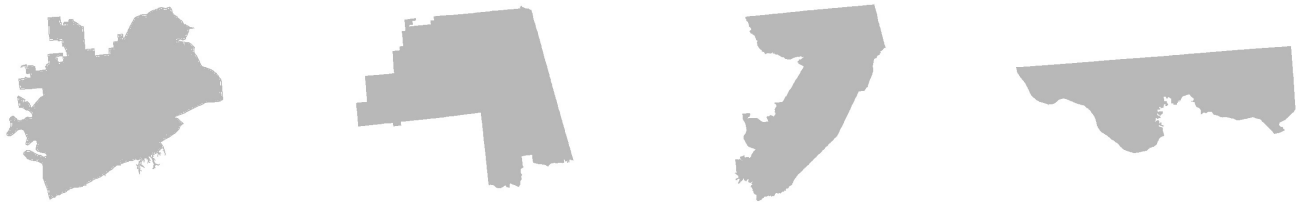

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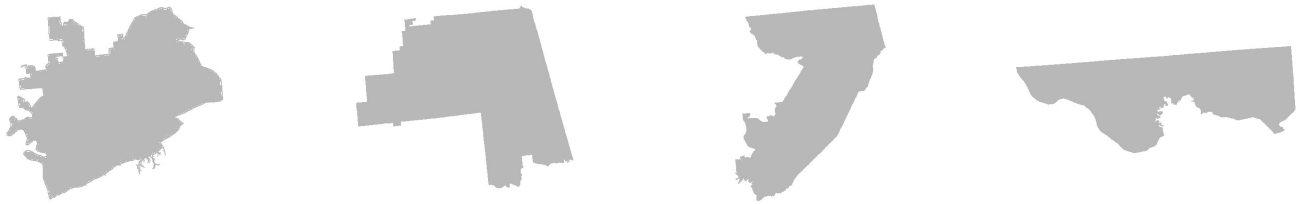

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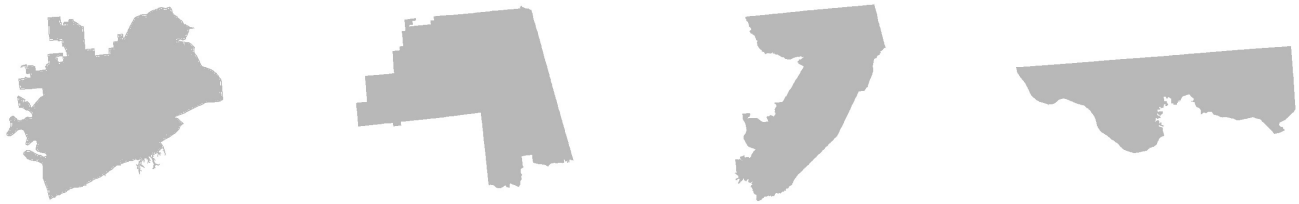

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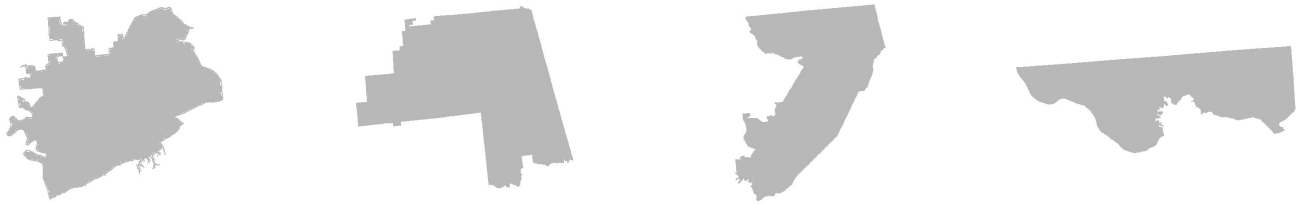

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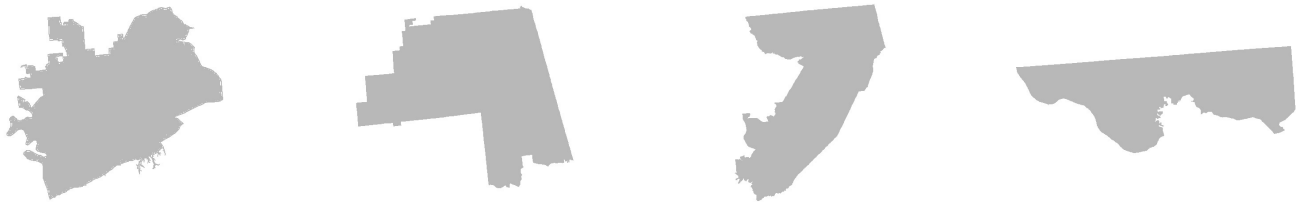

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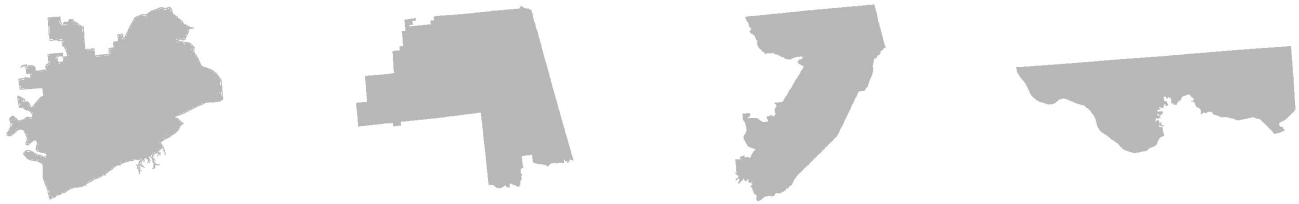

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Paired Comparisons (Fechner 1860; Thurstone 1912) v Ranking (very old, rarely used)

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Paired Comparison

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Paired Comparison

Utterly fails on inter- and intra-coder reliability

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Full Ranking

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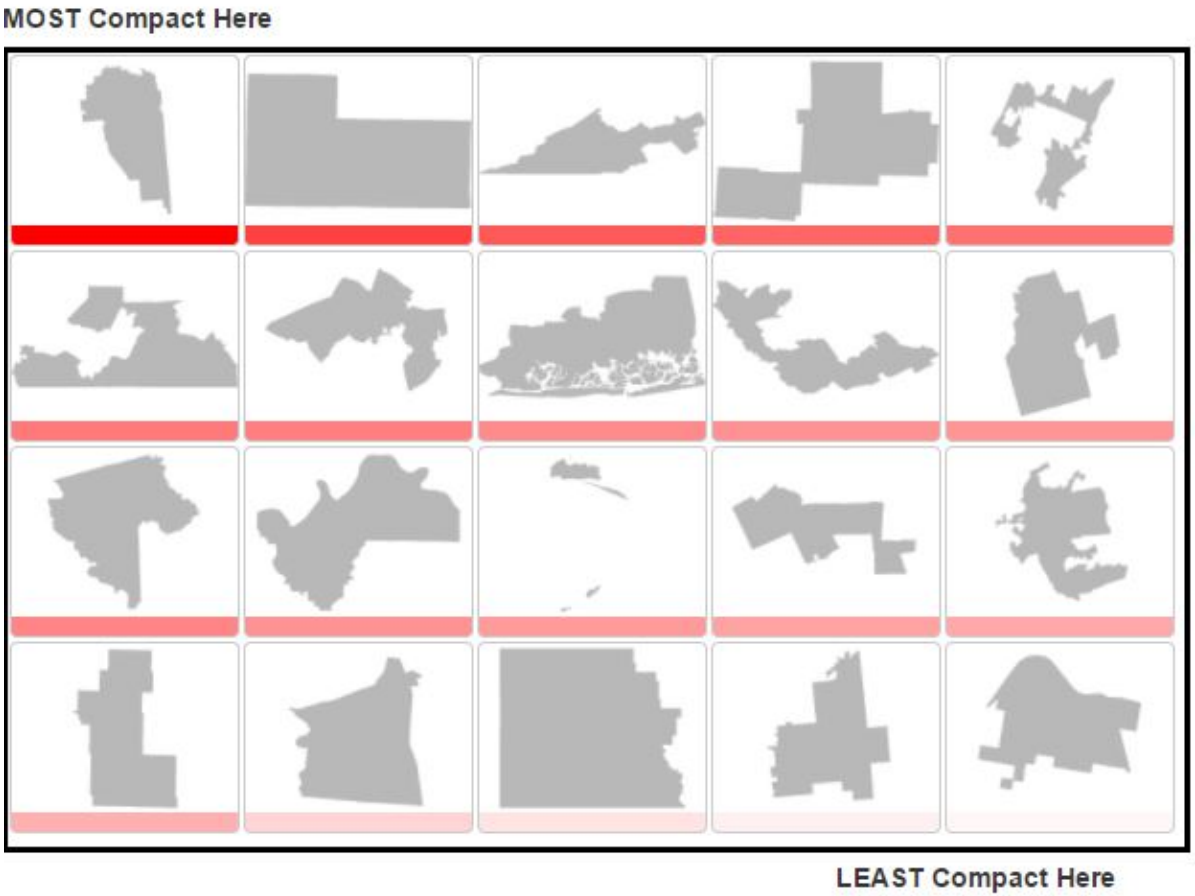
Full Ranking — on line



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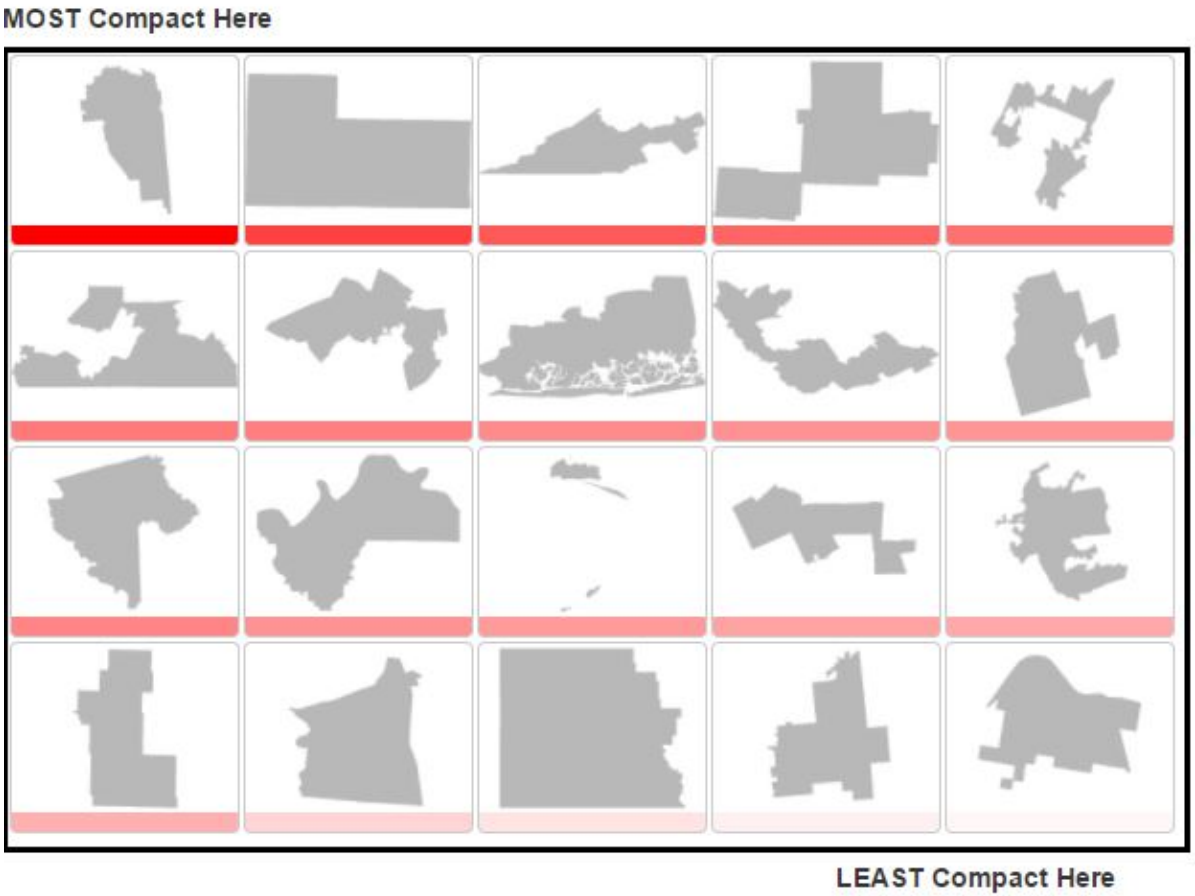

We show: very high reliability

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  - Everyone does what they are good at:
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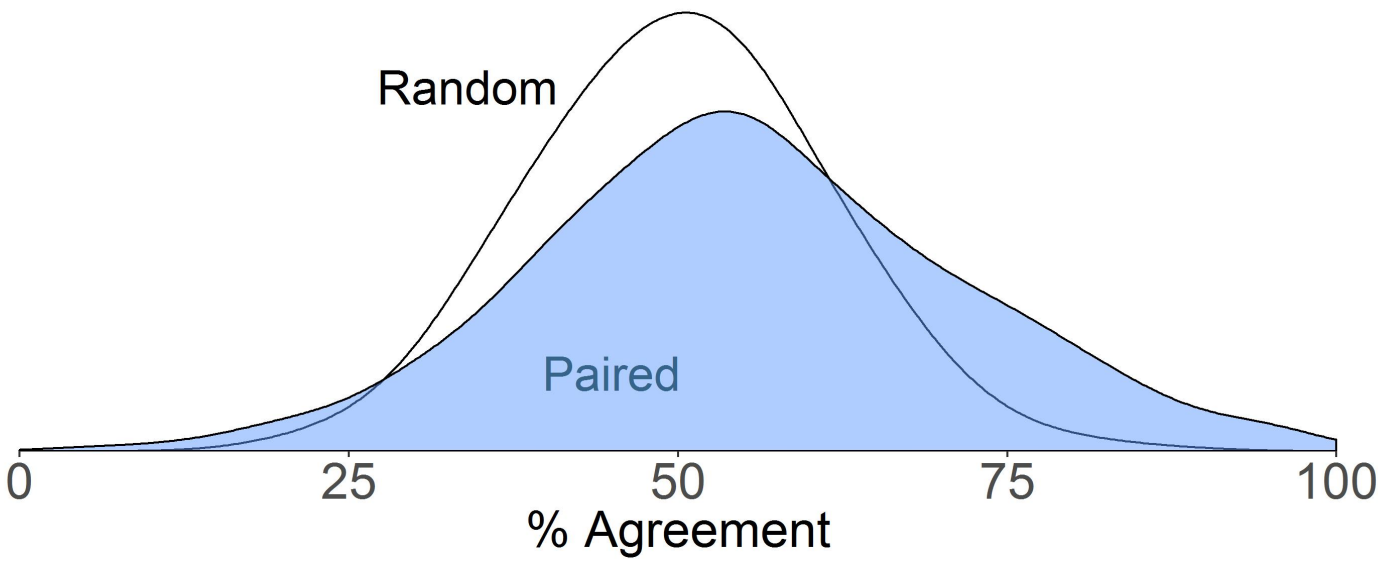

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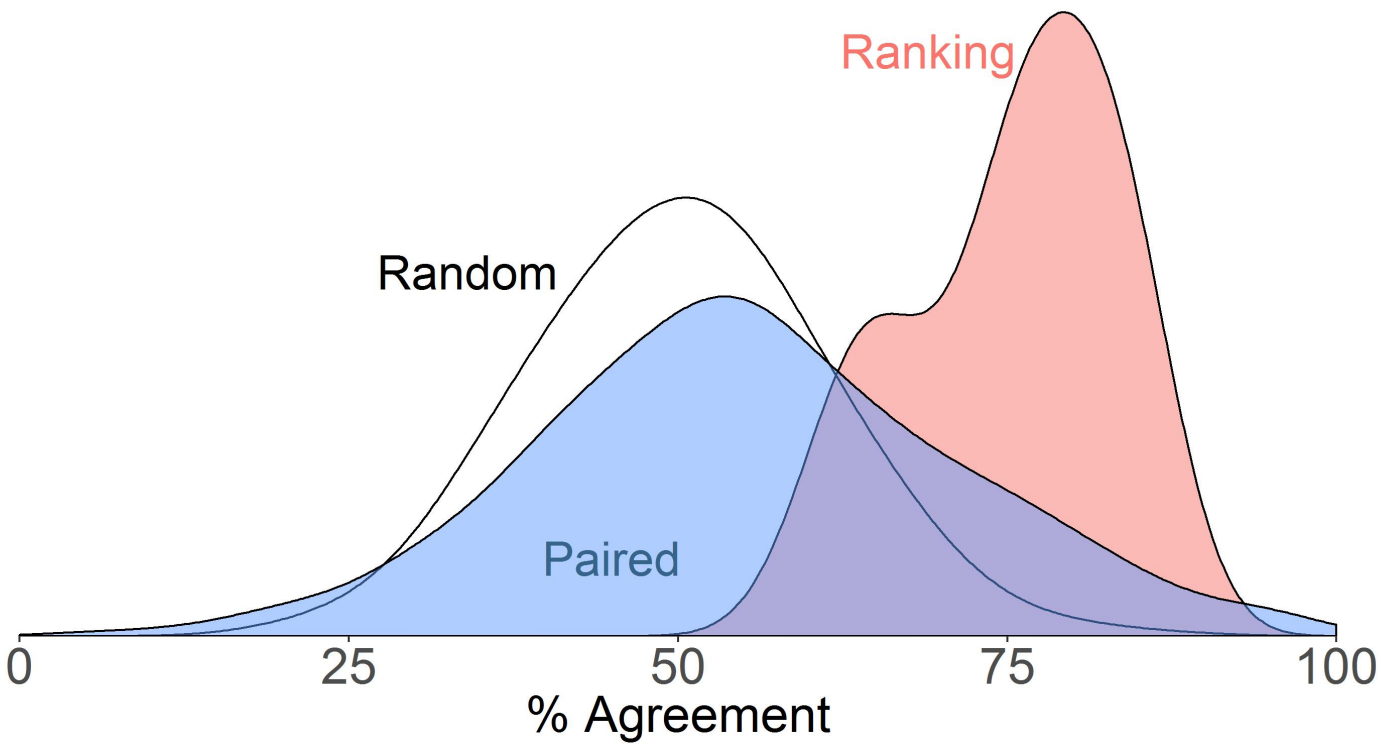

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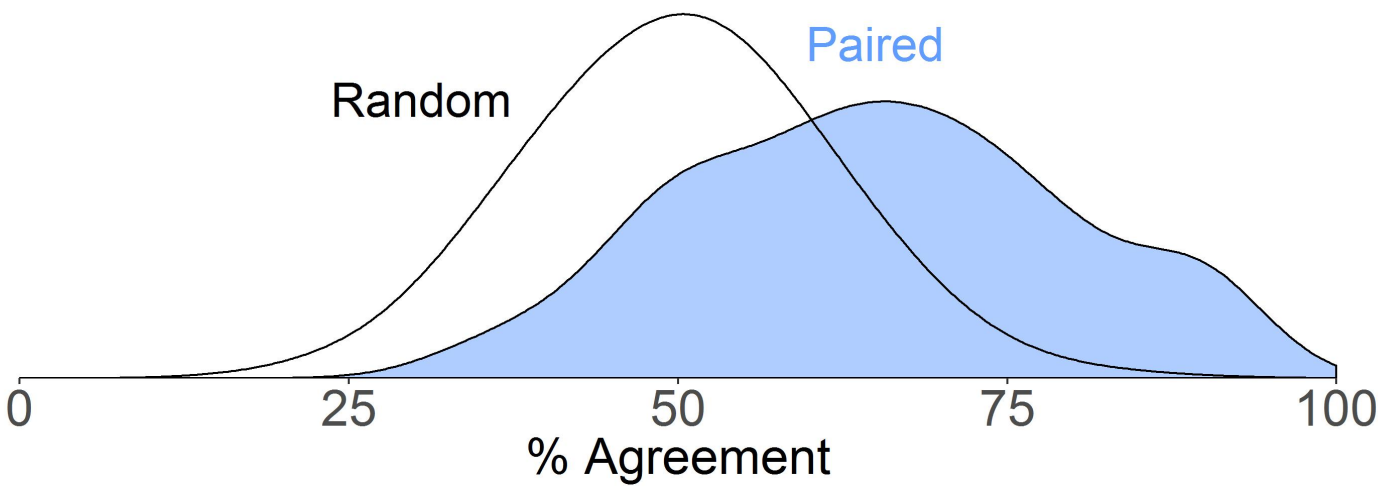

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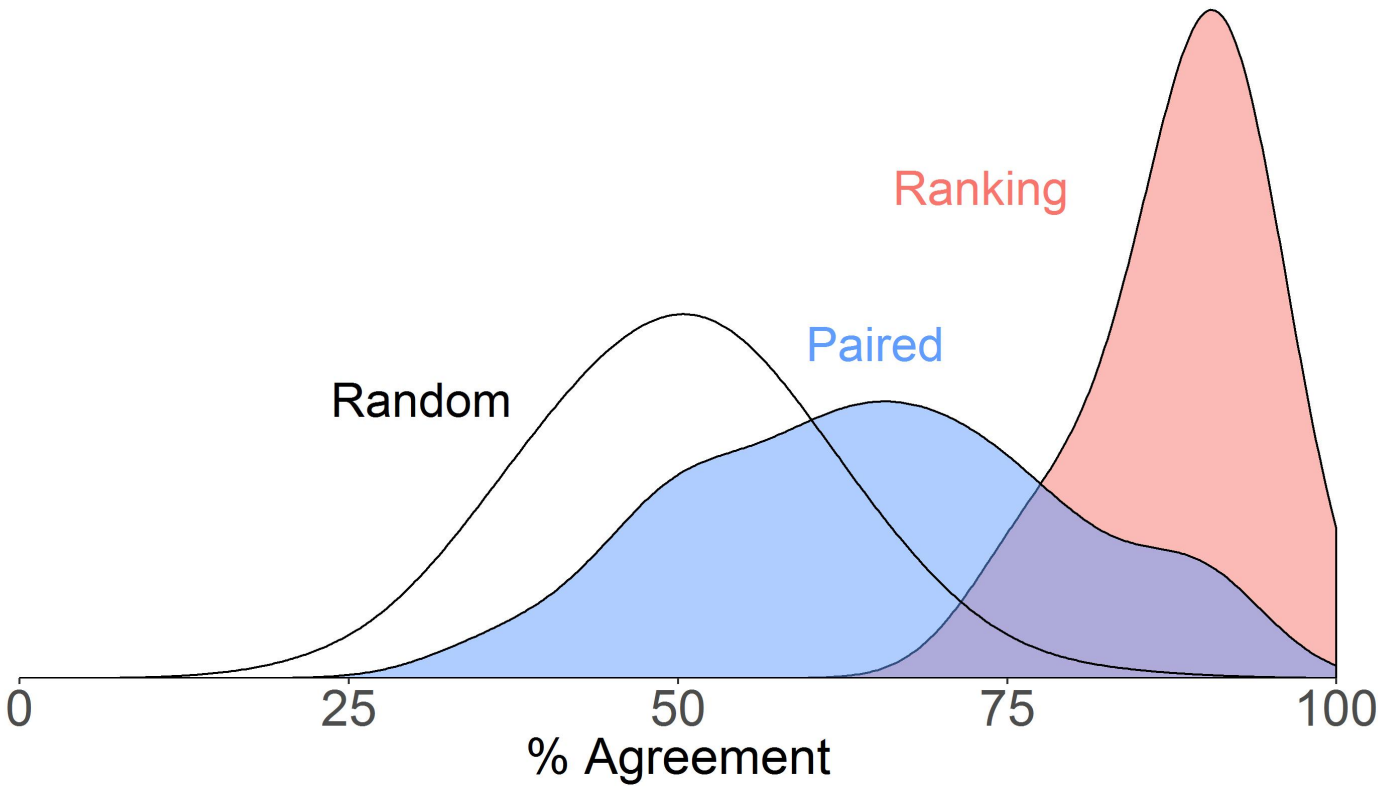

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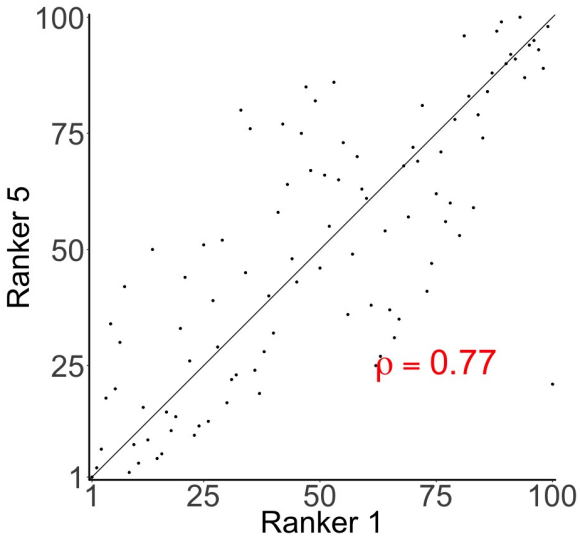

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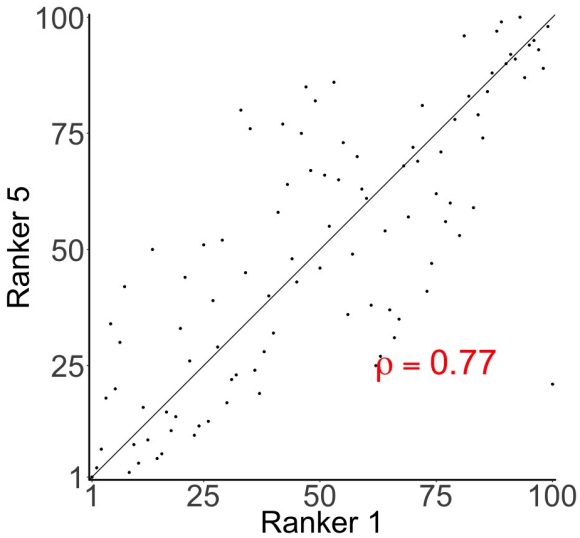

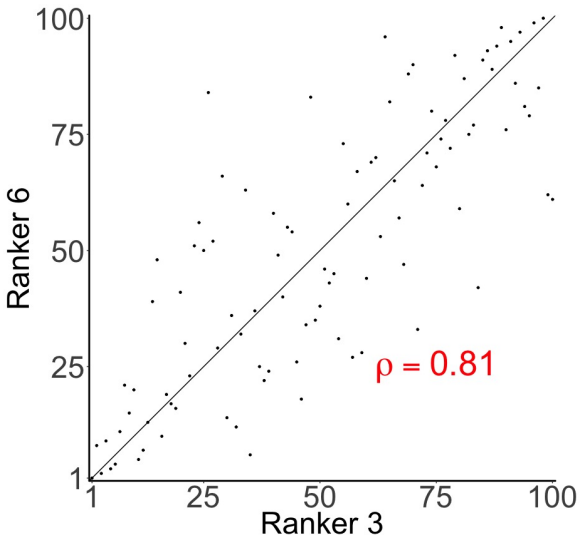

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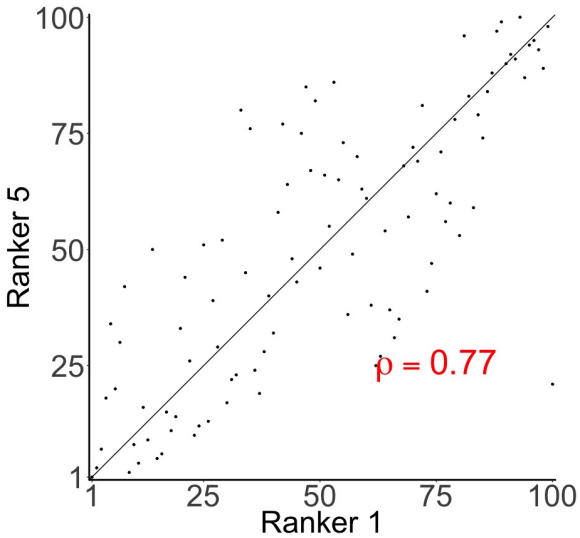

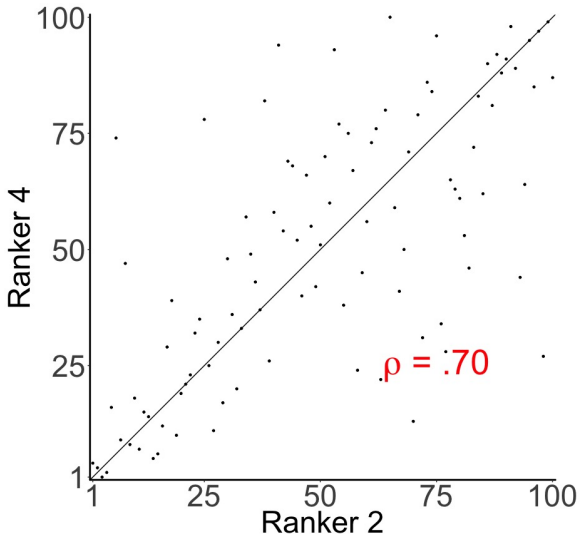

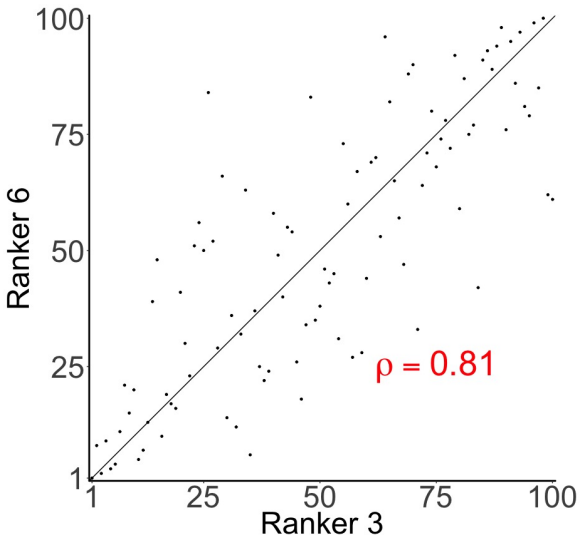

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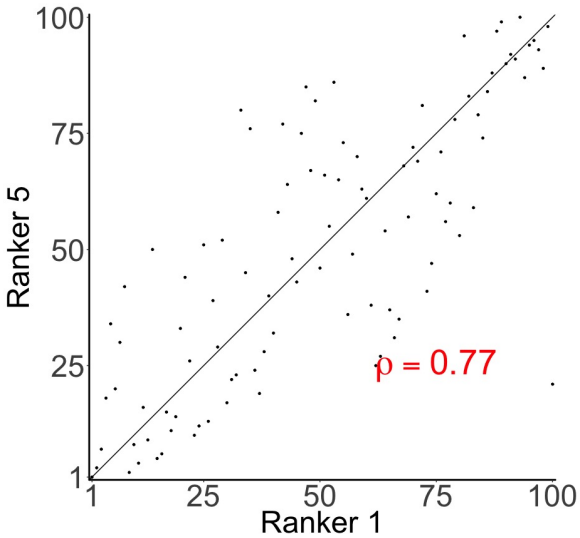

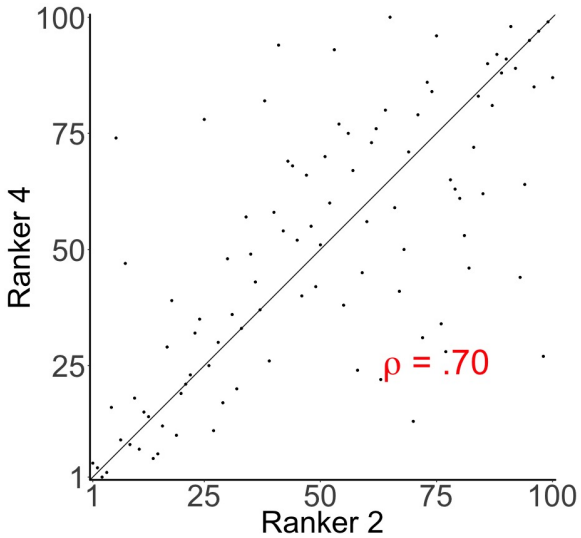

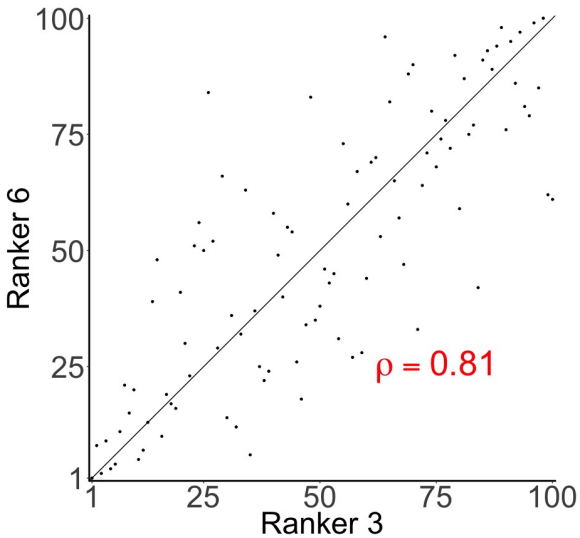

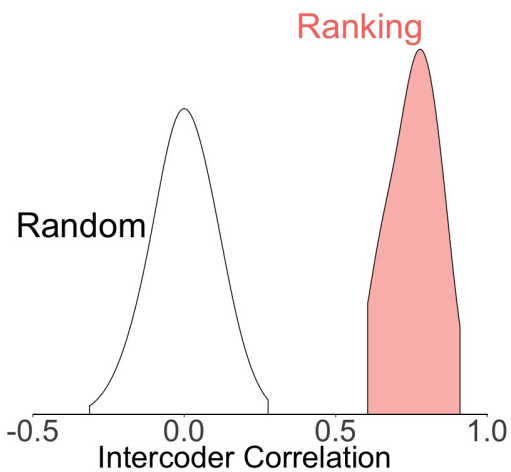

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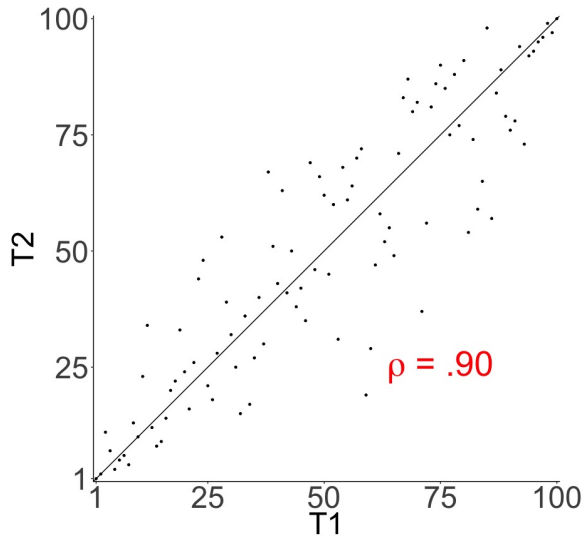

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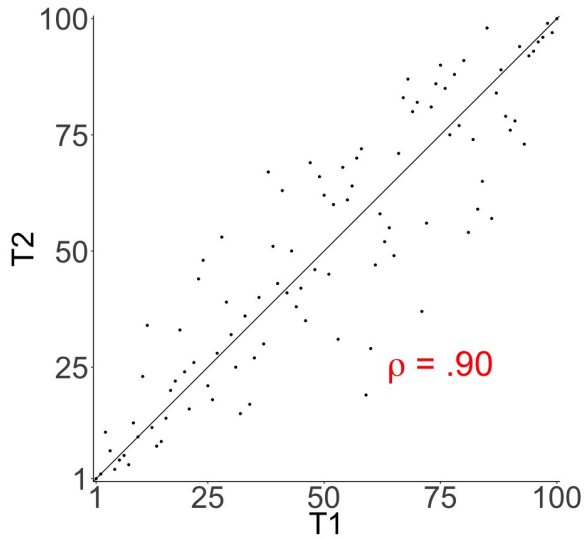

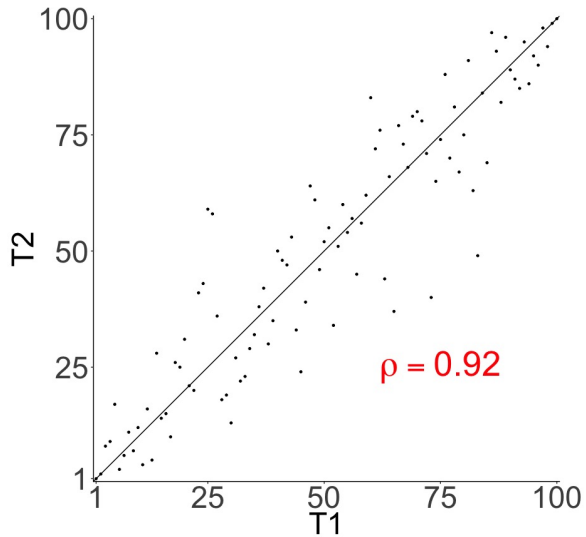

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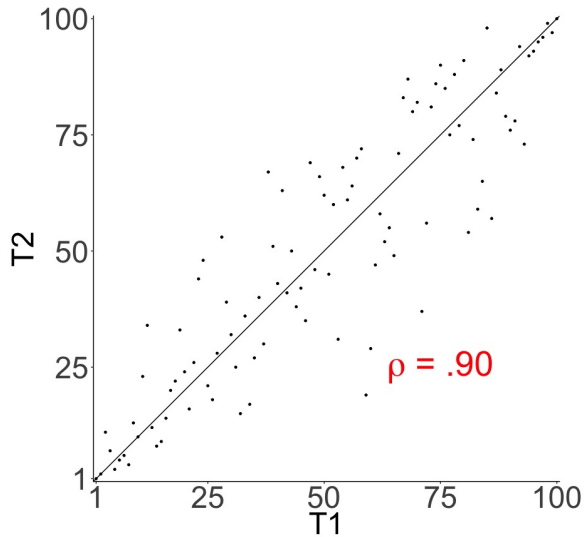

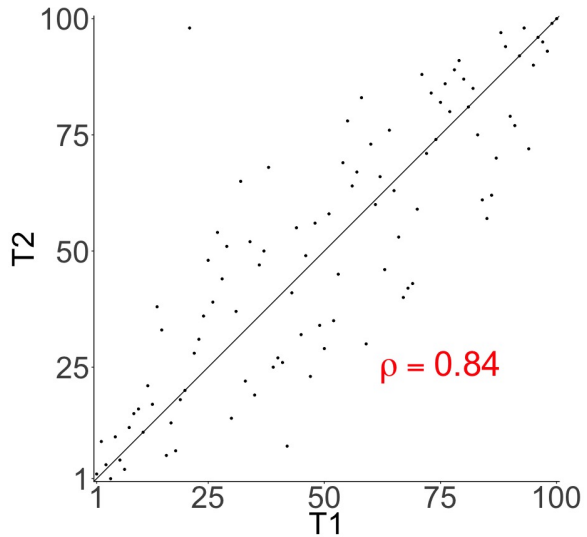

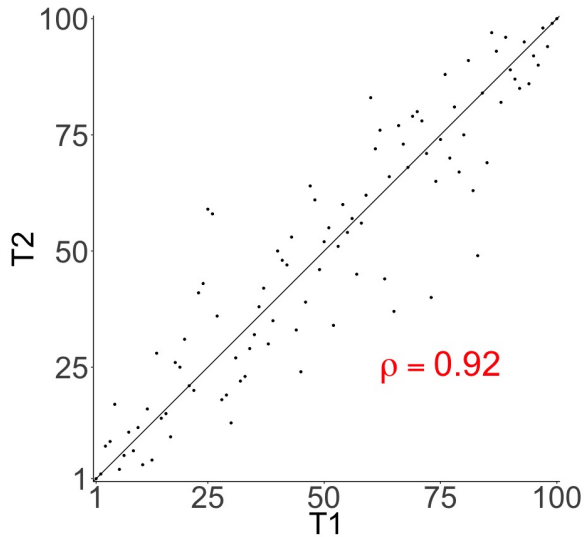

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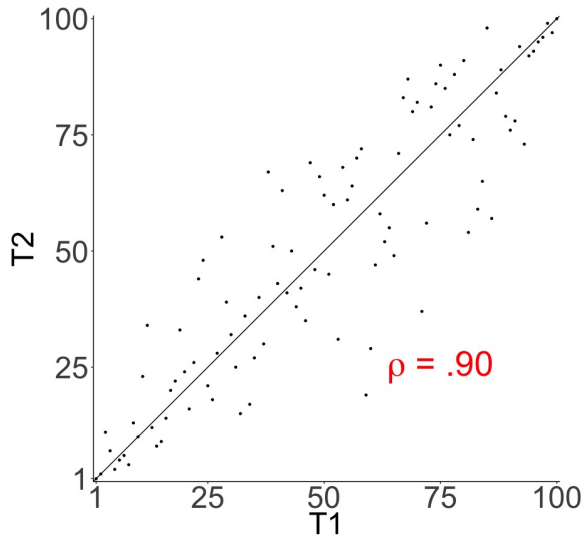

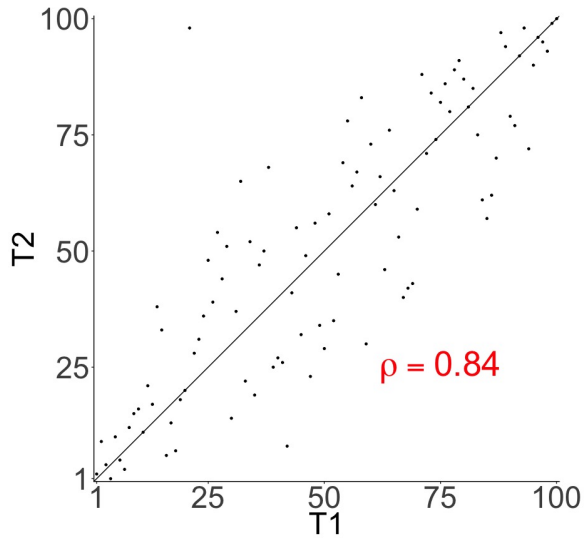

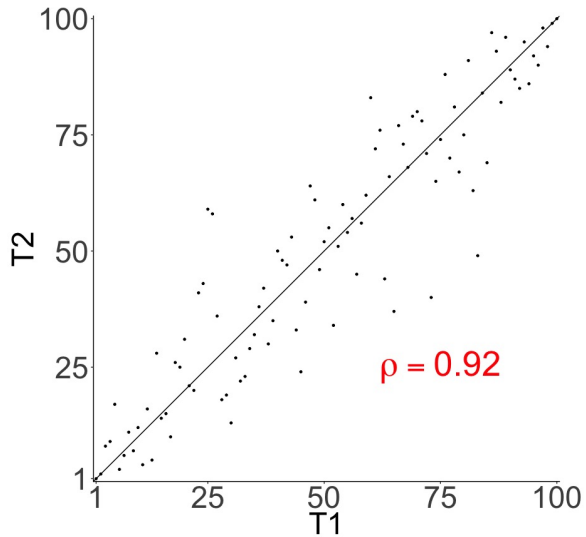

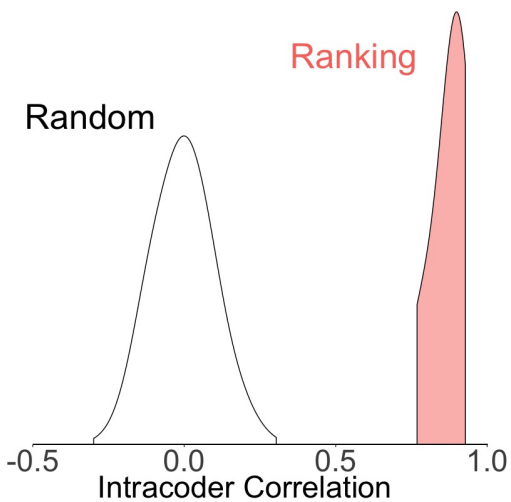

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Goal: Compactness score $= f(\text{shape})$

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Predict Test Set from 5 Training Sets

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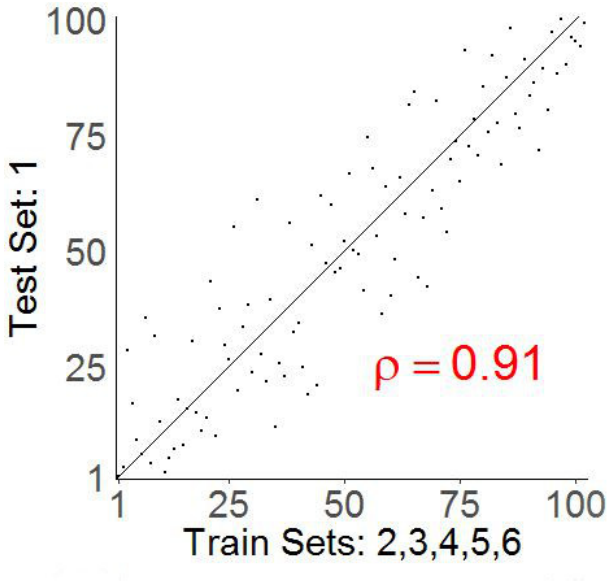

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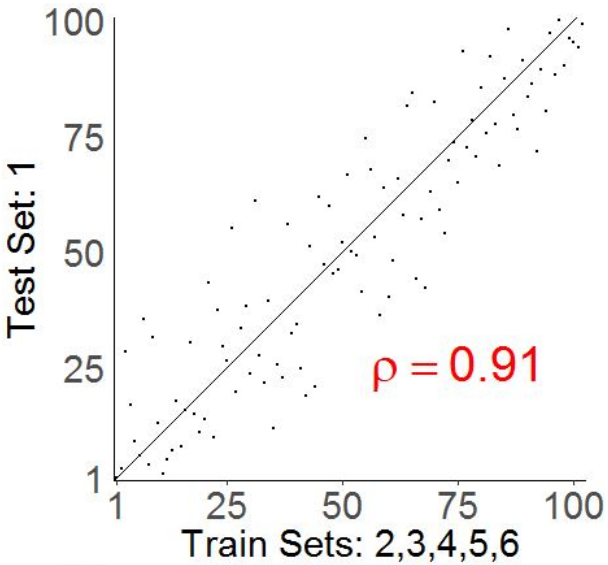

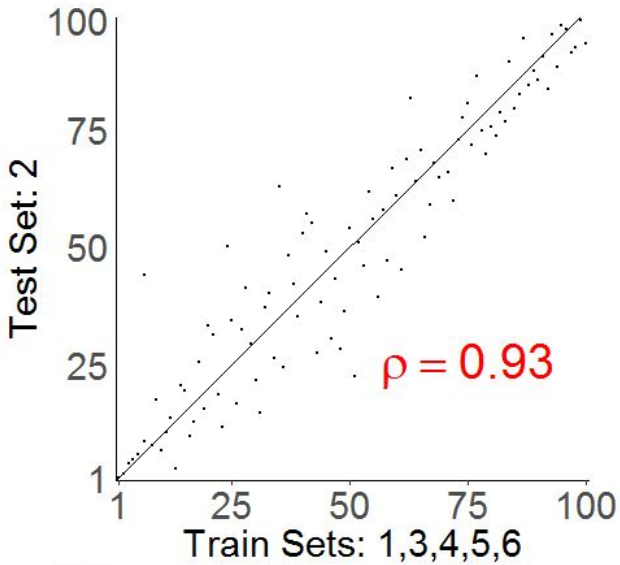

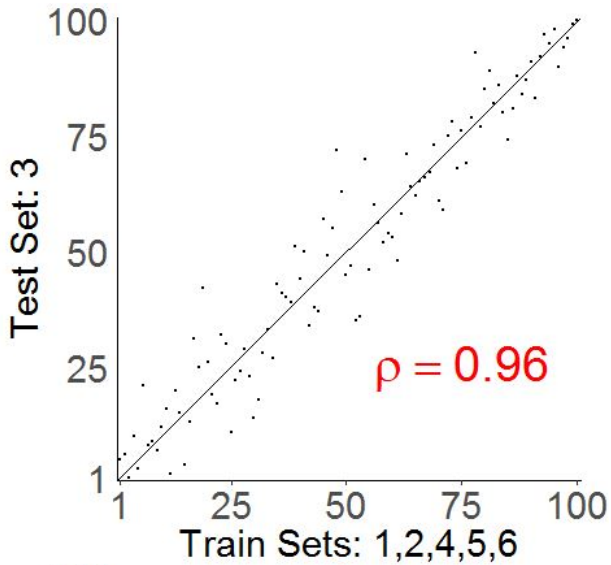

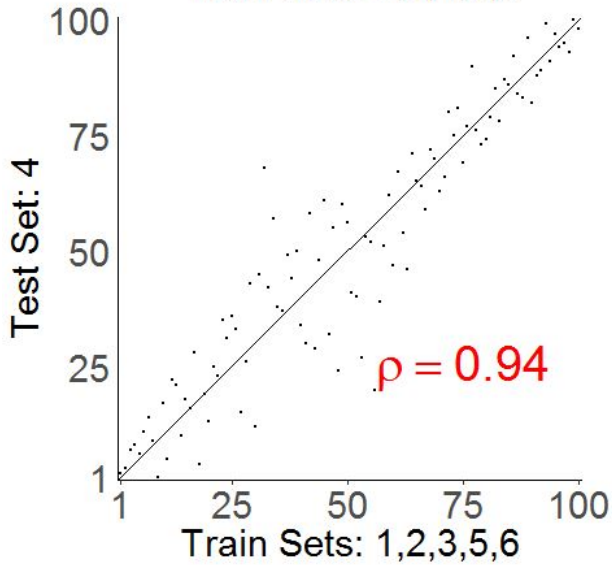

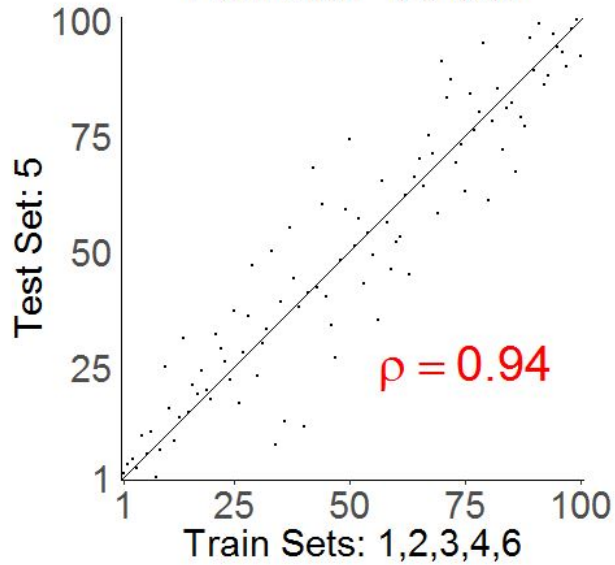

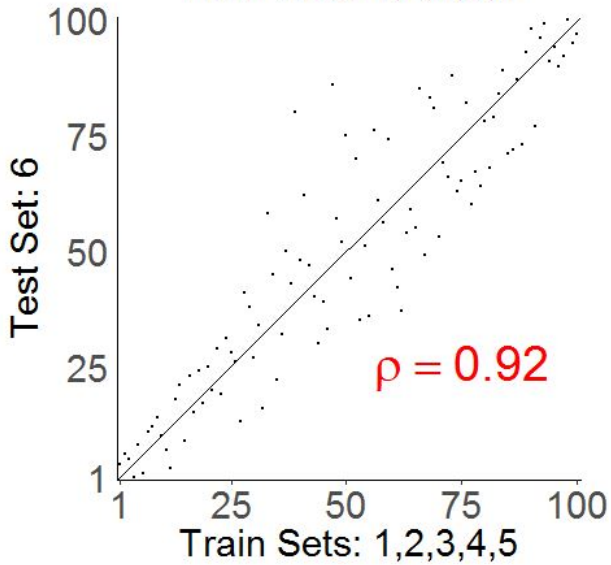

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Respondents ranging from ordinary citizens to those responsible for redistricting

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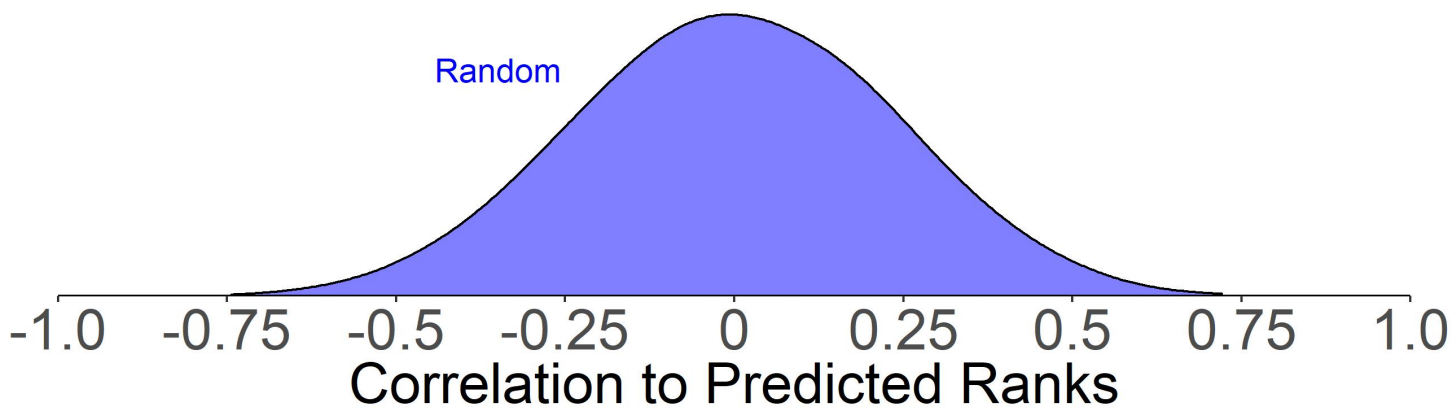

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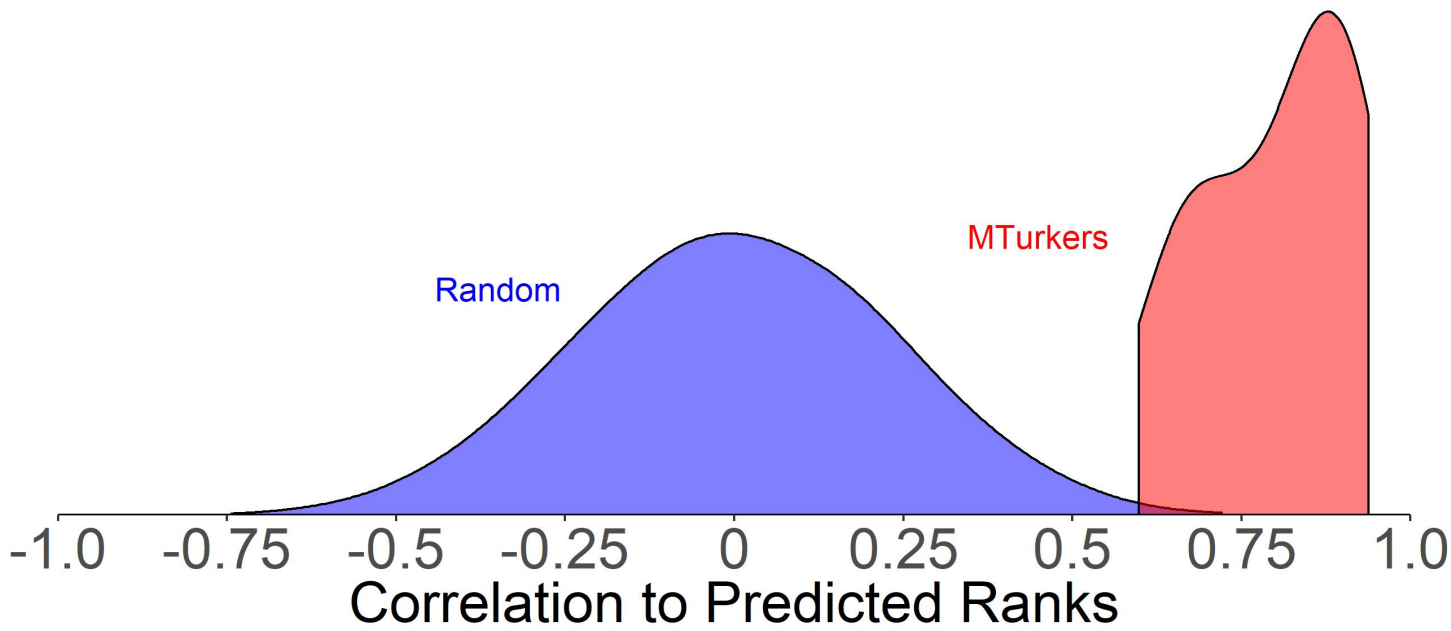

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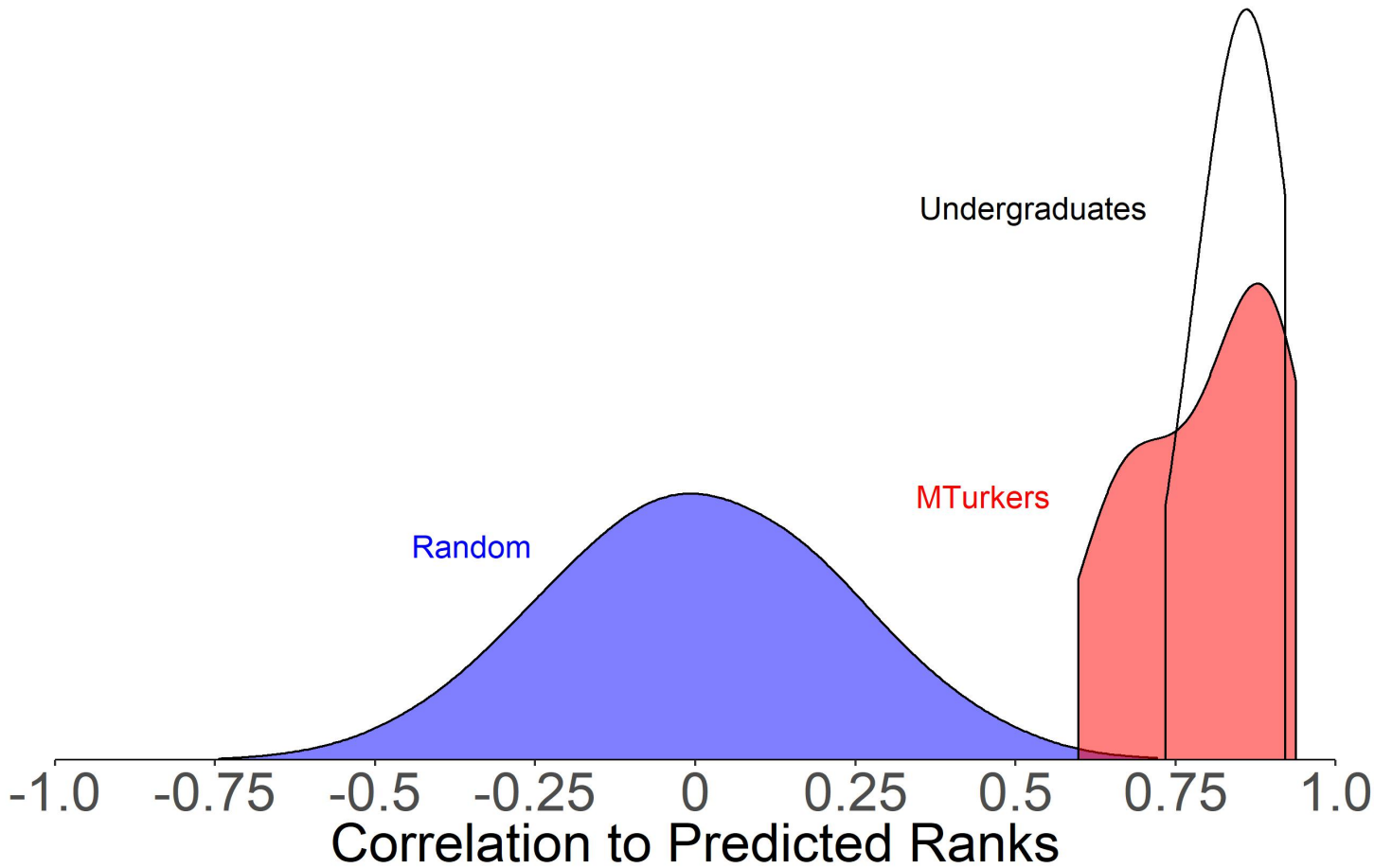

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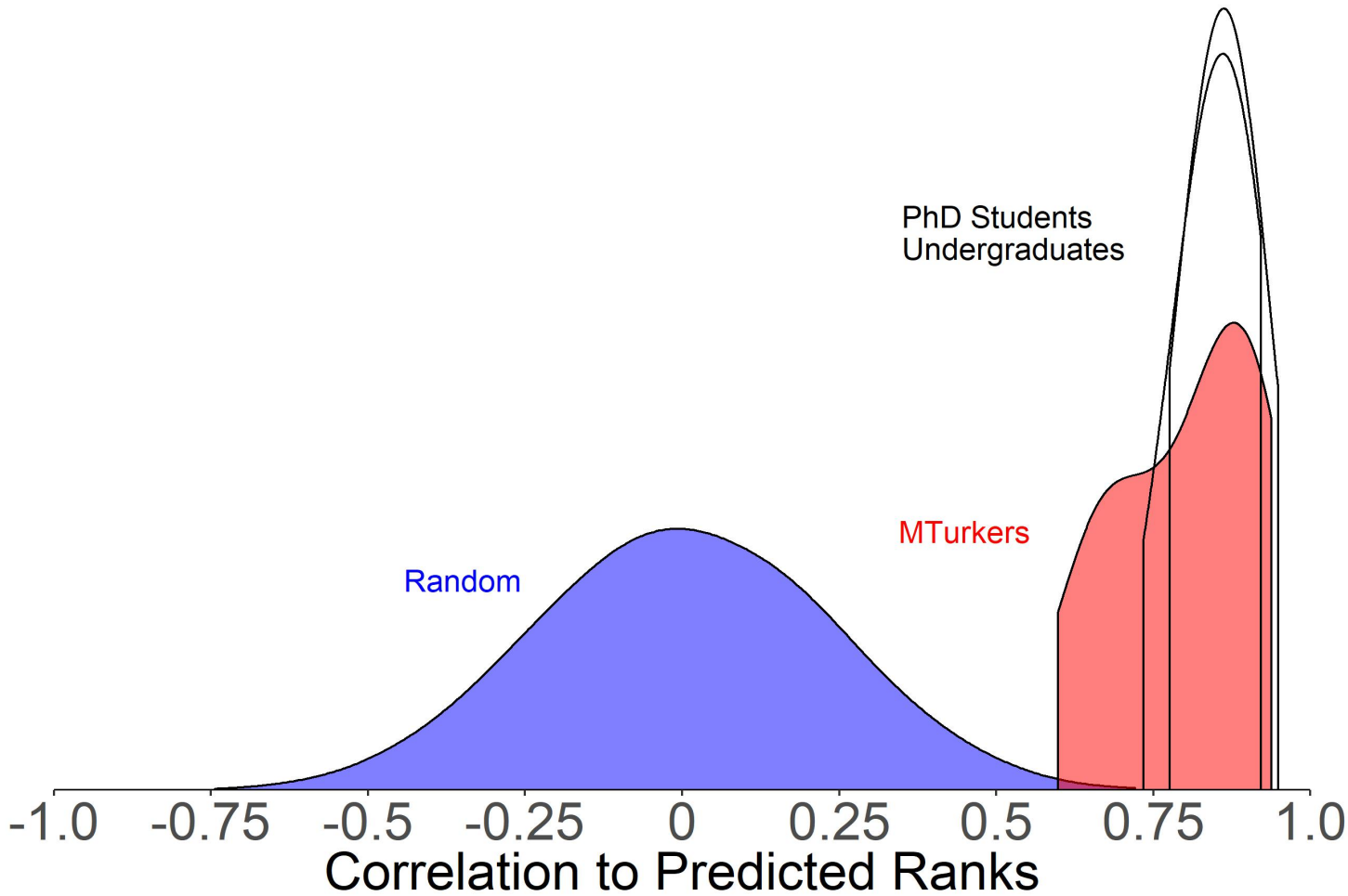

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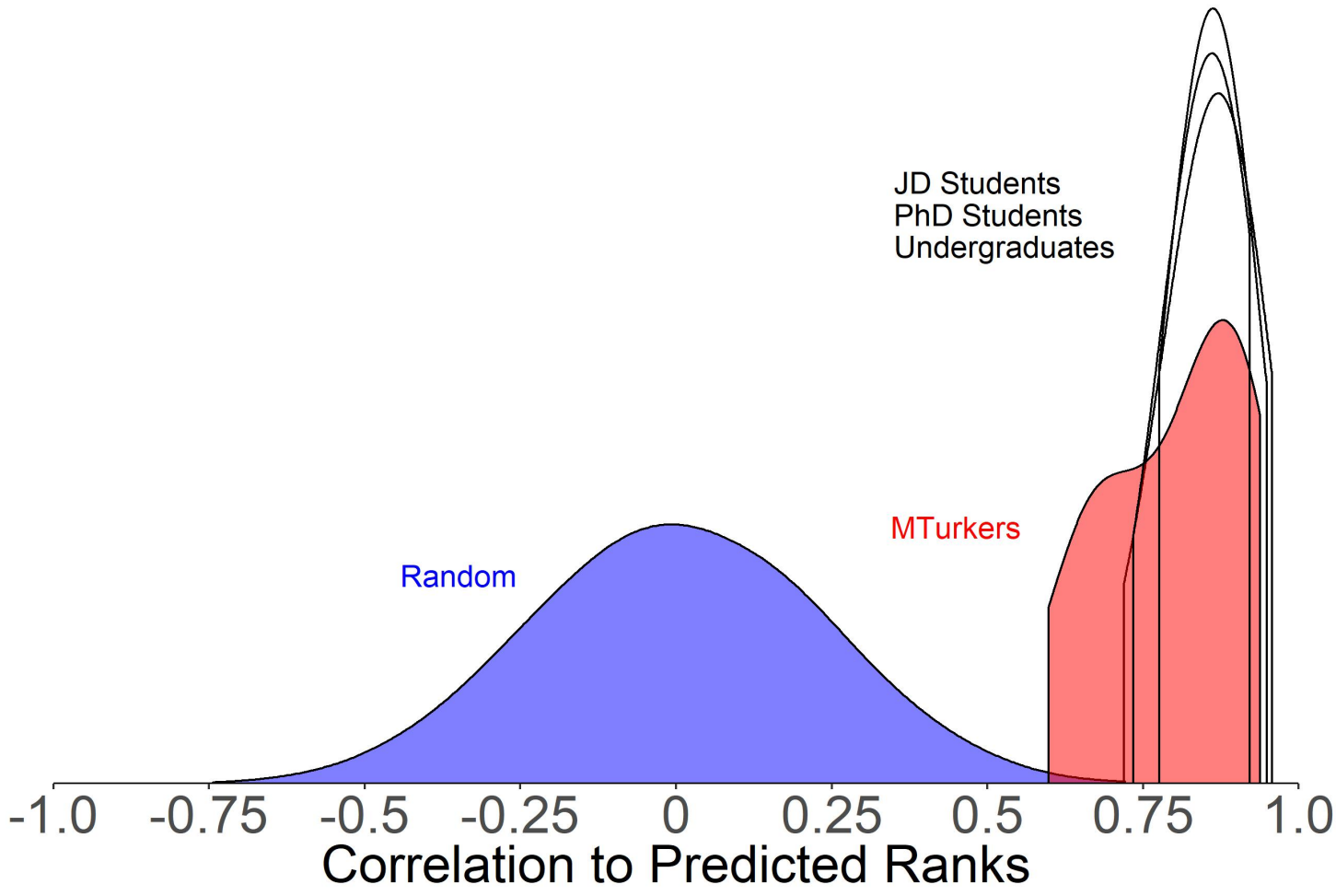

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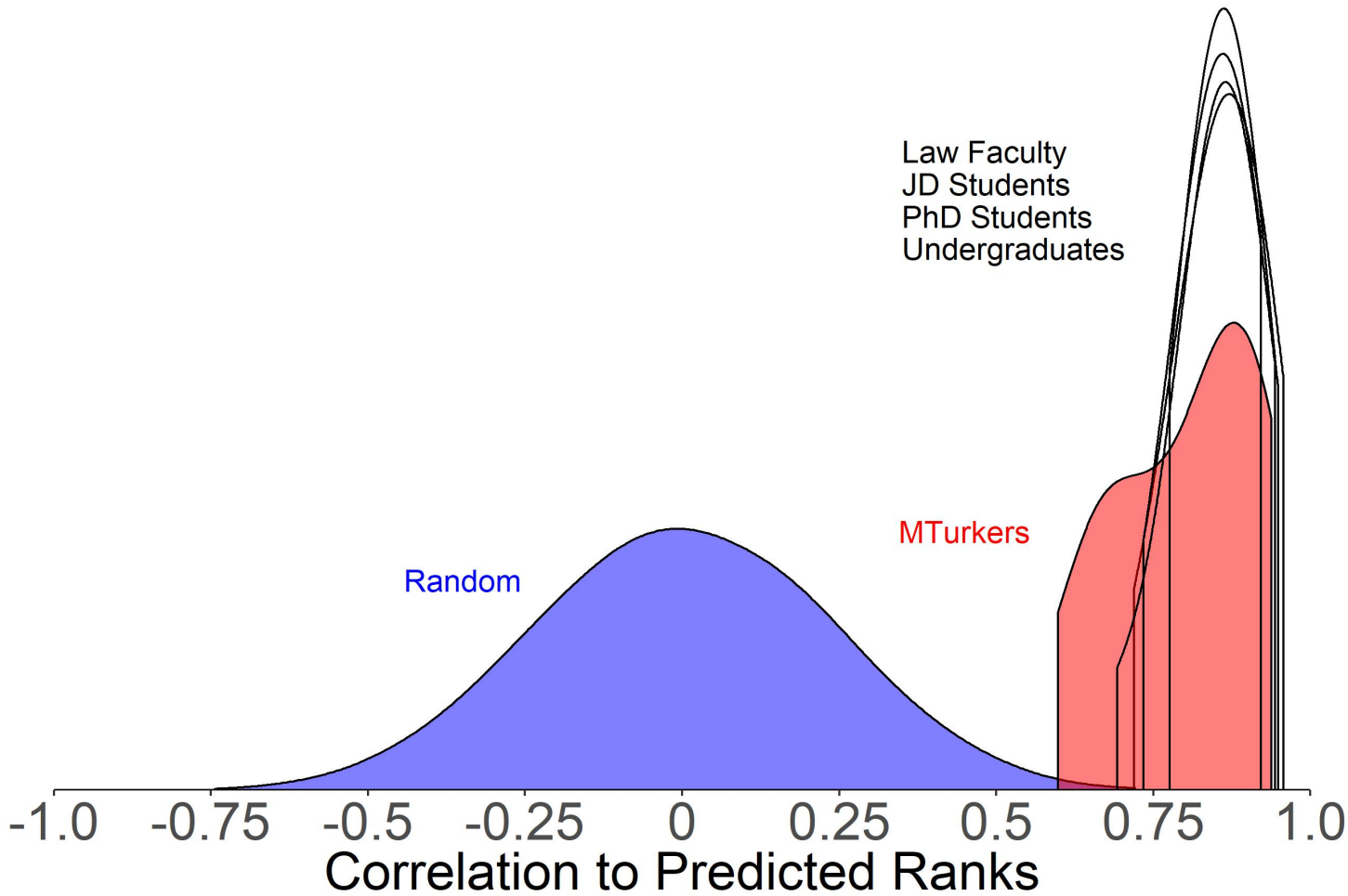

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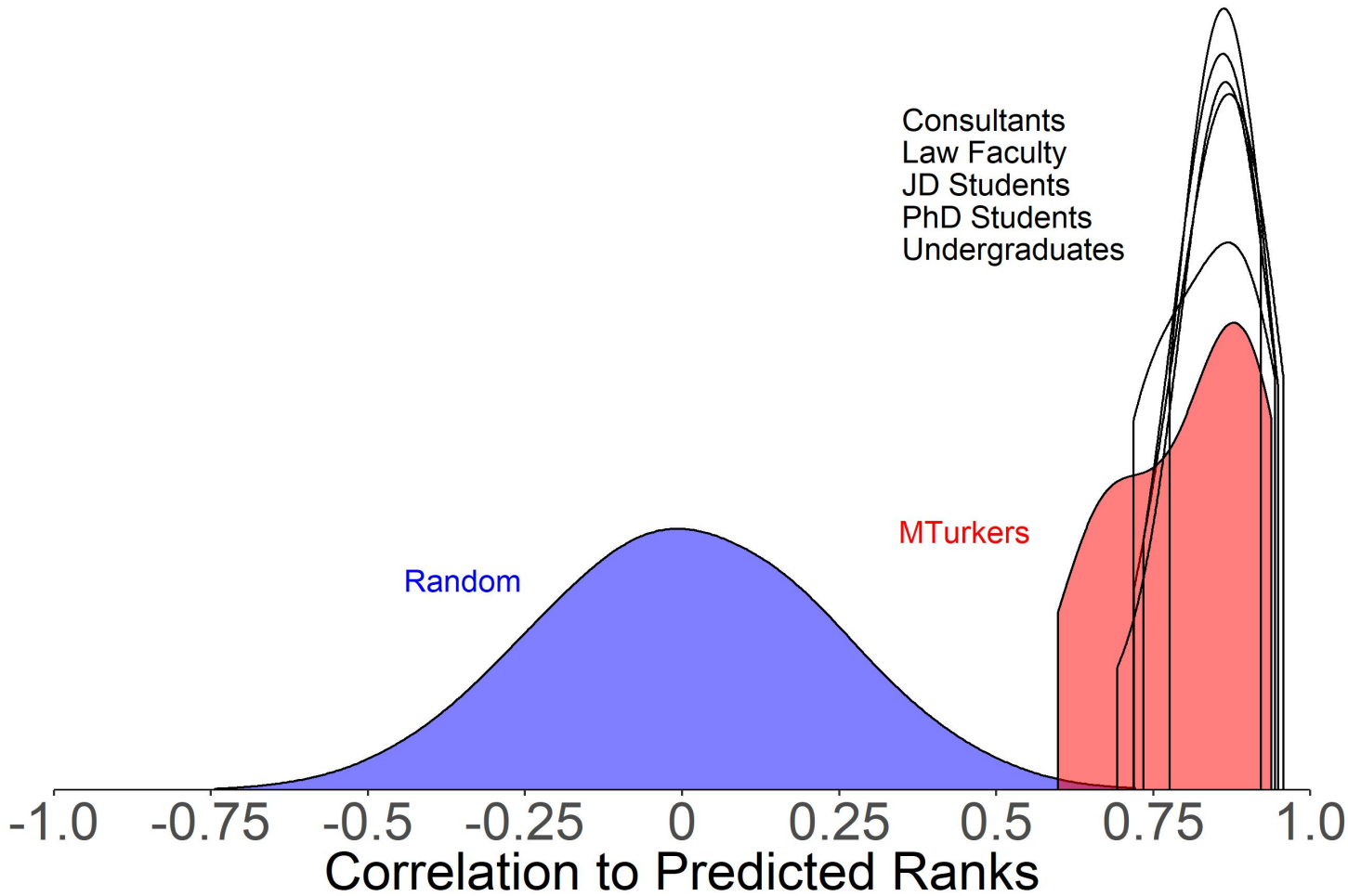

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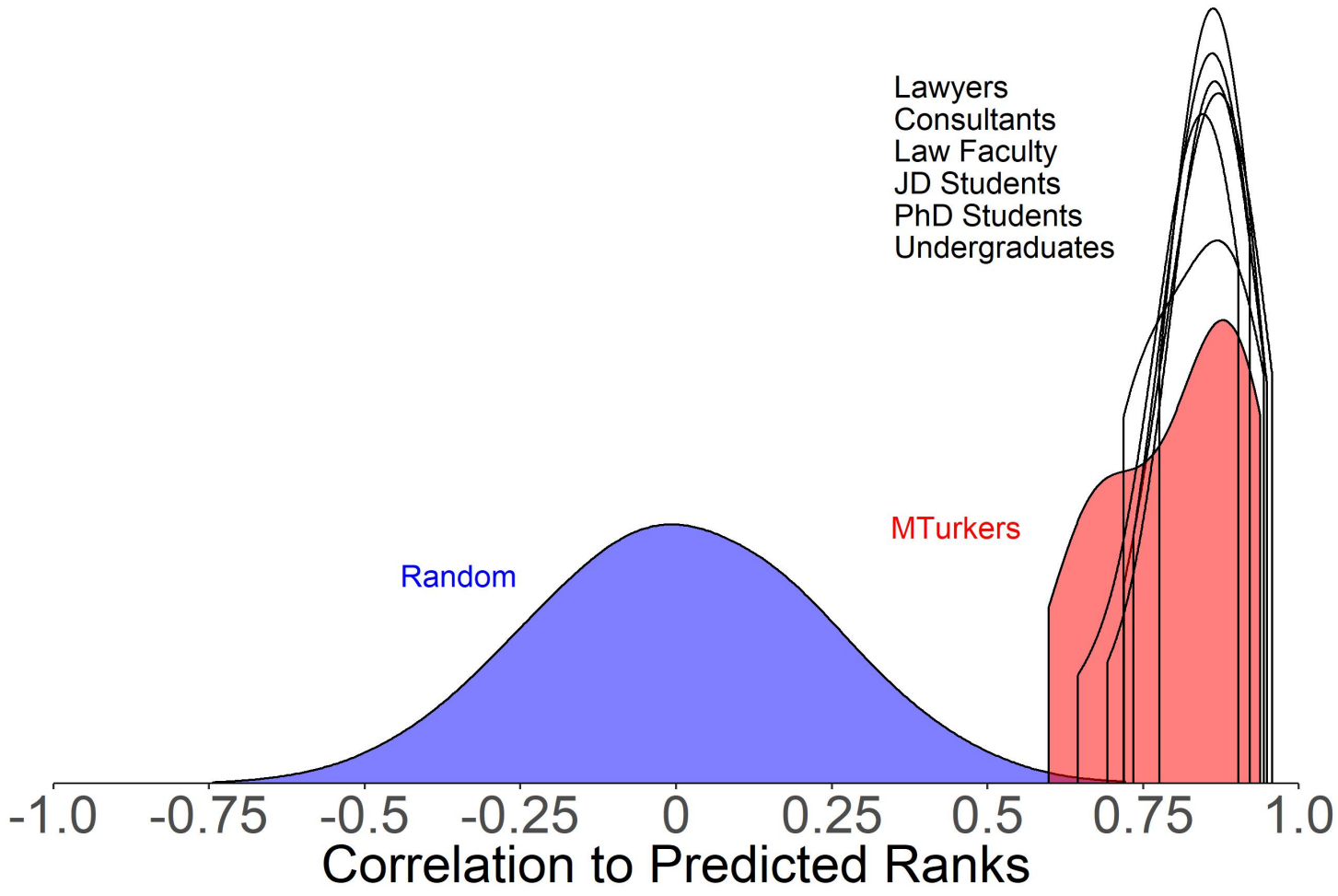

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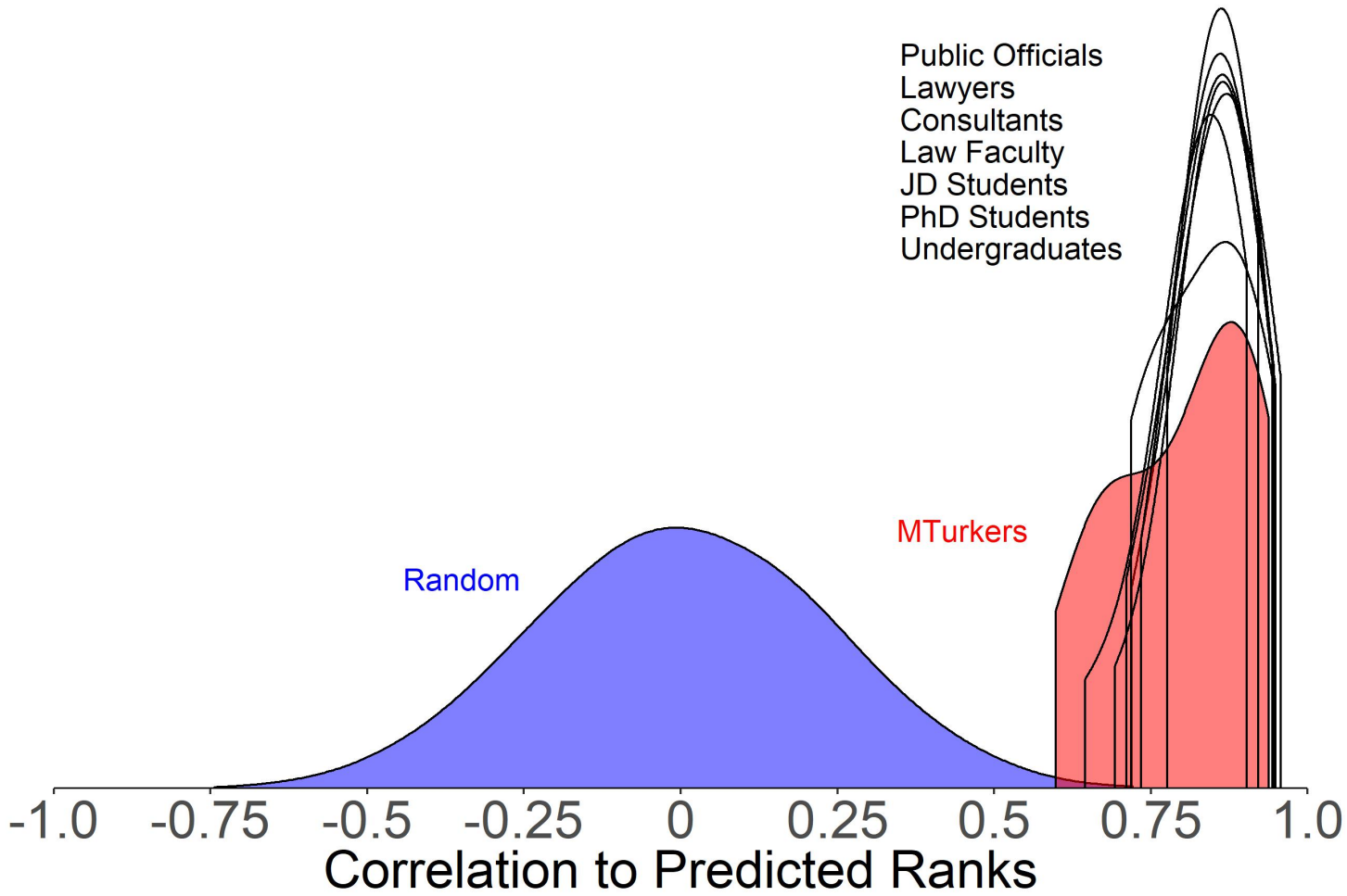

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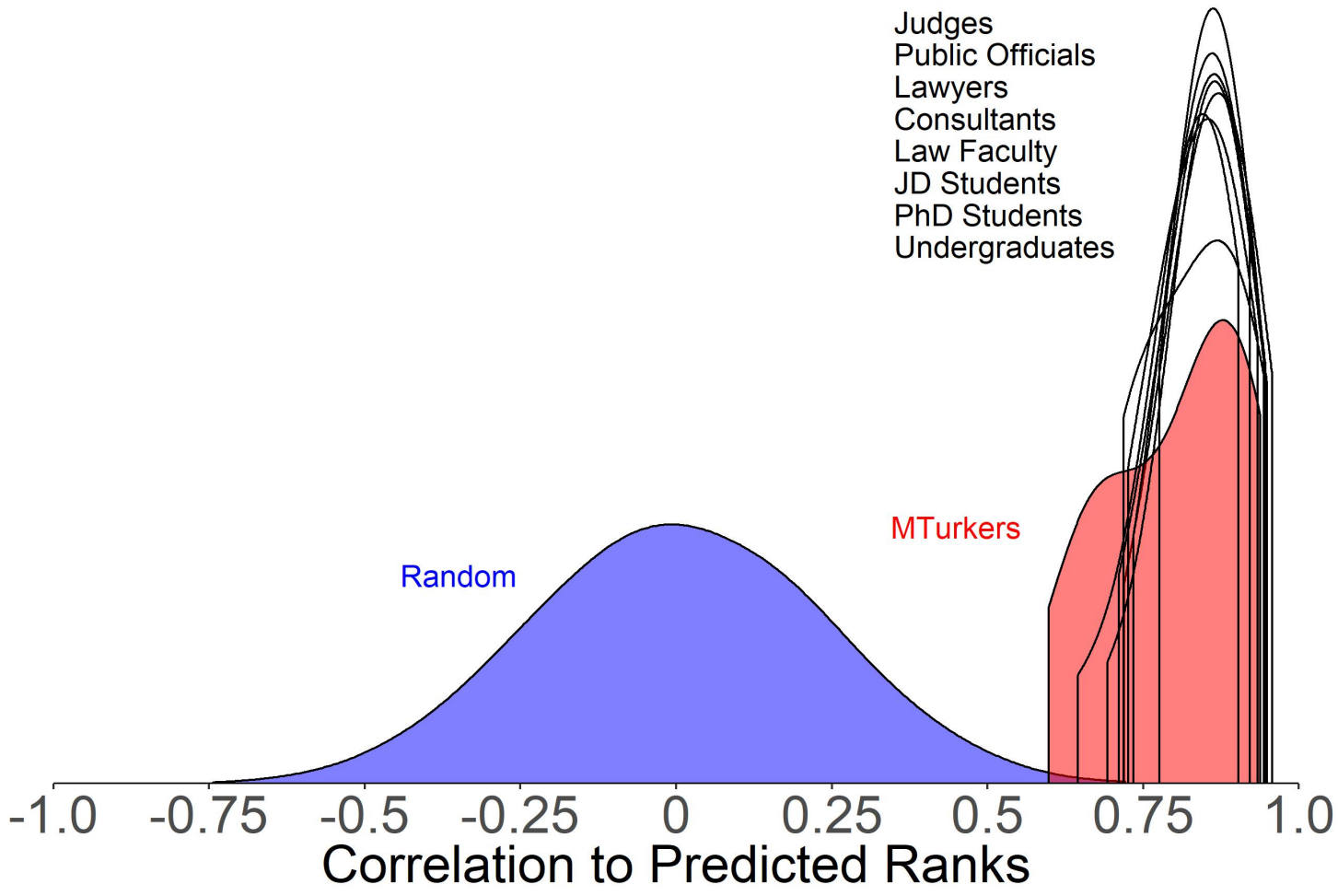

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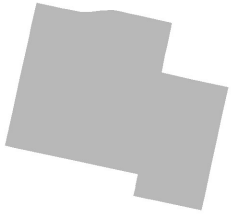
Boyce-Clark				

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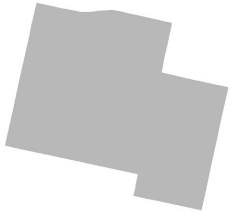
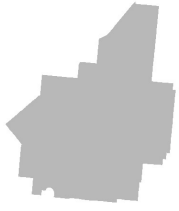
Boyce-Clark				
Length/Width				

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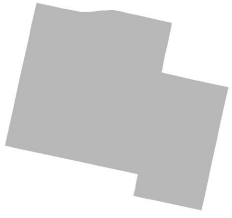
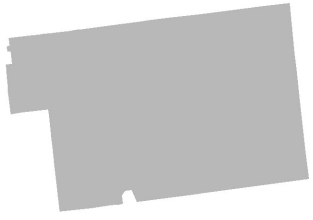
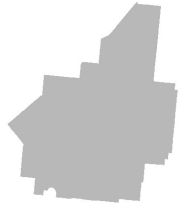
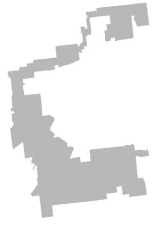
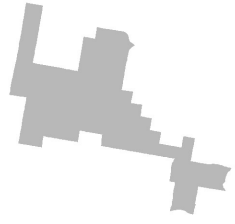
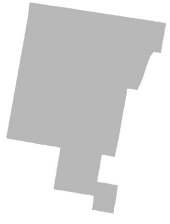
Boyce-Clark				
Length/Width				
X-Symmetry				

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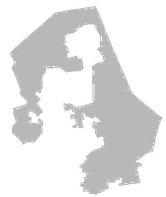
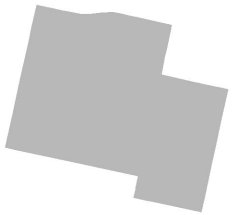
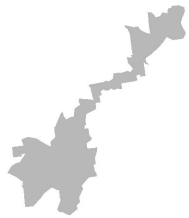
Reock				
Boyce-Clark				
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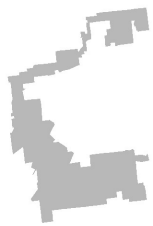
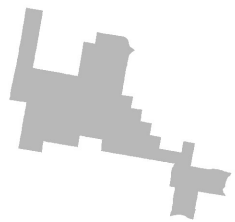
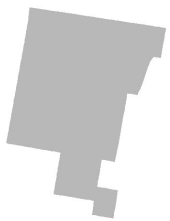
X-Symmetry				

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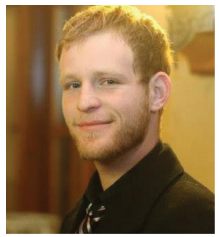
For more information



AaronRKaufman.com

GaryKing.org

MayyaKomisarchik.com

Paper, data, software, slides: j.mp/Compactness