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

Gary King[2]

Institute for Quantitative Social Science
Harvard University

University of Michigan, Statistical Learning Workshop, 4/18/2019

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

[2] GaryKing.org

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- Is this any way to run a democracy? Our discipline ought to help.

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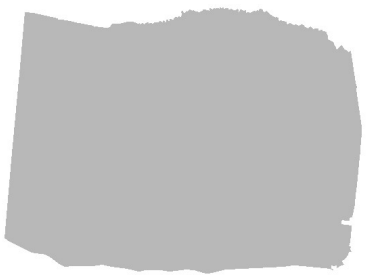

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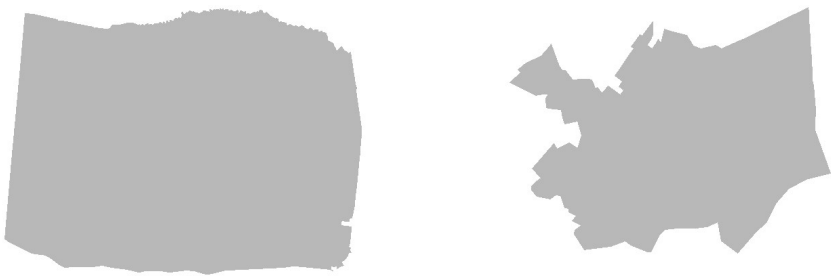

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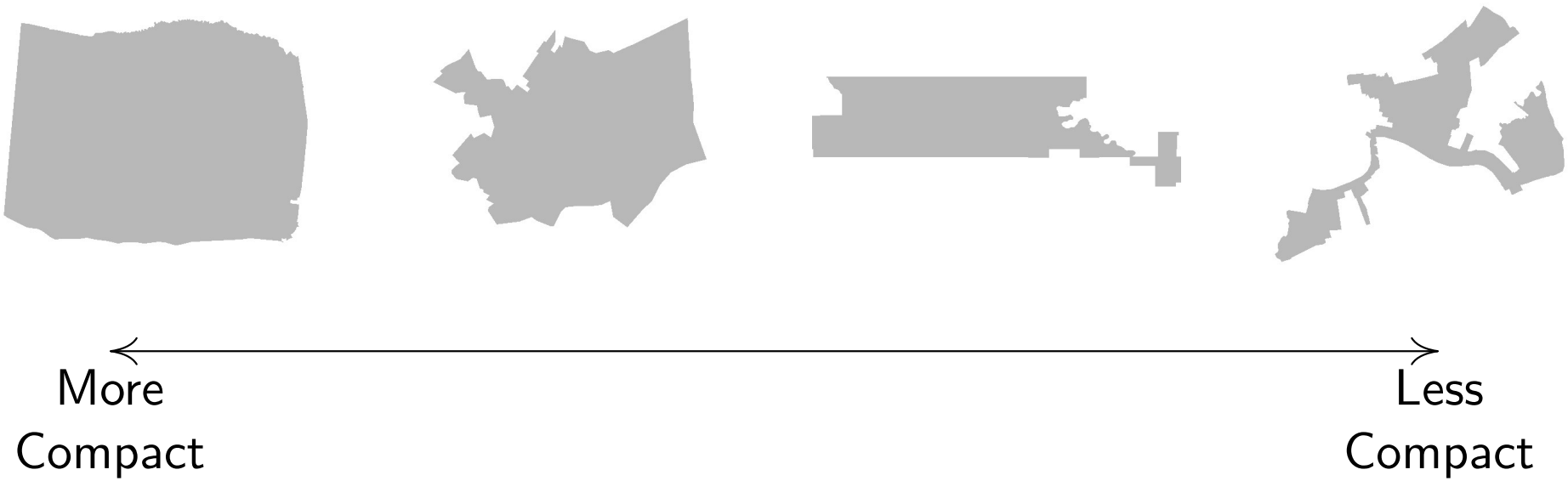

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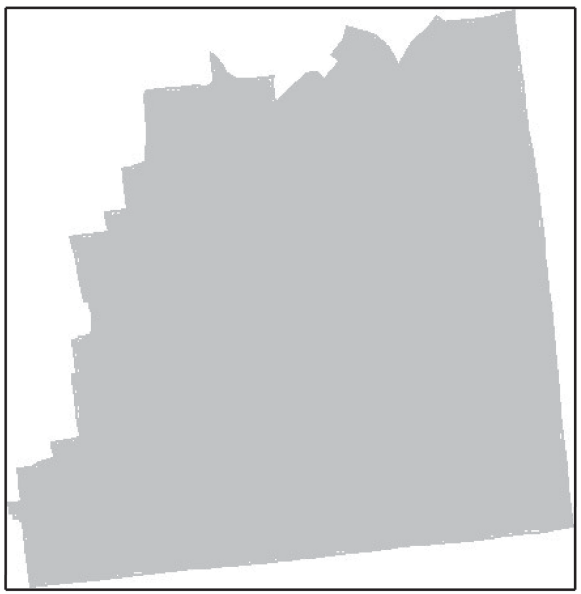

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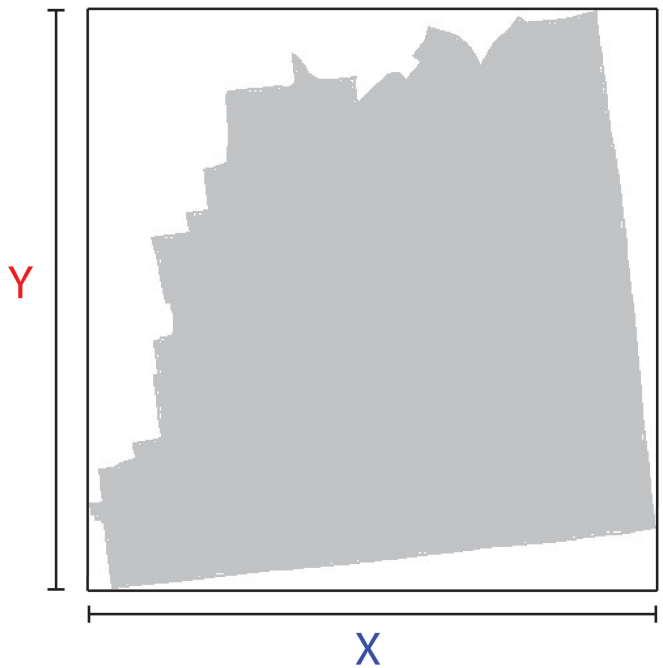

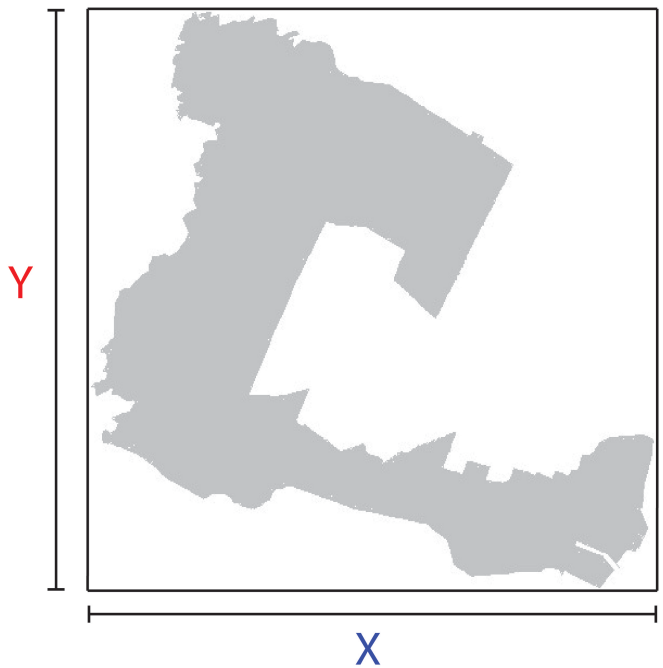

Measure 1: Length/Width Ratio of Min Bounding Box

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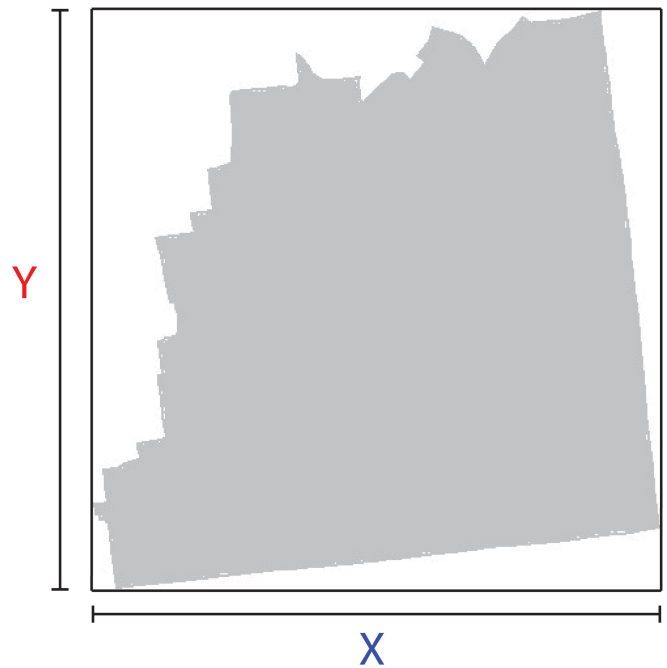

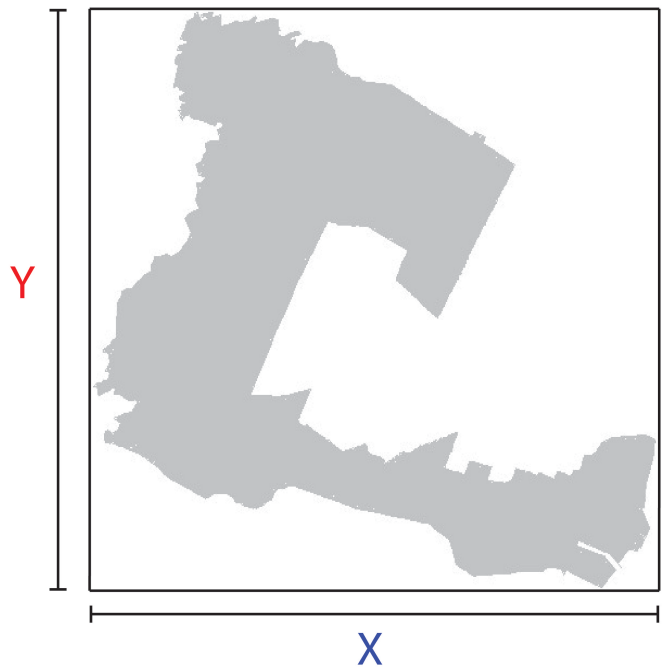

In both districts: $X/Y \approx 1.30$

Measure 2: Reock, District / Bounding Circle Areas

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Circular districts are most compact

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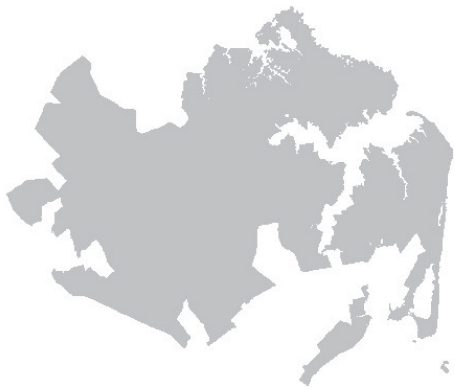

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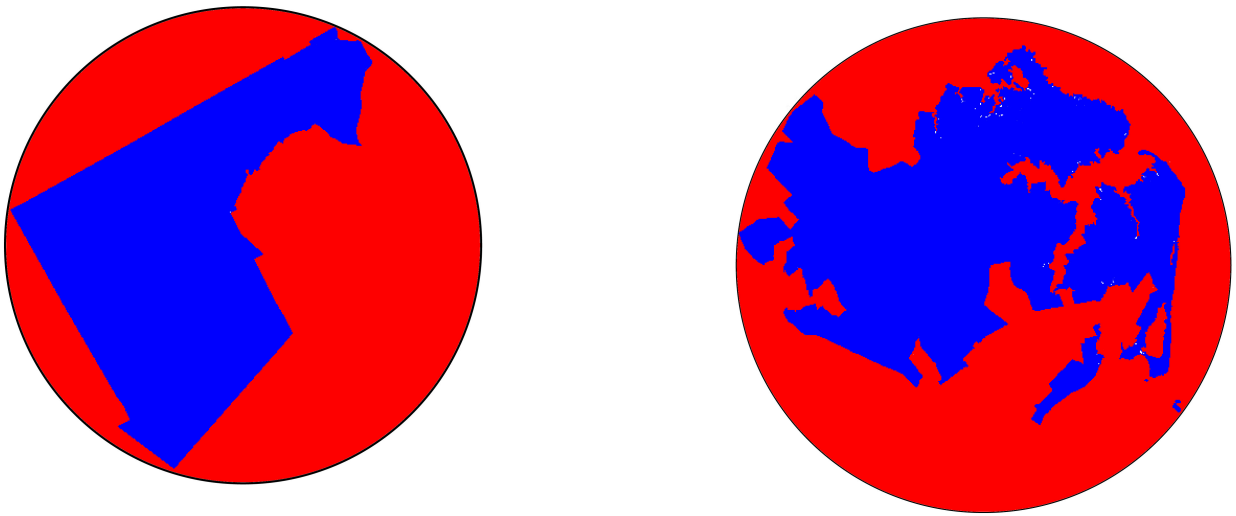

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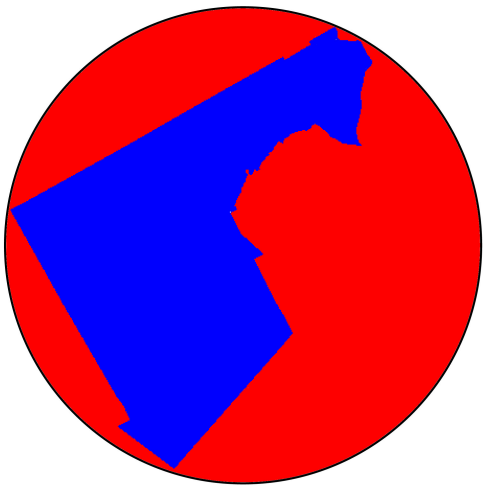

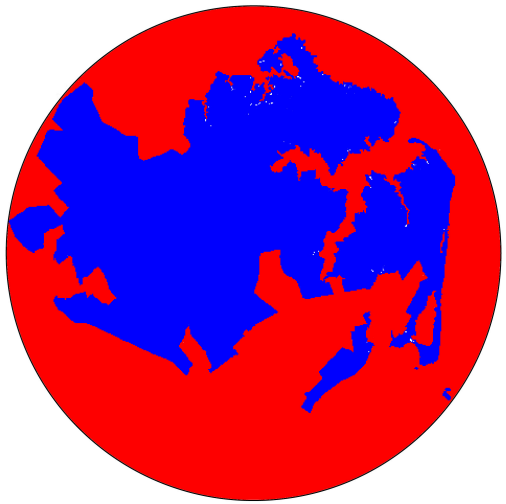

In both cases, $X/(Y + X) \approx 0.37$

Measure 3: Boyce-Clark, Variation in Centroid Deviations

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All travel distances from center should be similar

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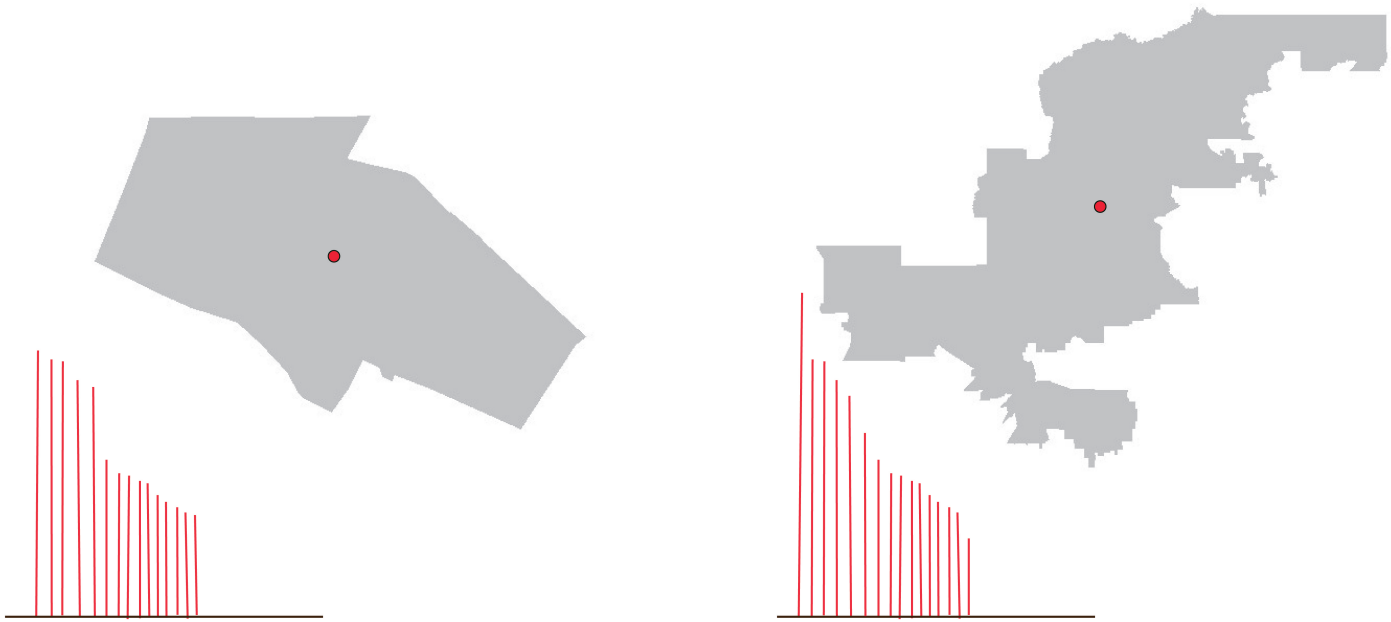

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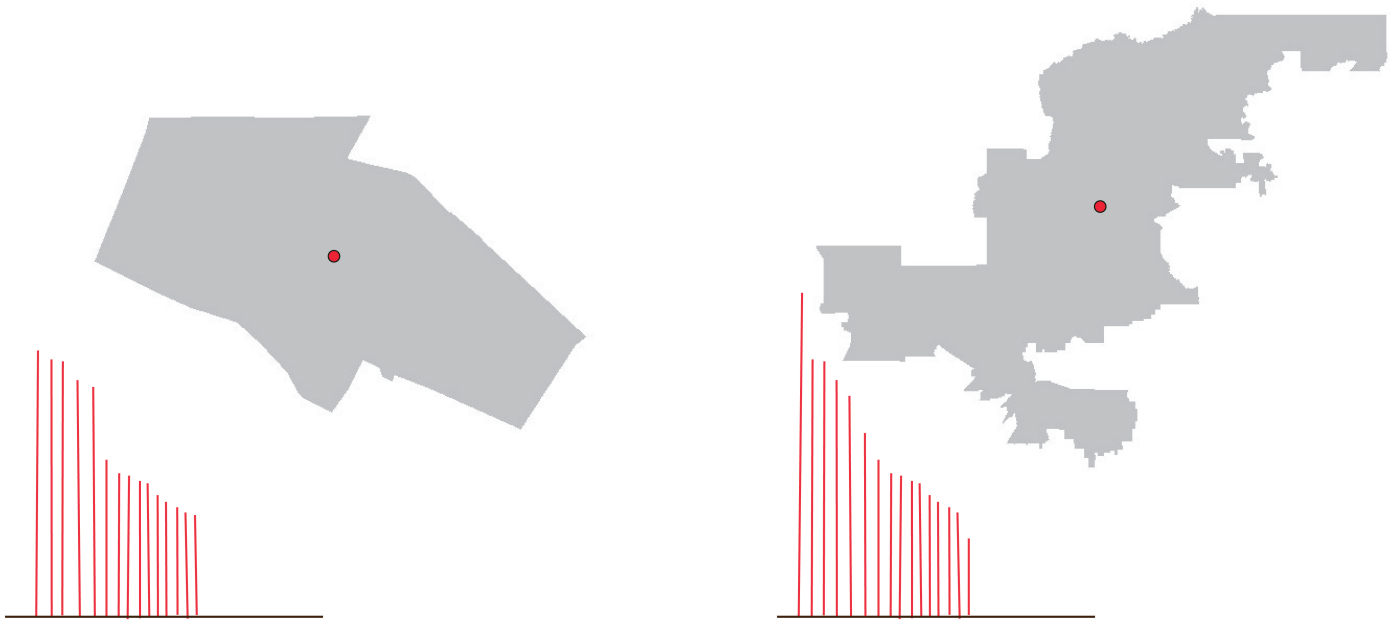

In both cases, $\text{MAD}(r)/\bar{r} \approx 0.31$

A Brief Rotational Invariance Interlude:

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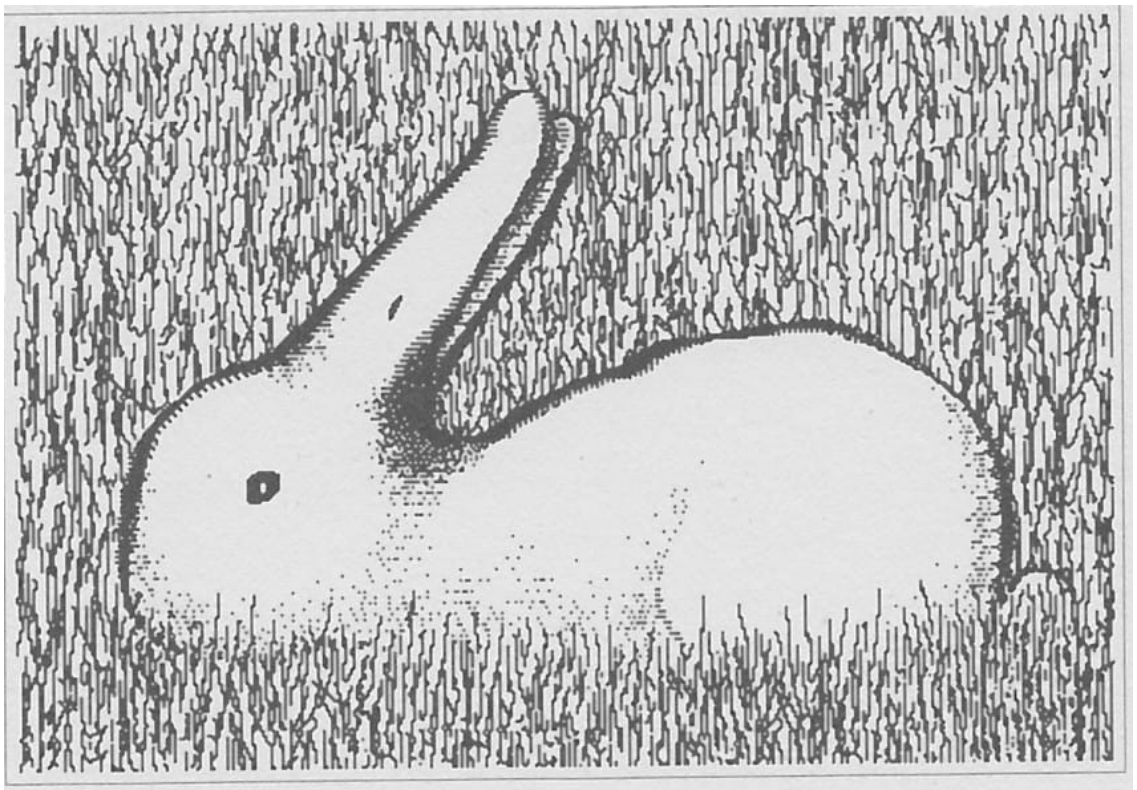
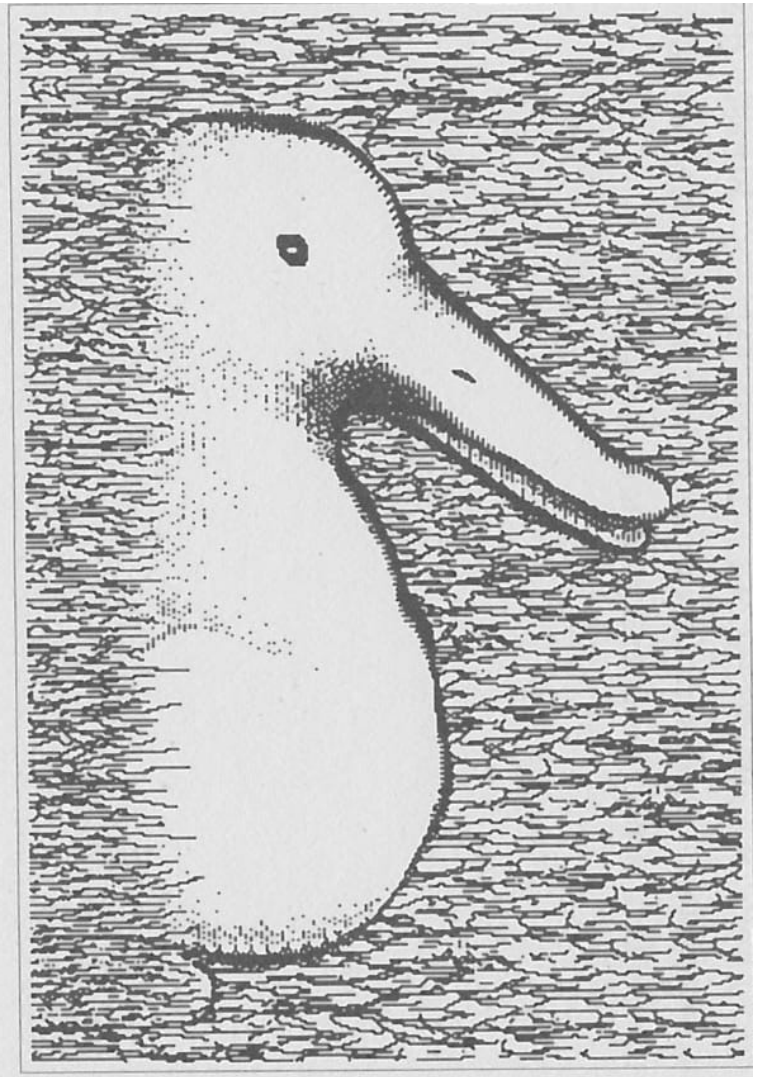
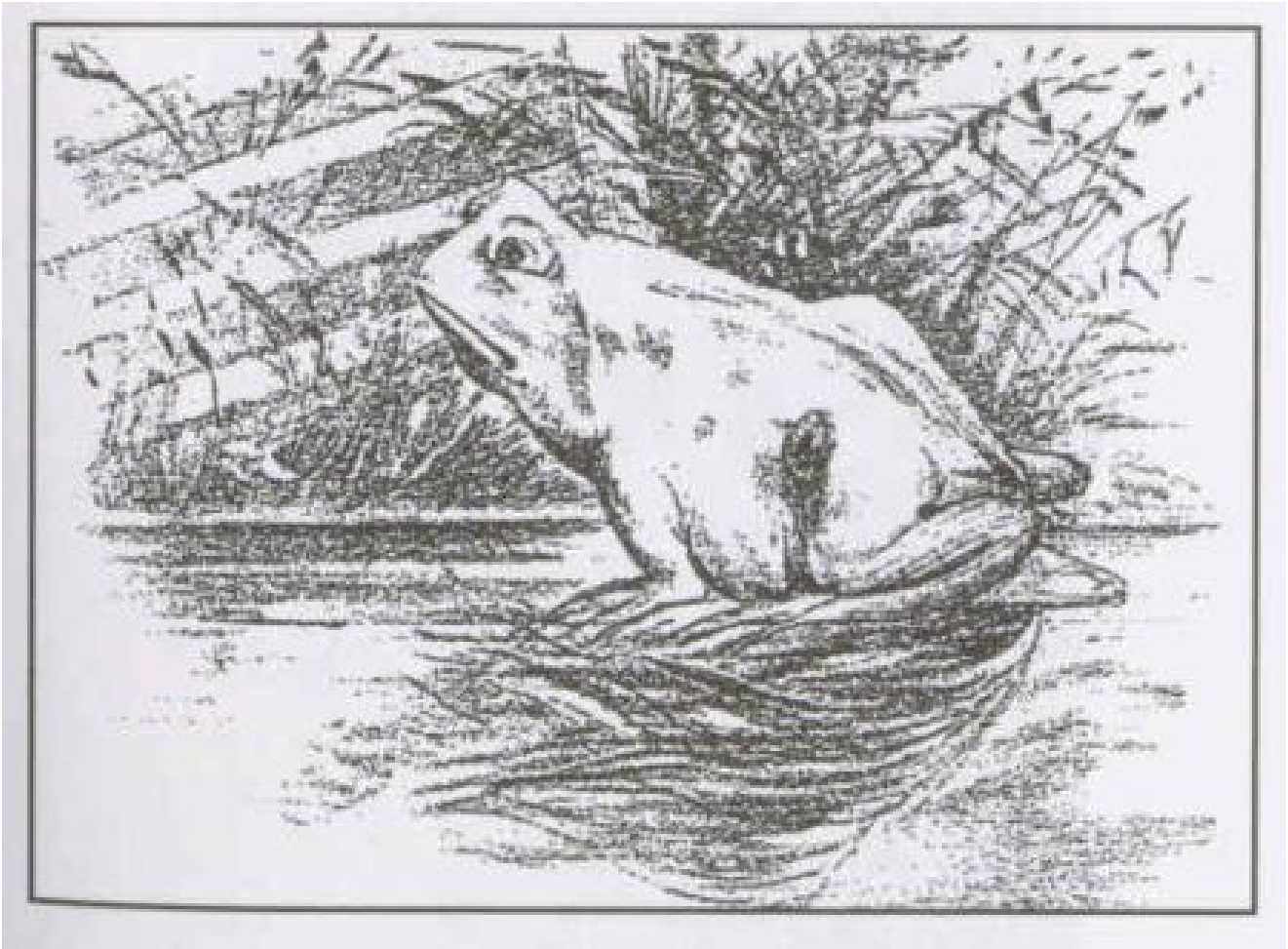
A Brief Interlude on Perception: See the Rabbit?



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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  - Nearly 100 proposed

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  - Blind to what humans perceive
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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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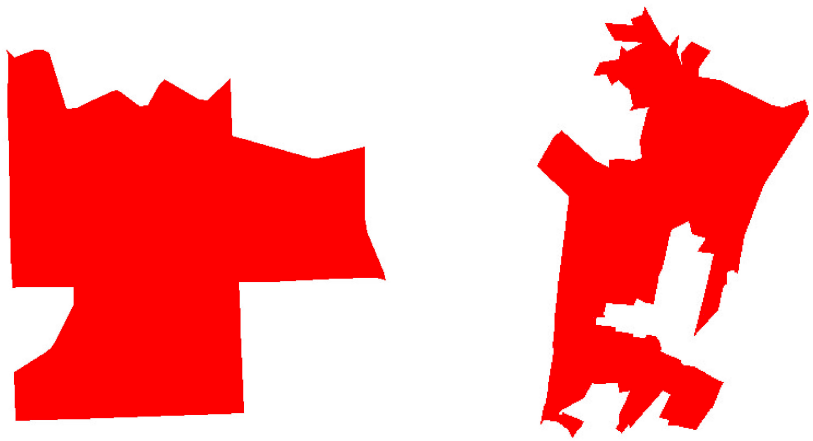

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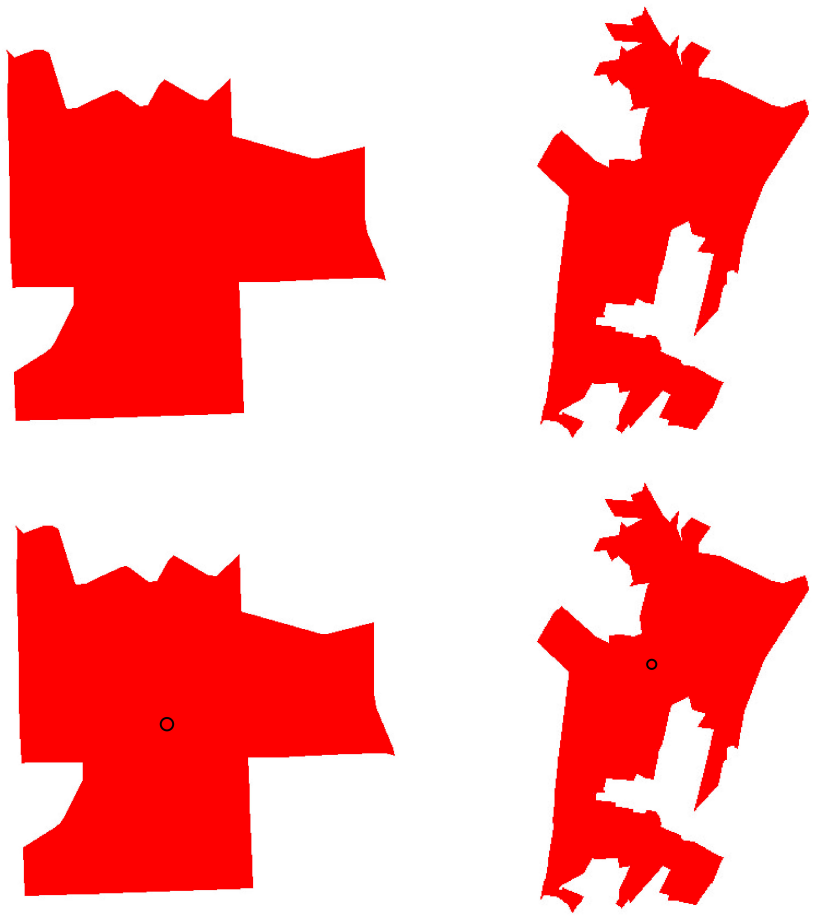

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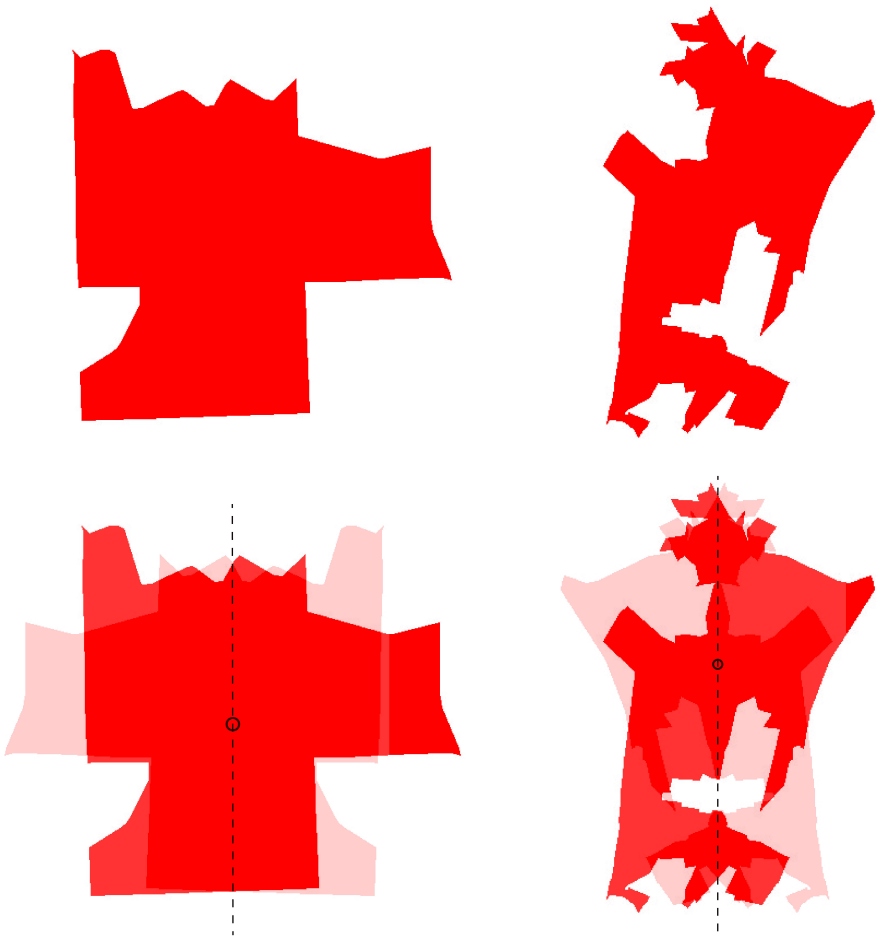

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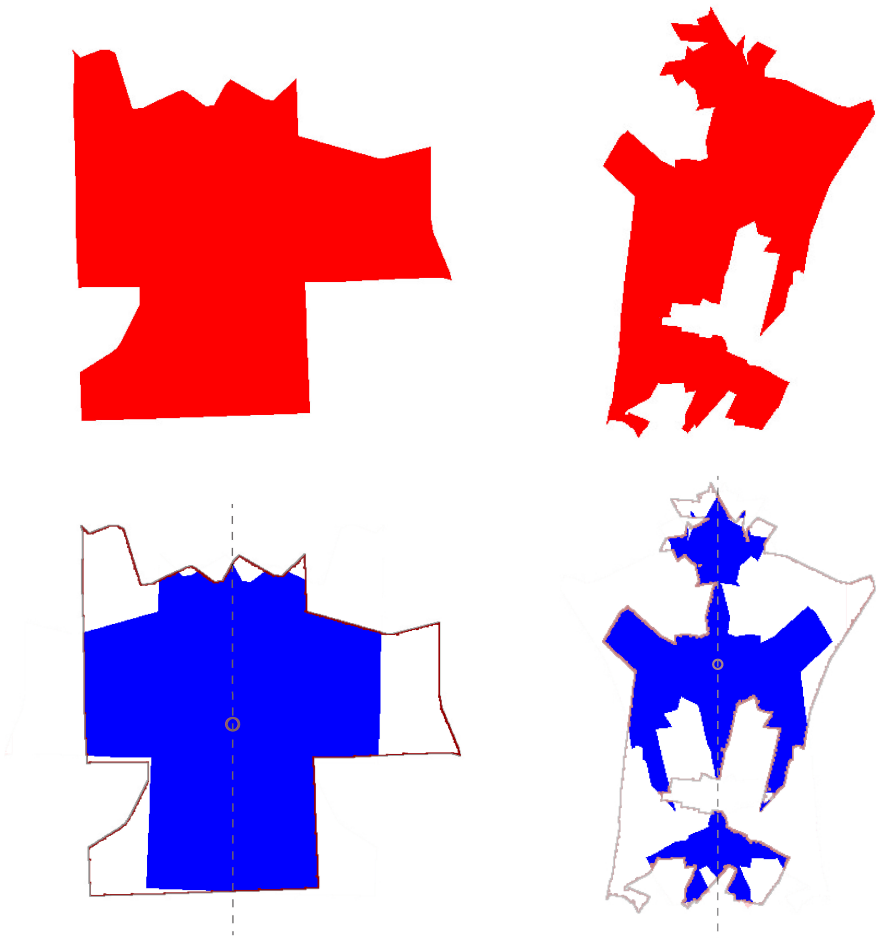

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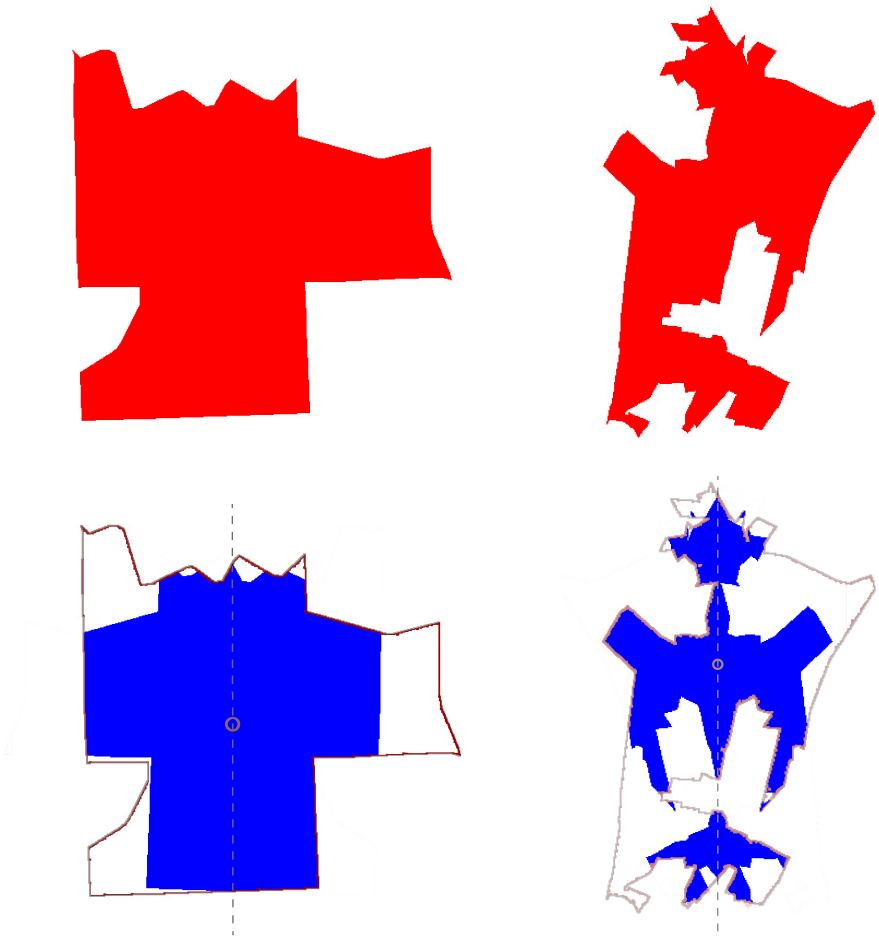

In both cases, Overlap/Original Area ≈ 0.34

New Measure 2: Number of Visually Significant Corners

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Computer vision algorithm identifies "objects" in photos

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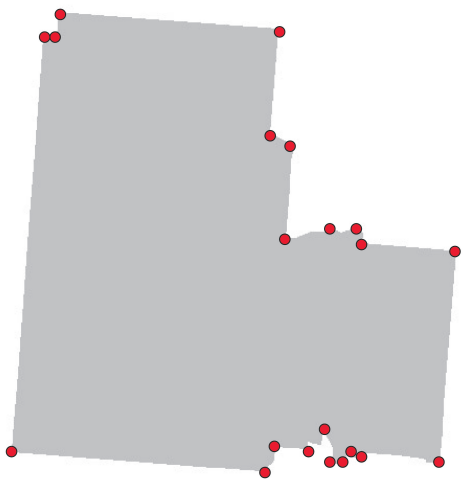

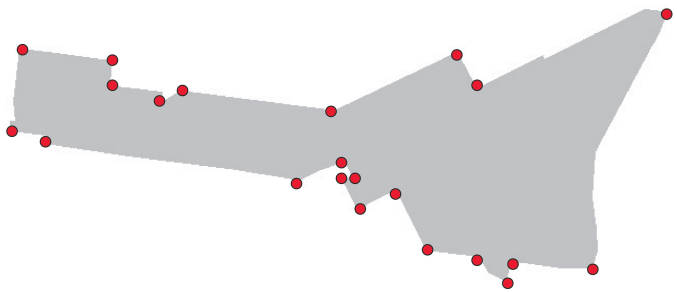

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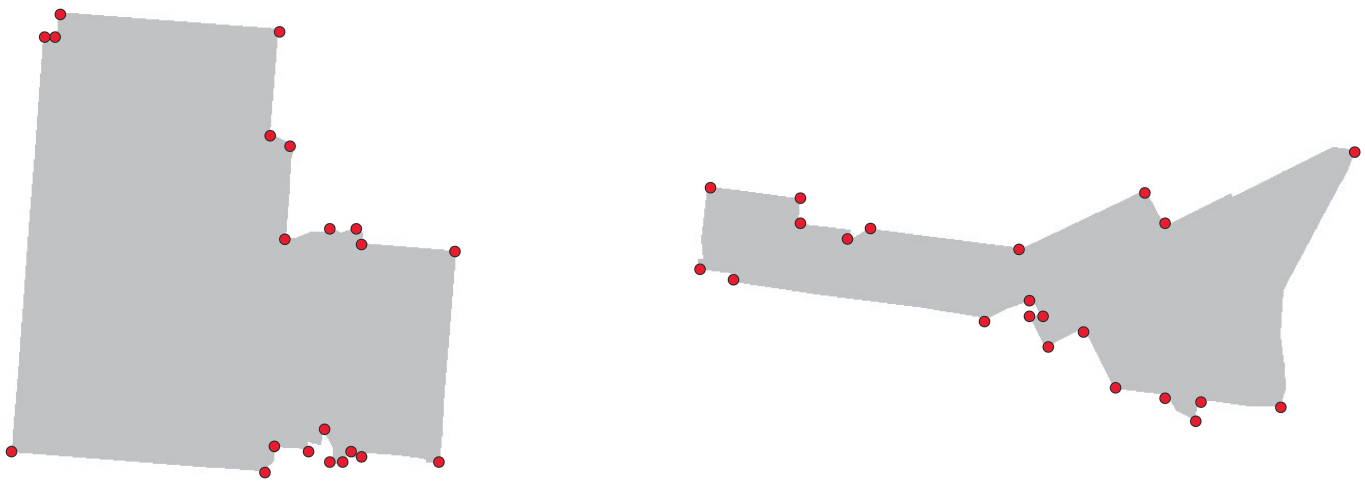
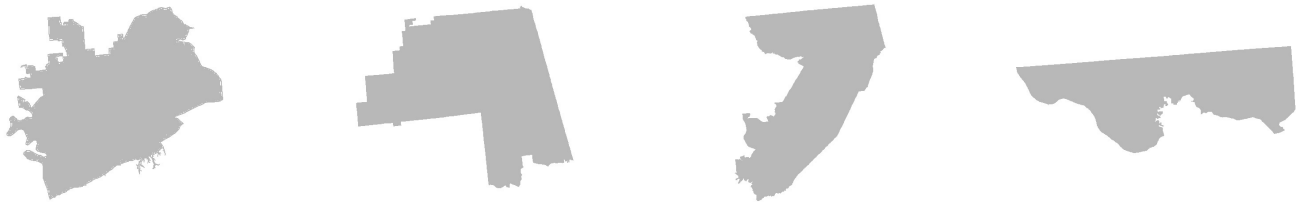


Both districts have 21 significant corners

Which is more compact?



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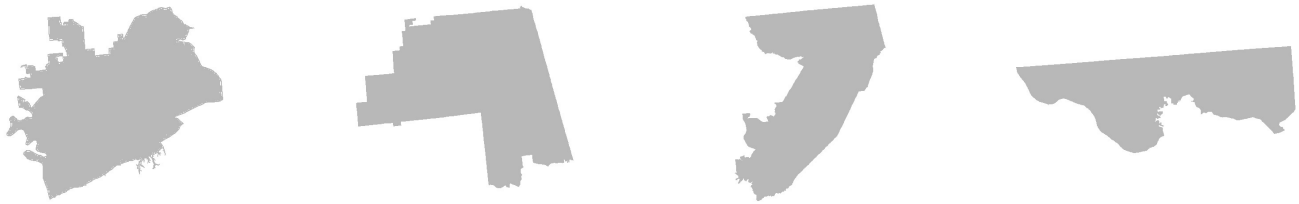

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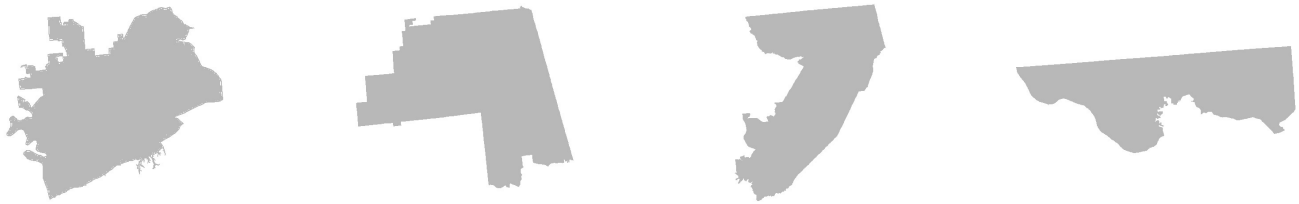

Convex Hull	4	3	2	1

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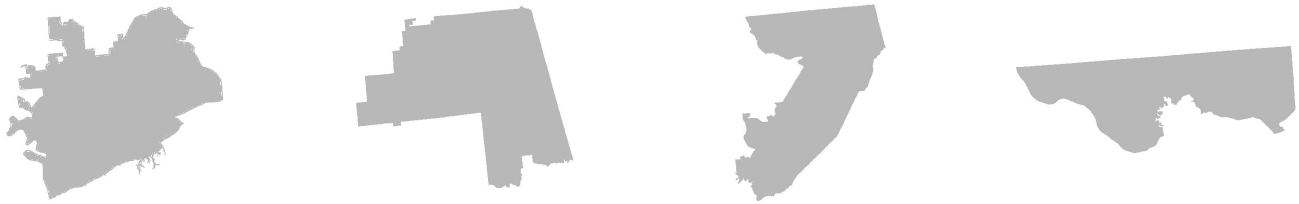

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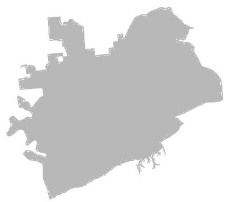
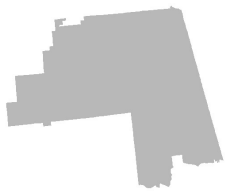

Convex Hull	4	3	2	1
Reock	1	2	3	4
Polsby-Popper	4	1	2	3

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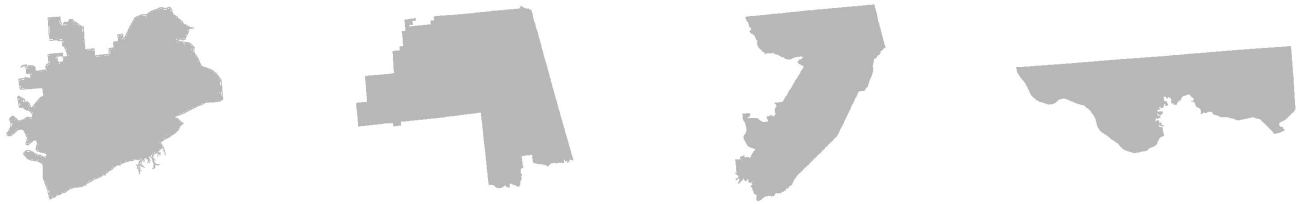

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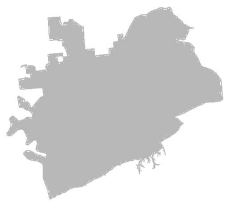
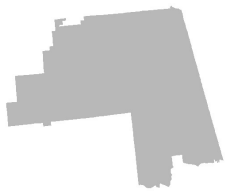

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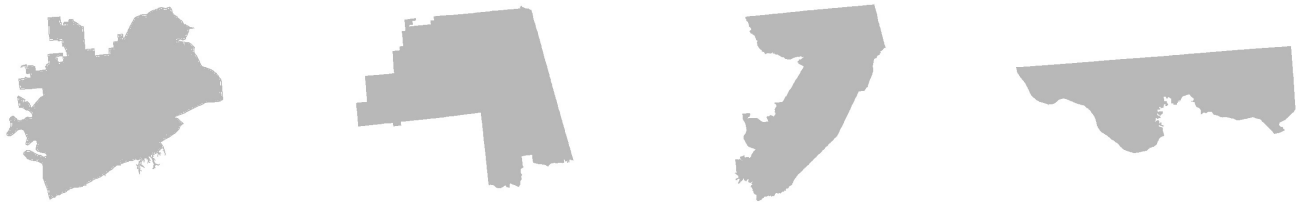

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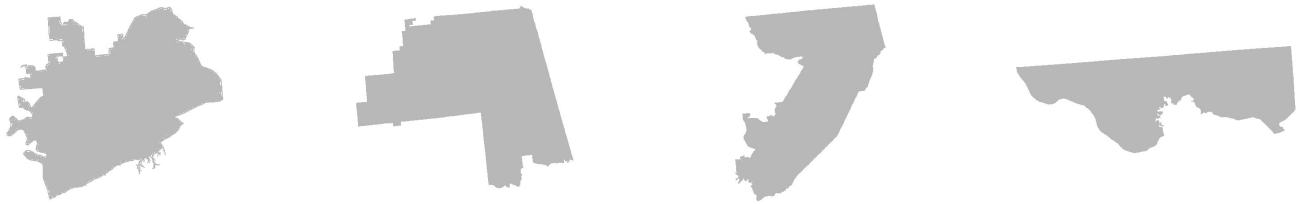

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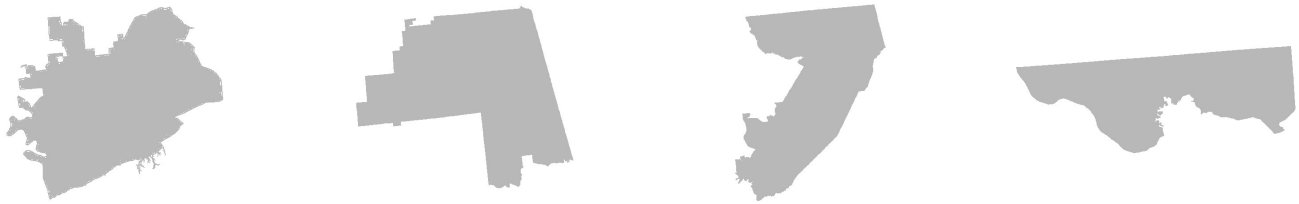

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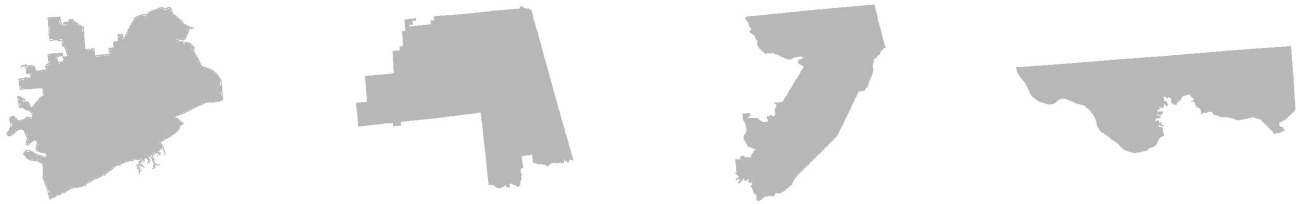

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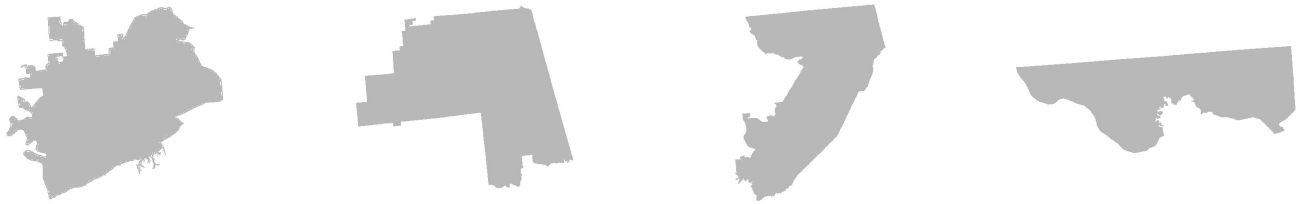

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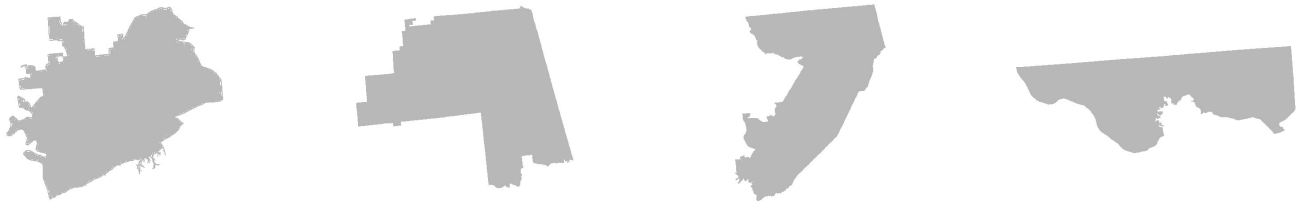

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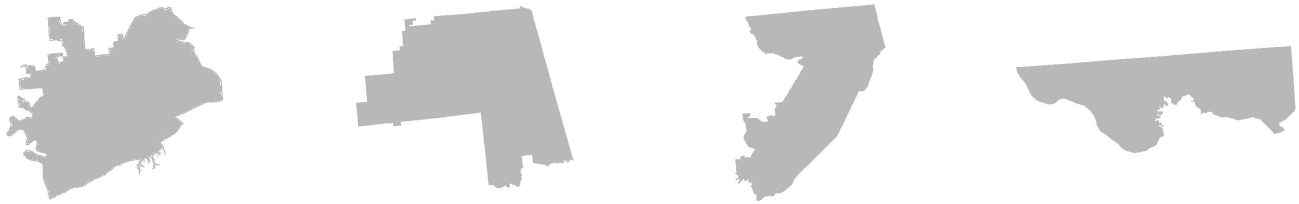

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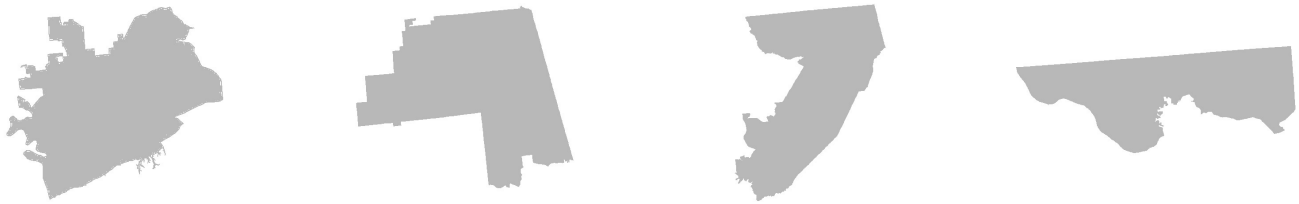

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Spanning the Academic–Legal Divide

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  - Public officials and many other types of people:

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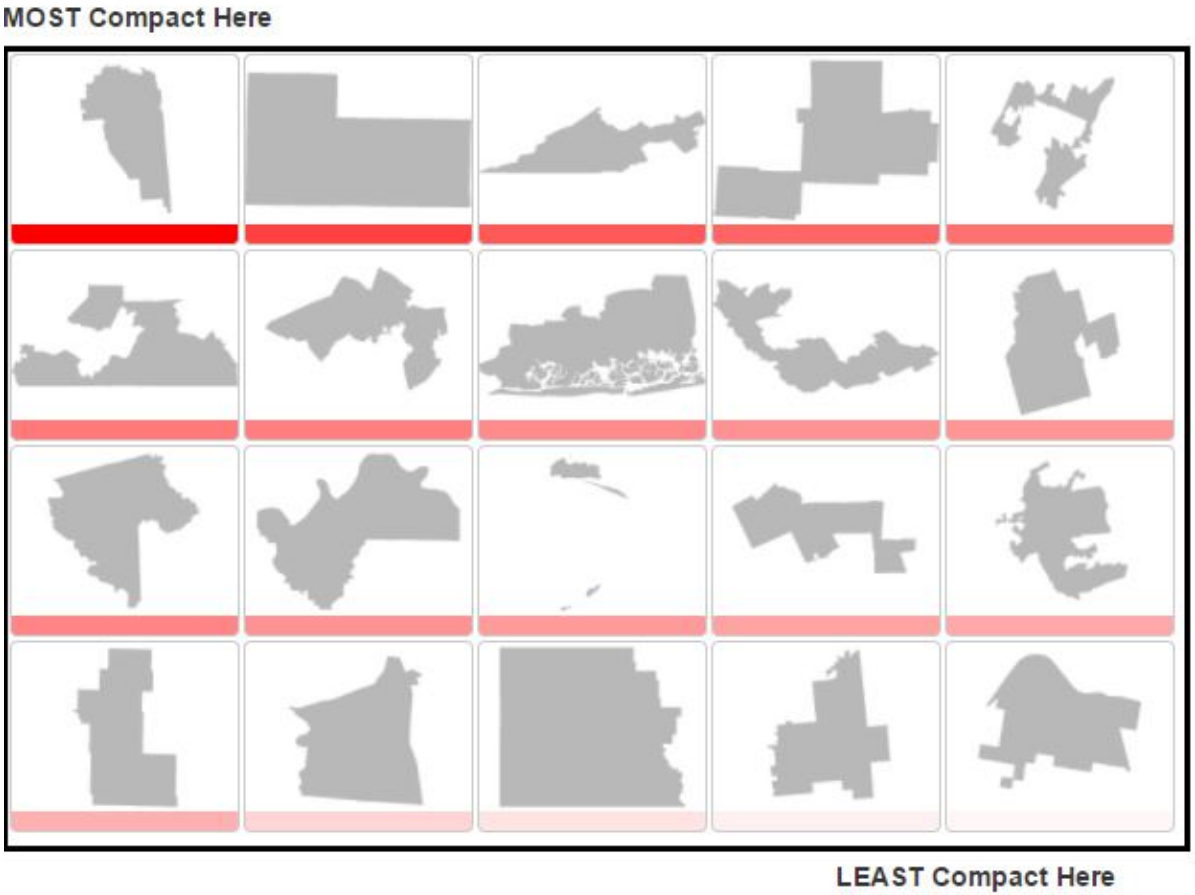
Full Ranking — on line



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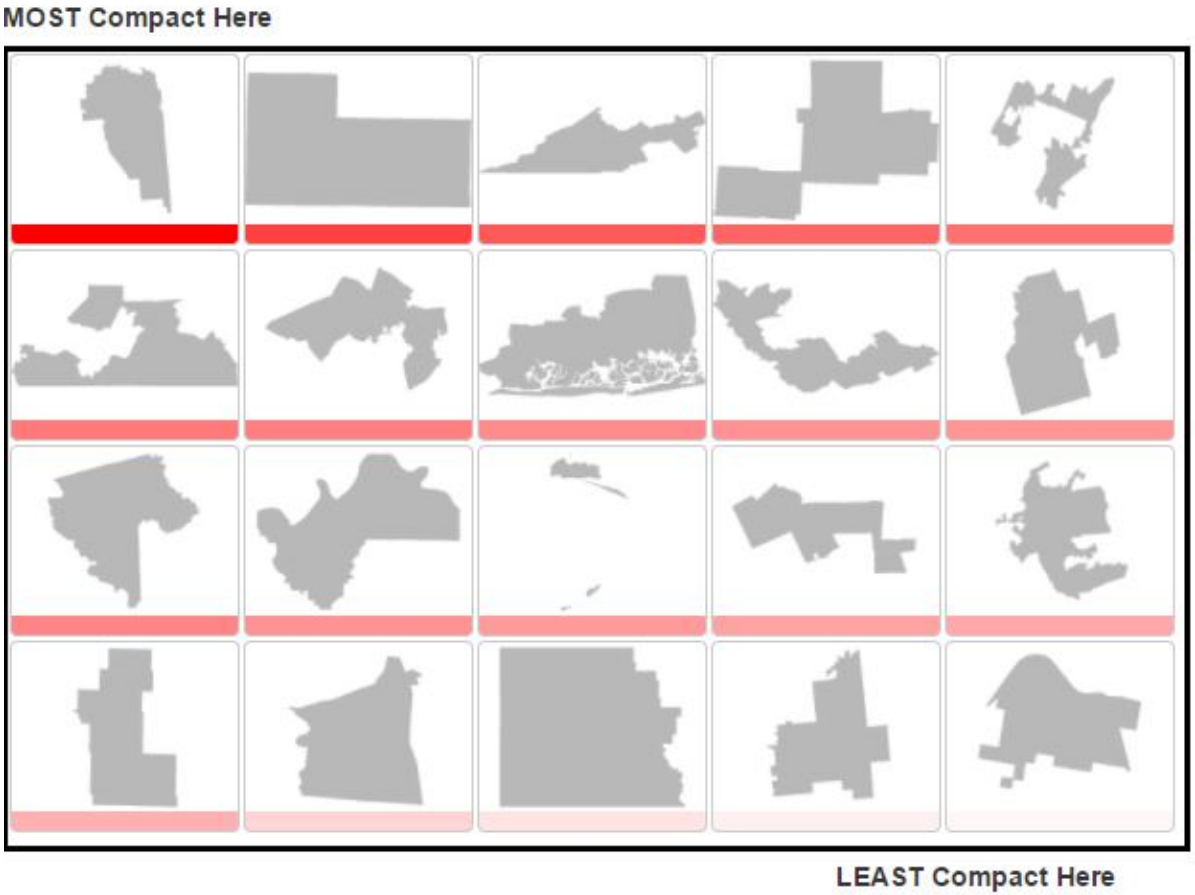

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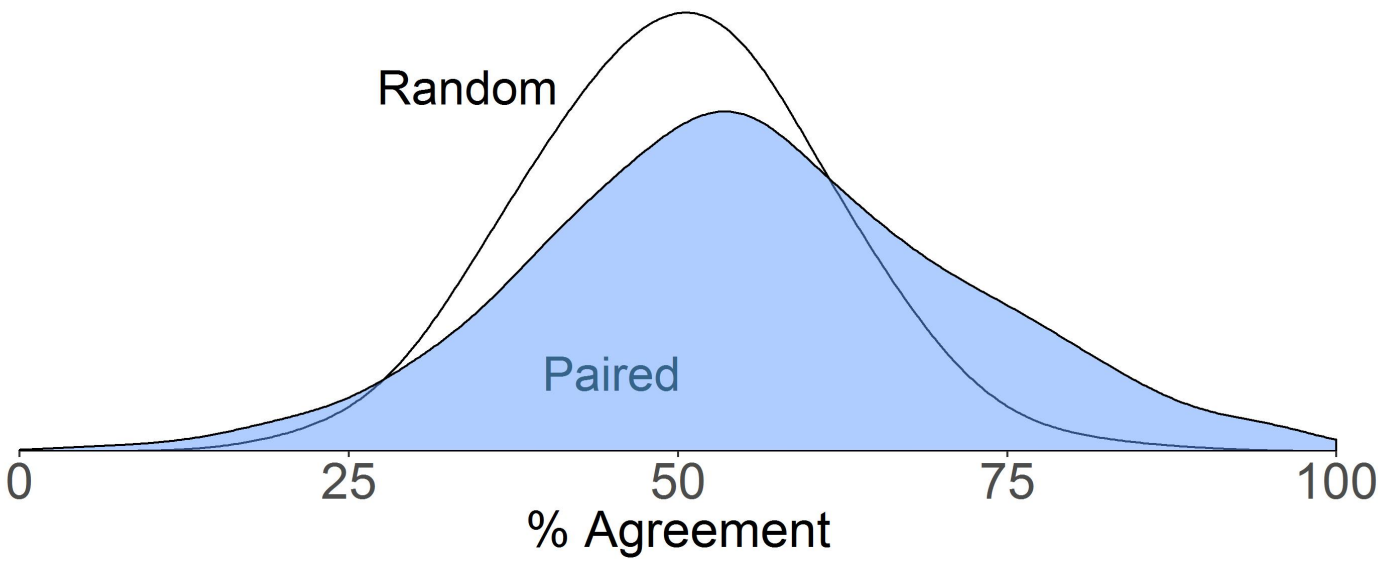

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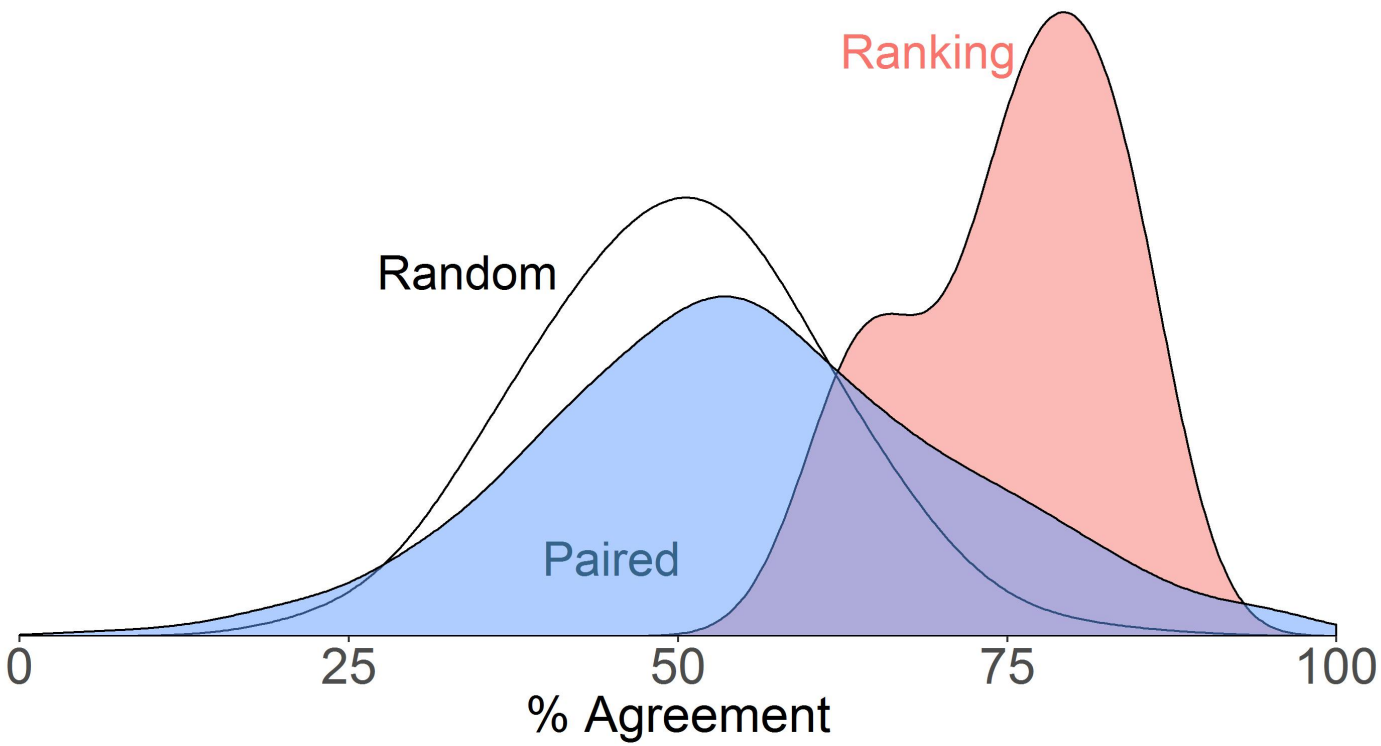

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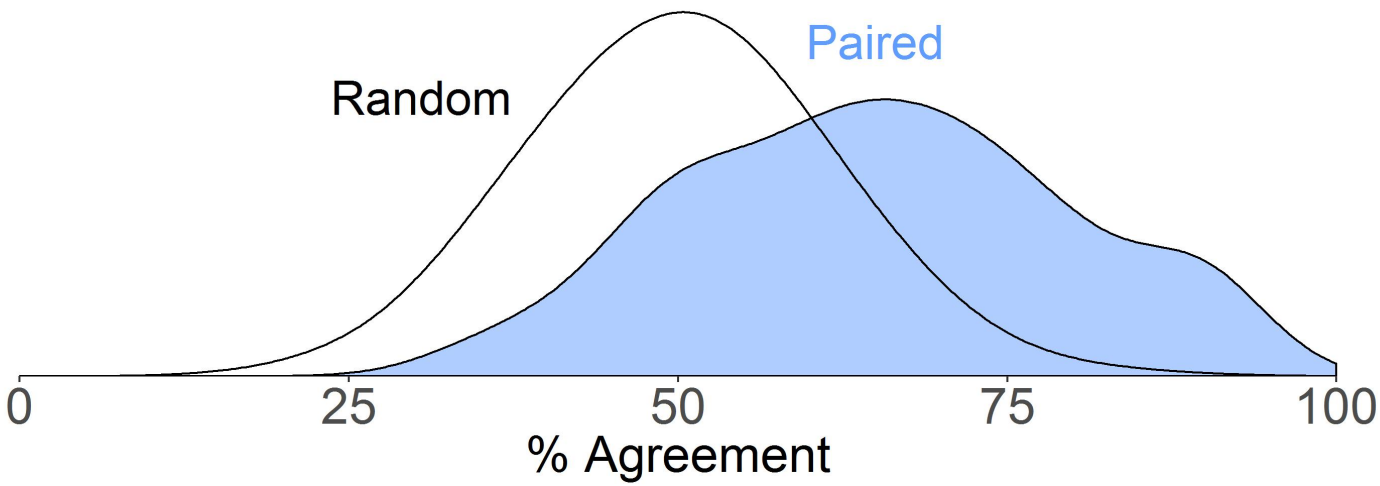

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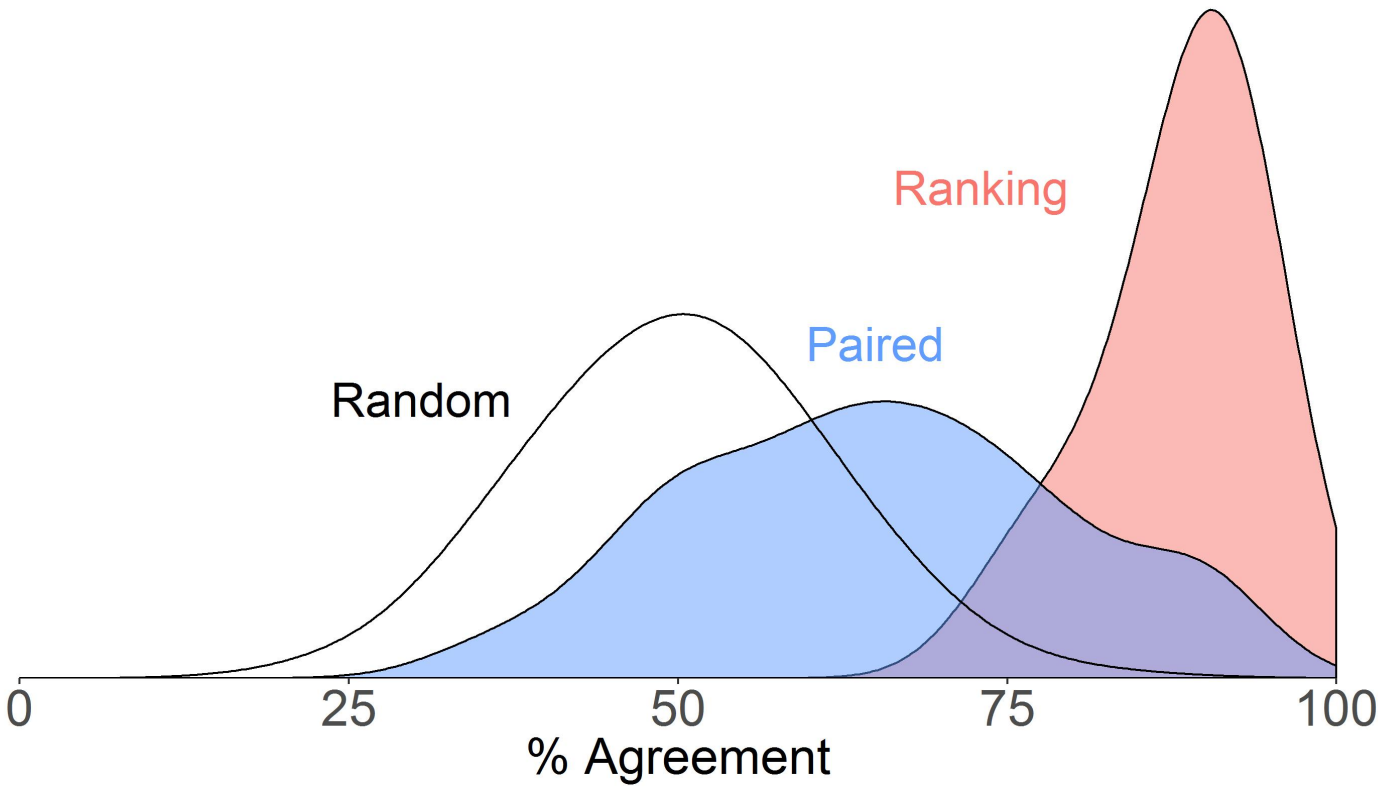

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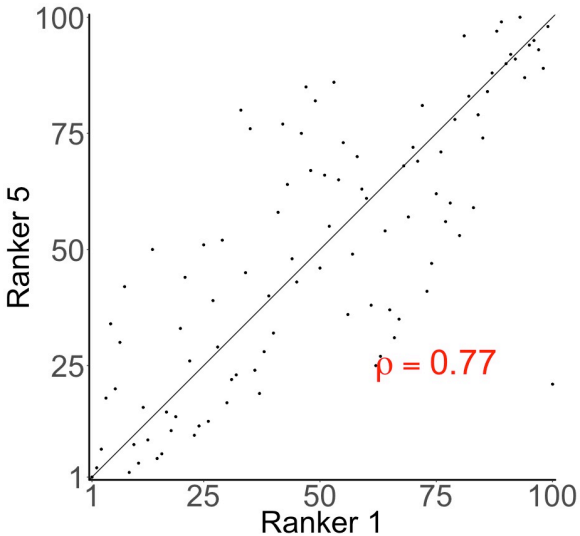

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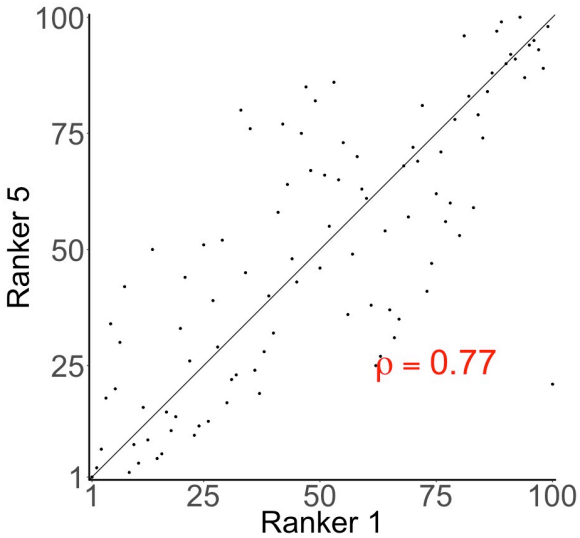

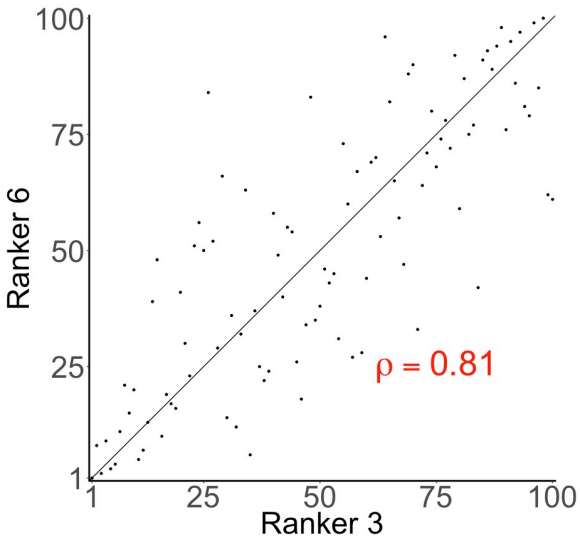

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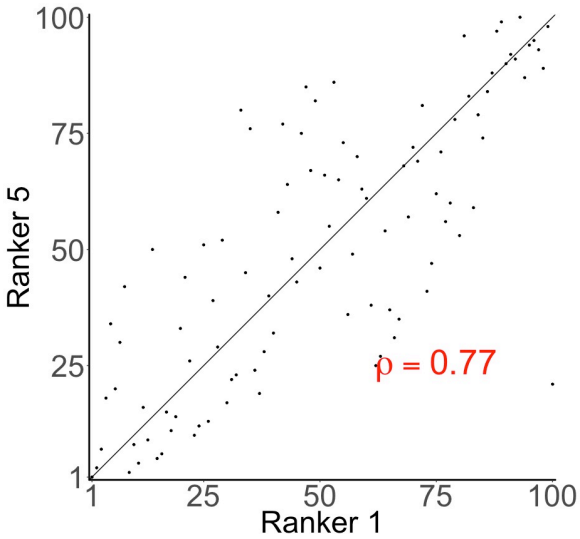

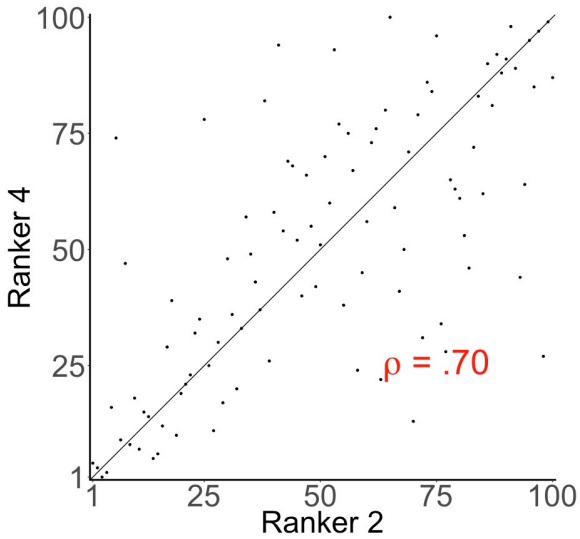

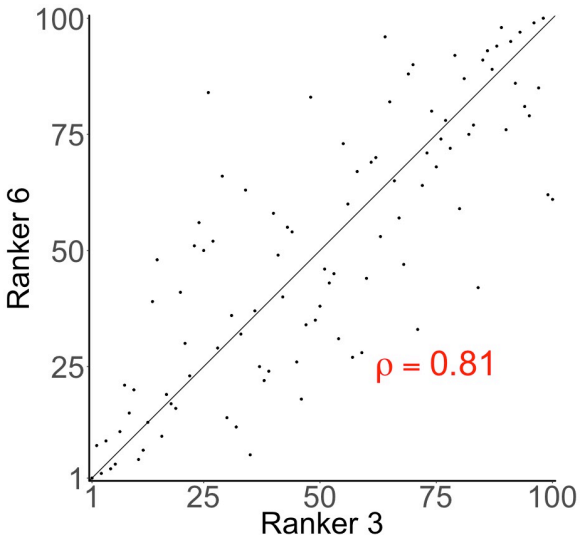

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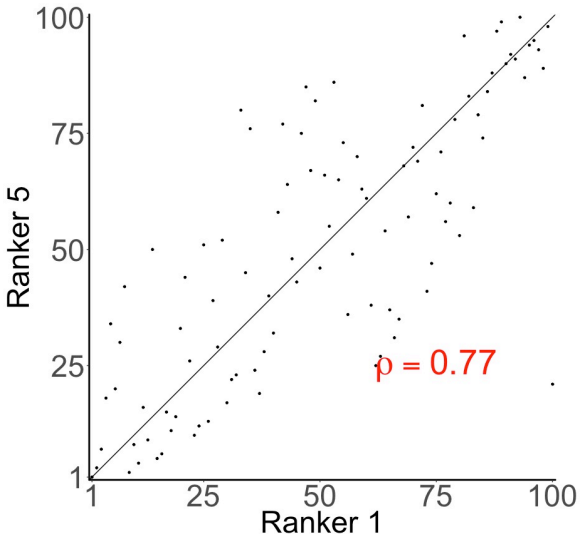

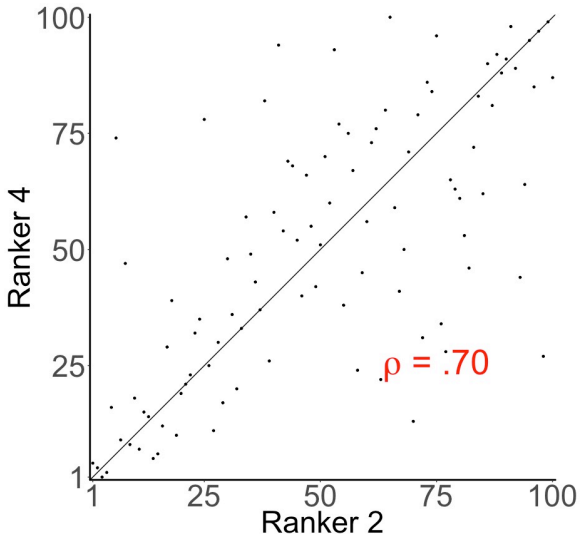

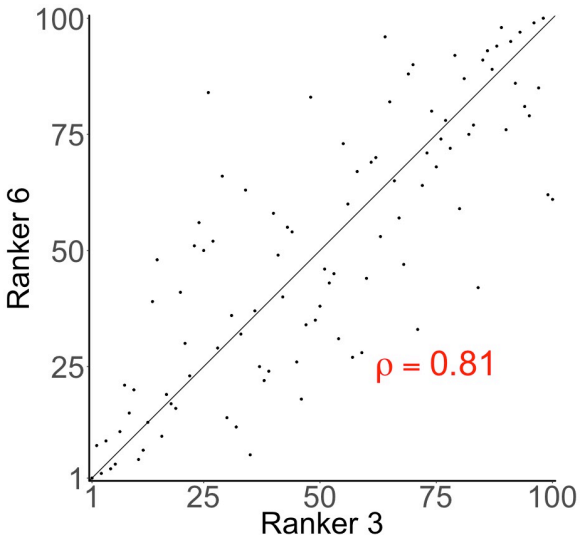

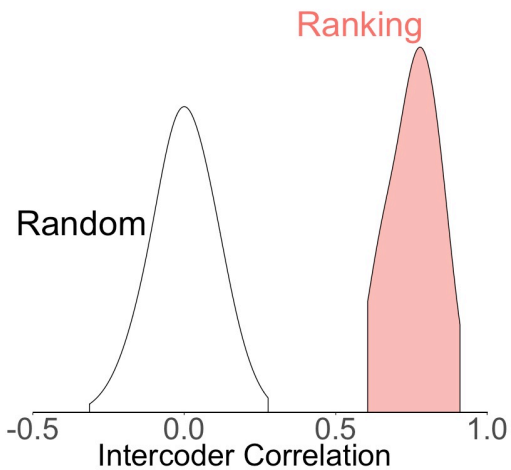

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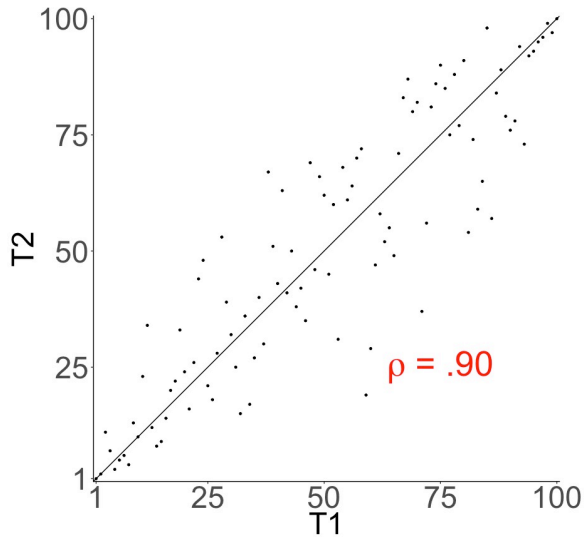

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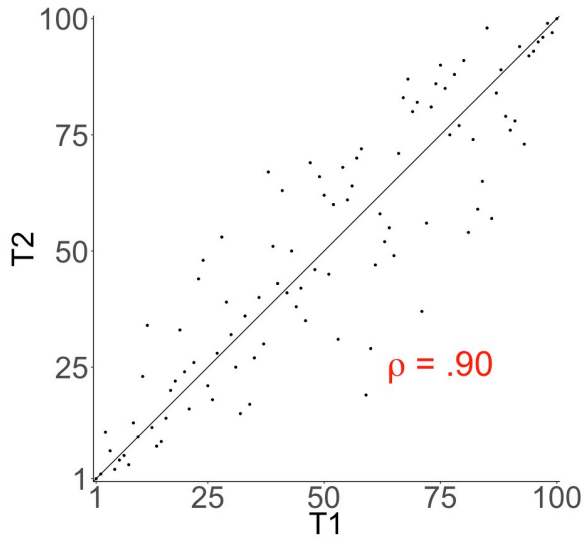

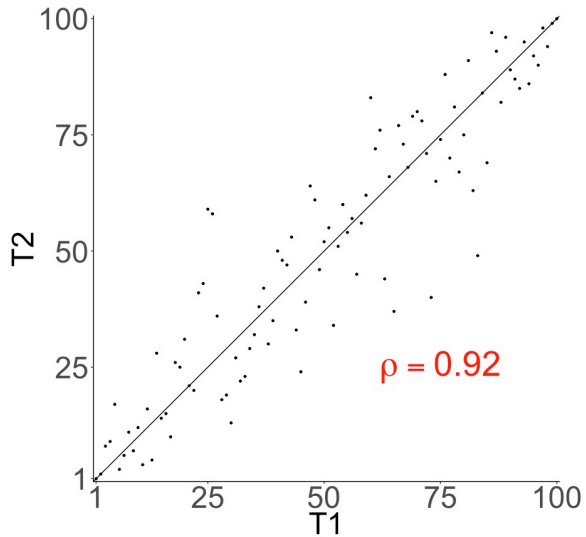

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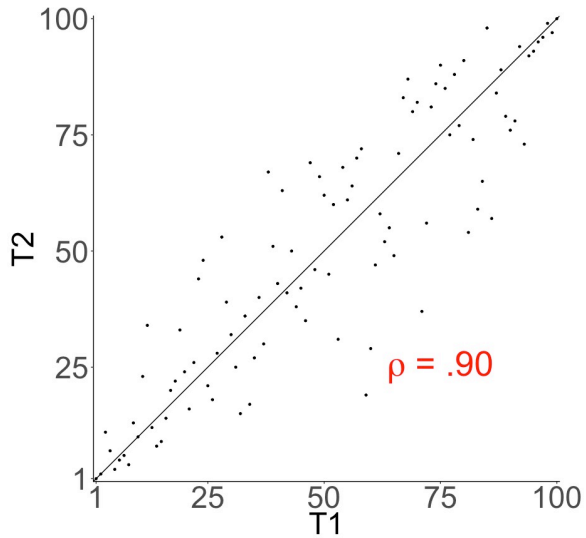

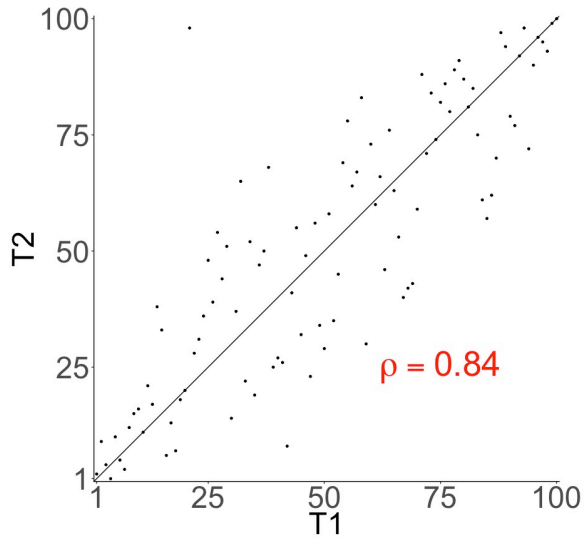

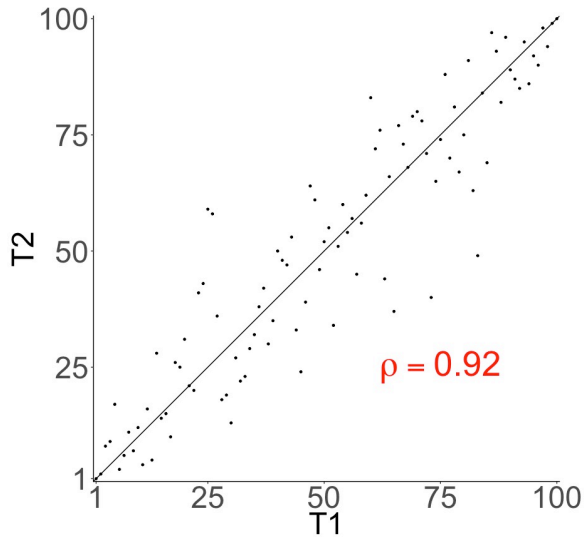

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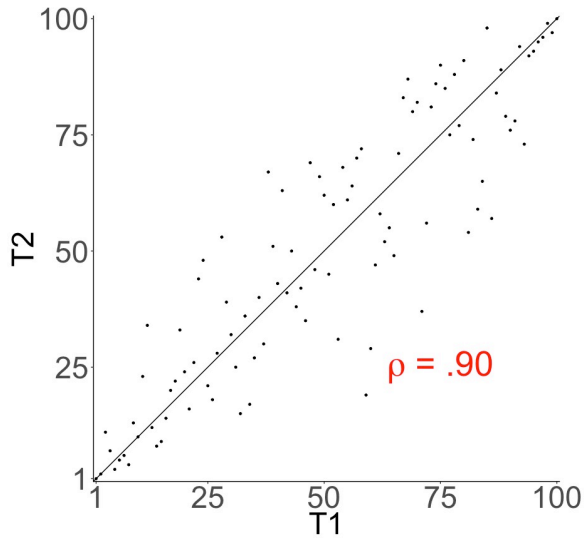

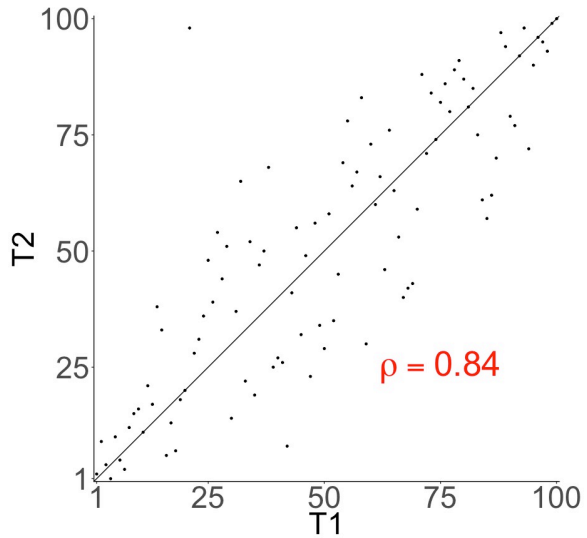

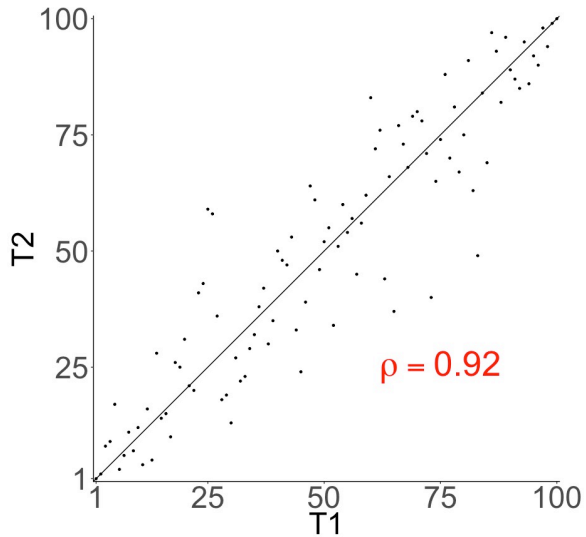

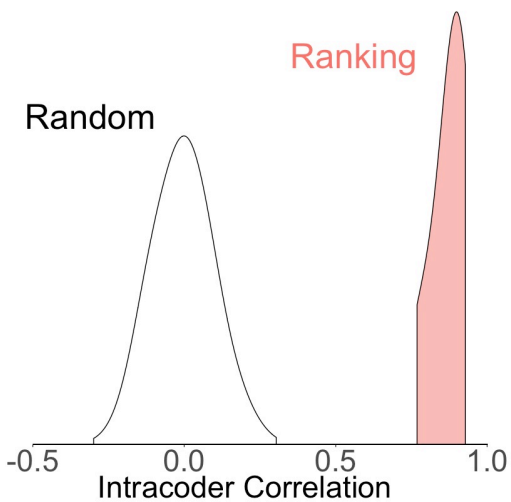

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Goal: Compactness score = f(shape)

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Model Validation: 6-Fold Cross-validation

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Predict Test Set from 5 Training Sets

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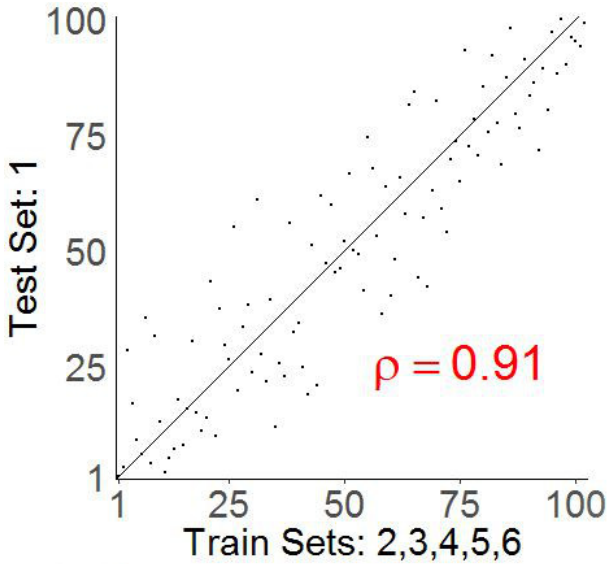

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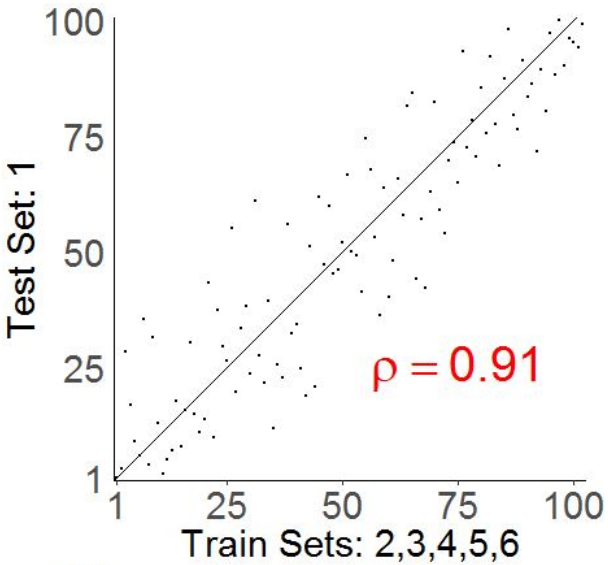

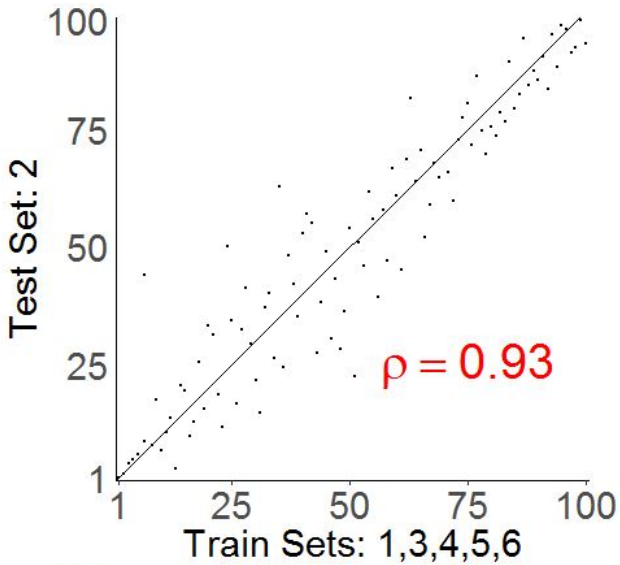

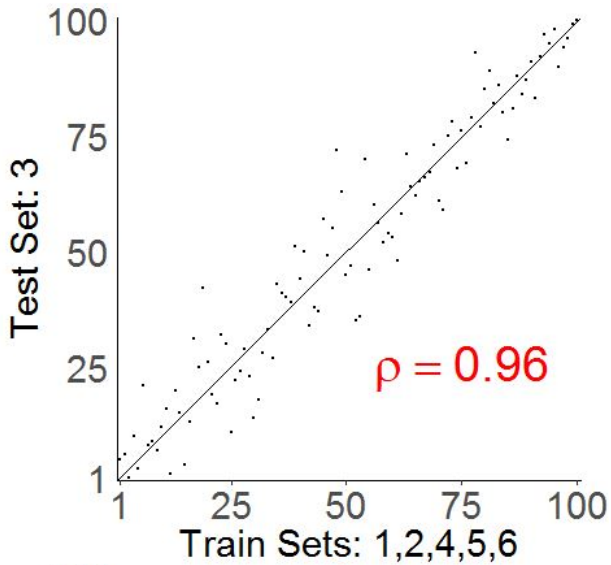

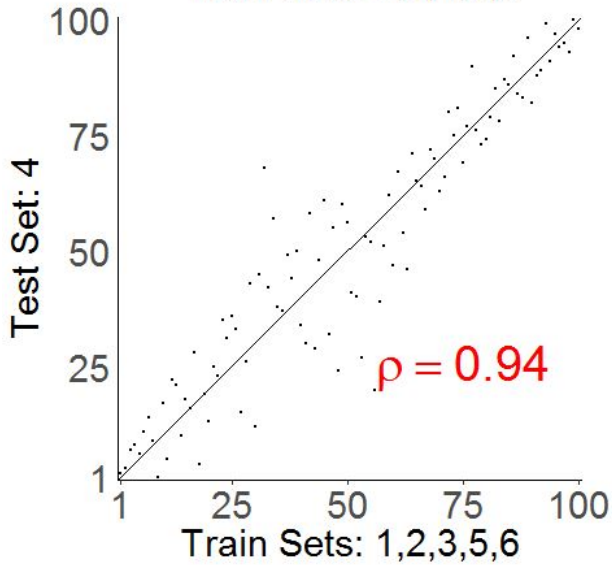

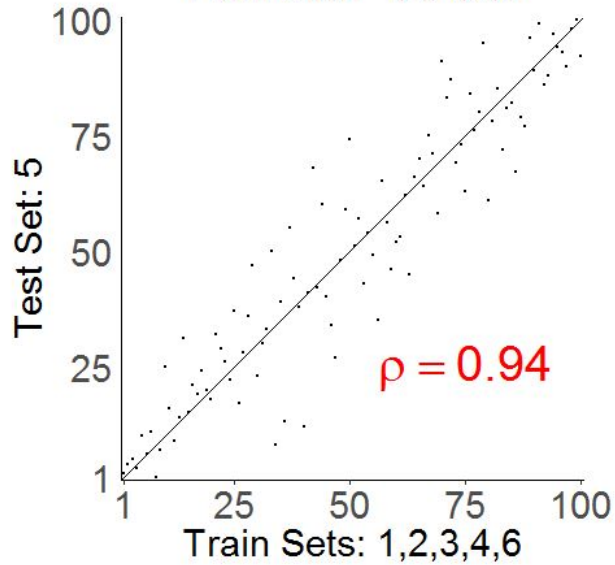

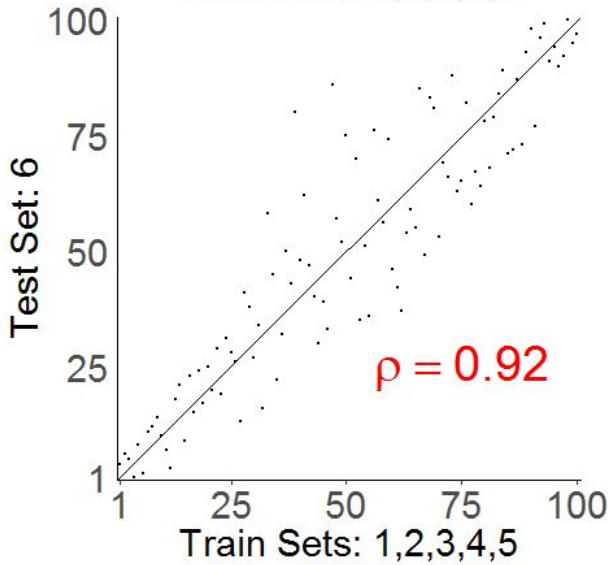

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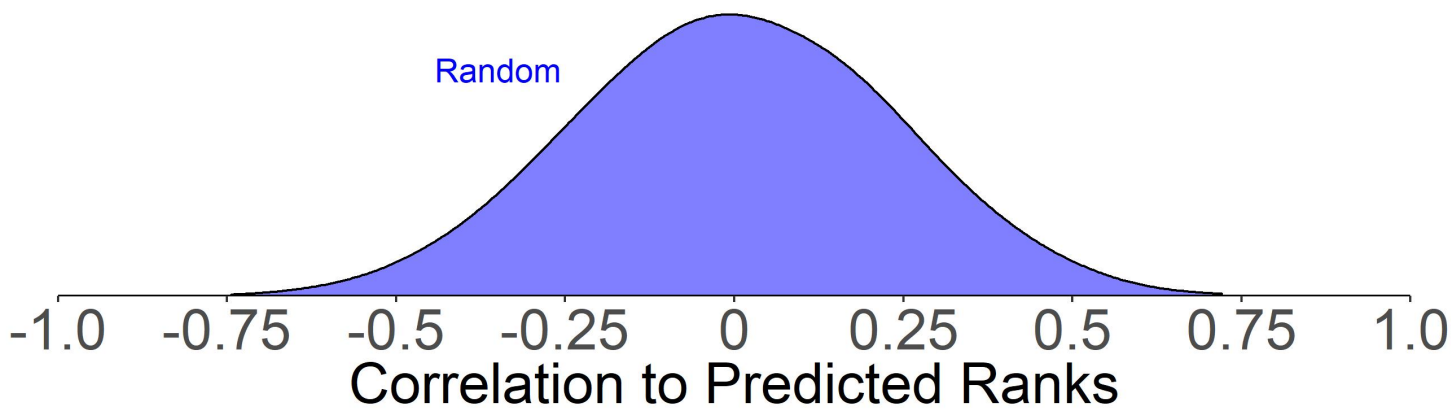

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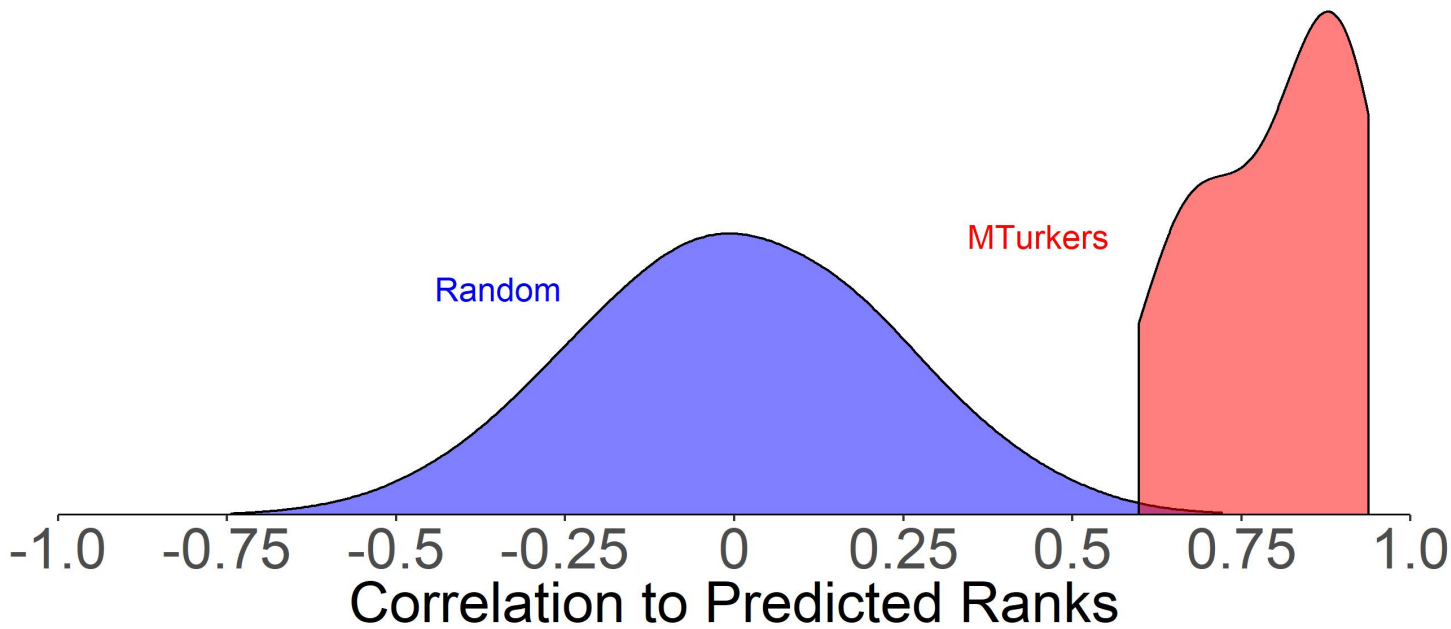

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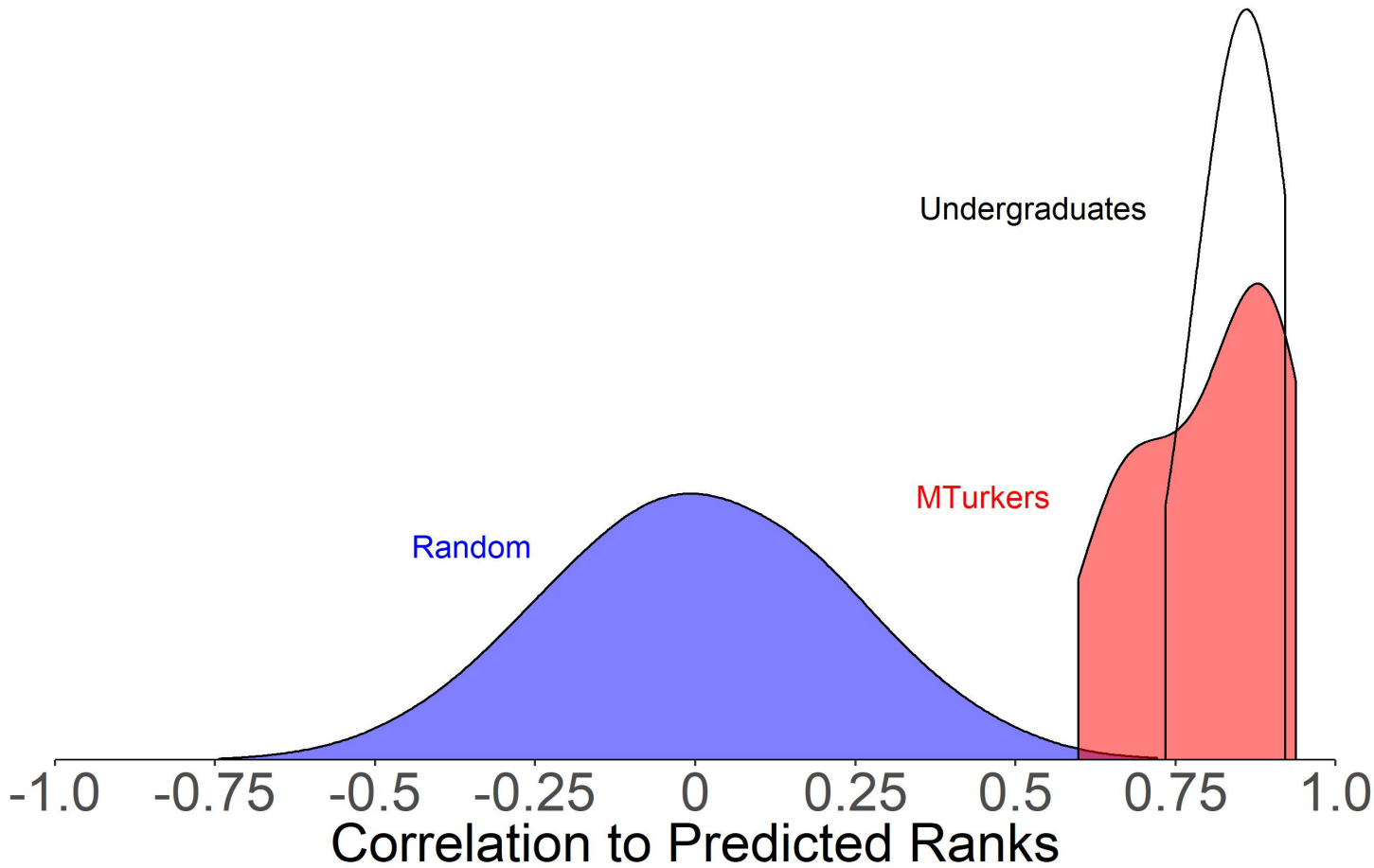

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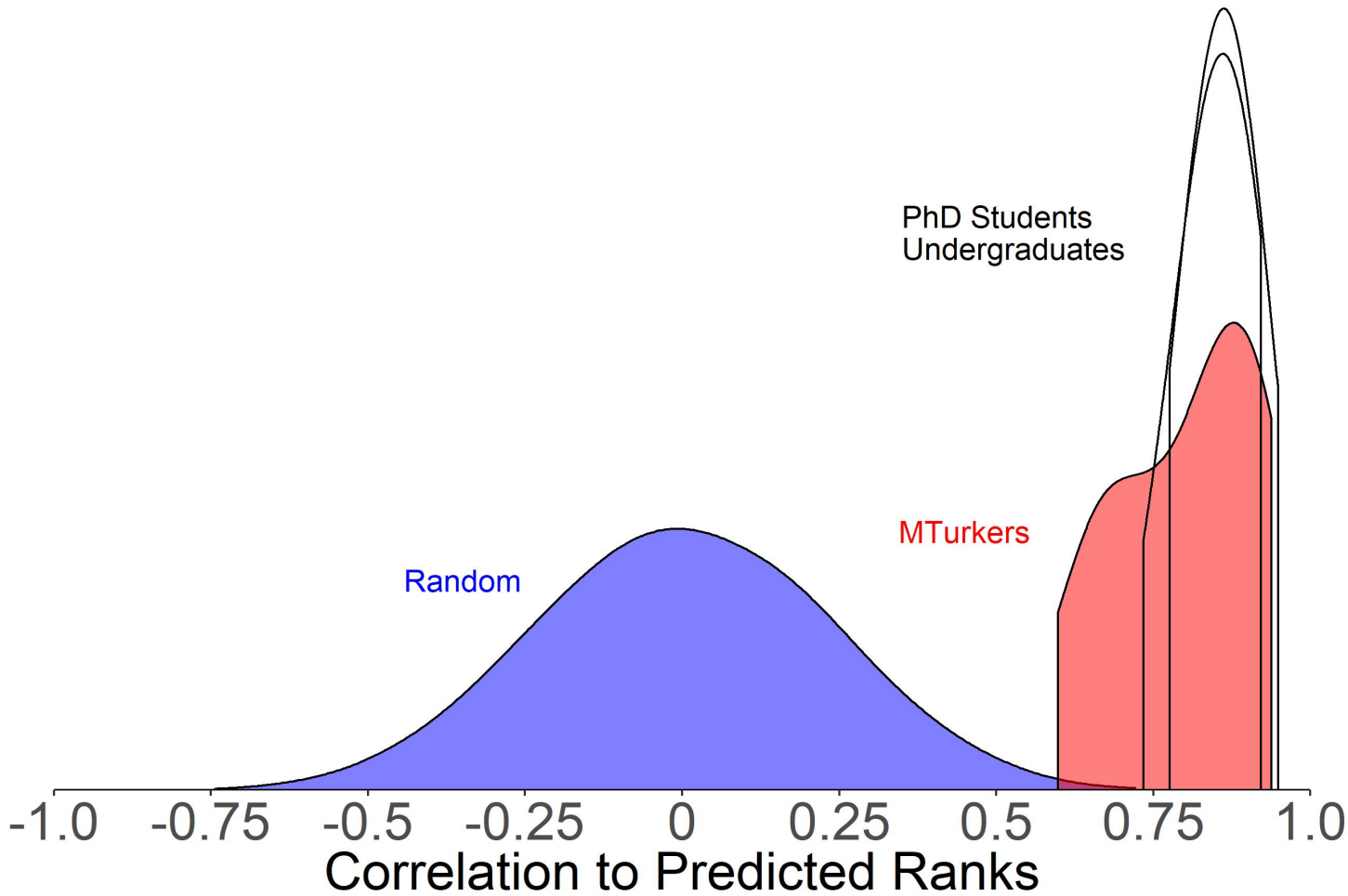

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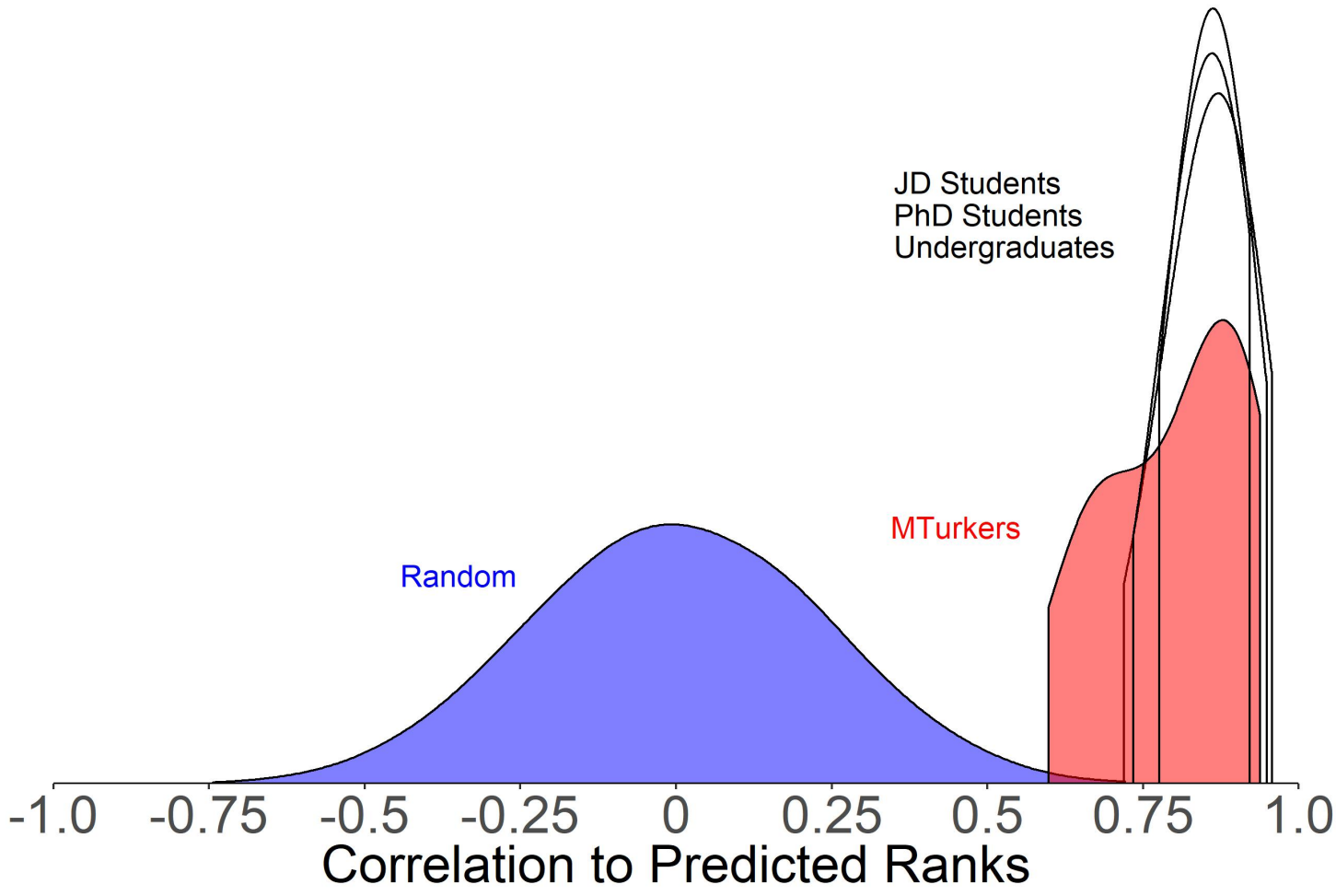

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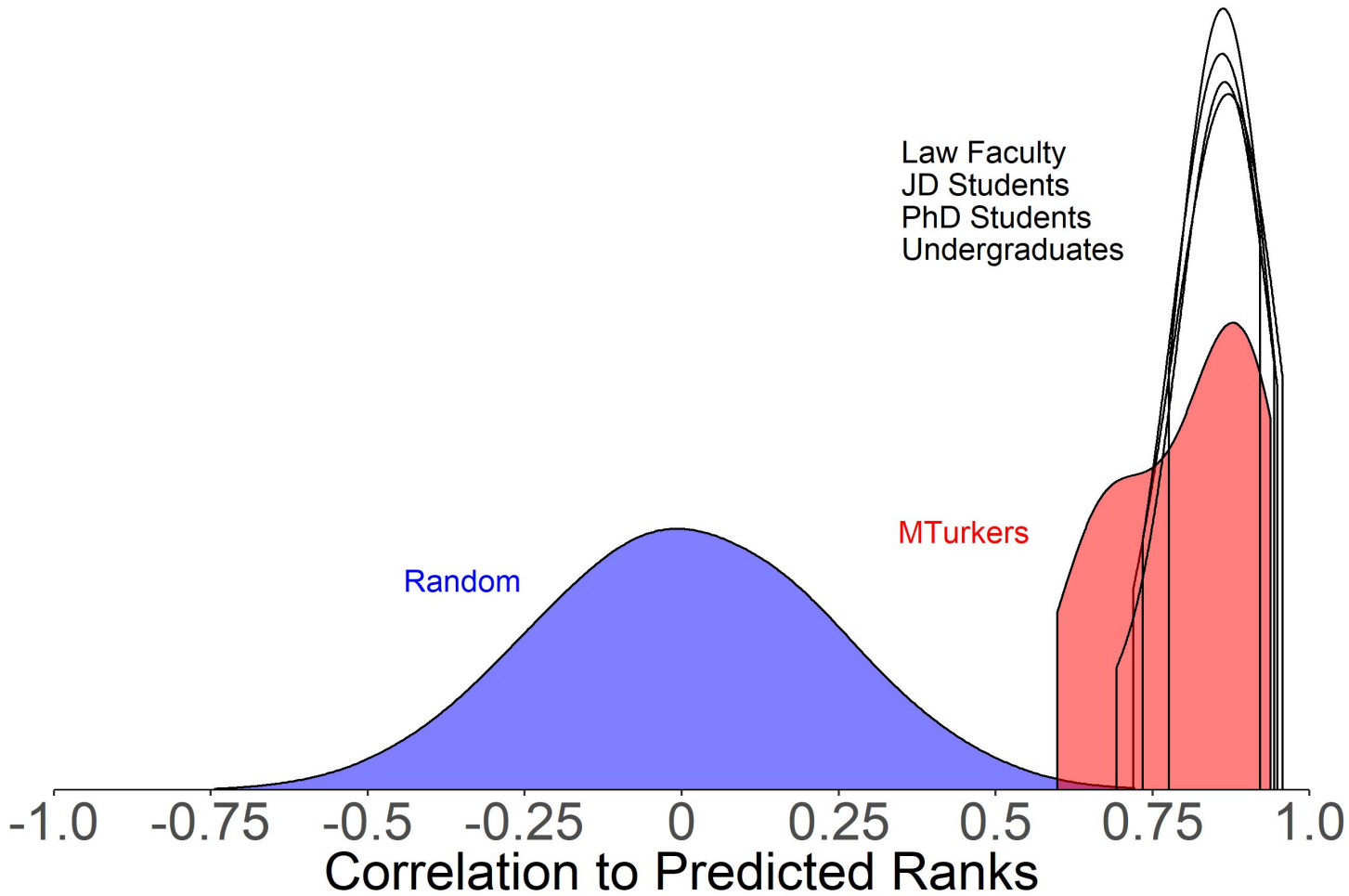

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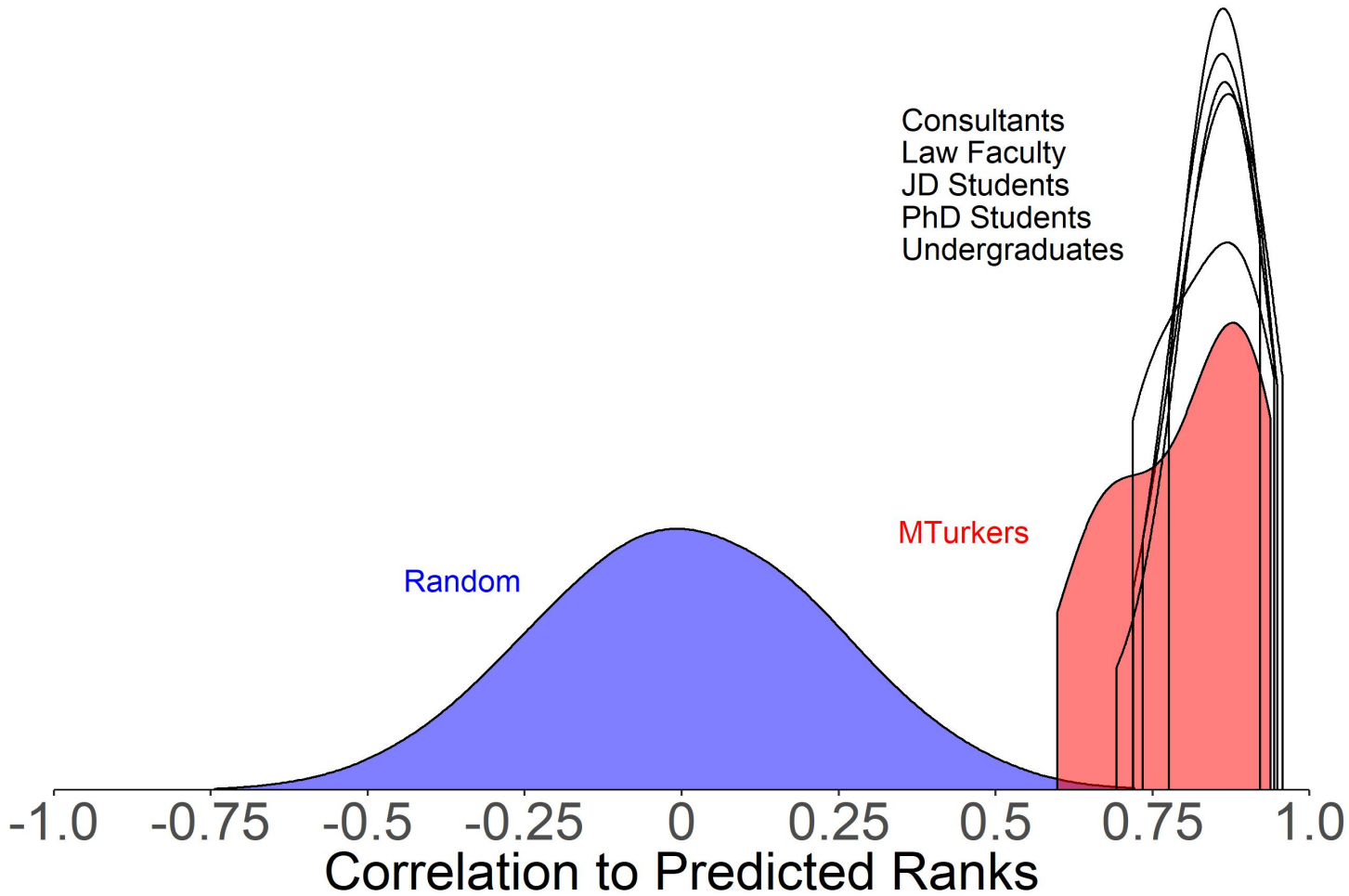

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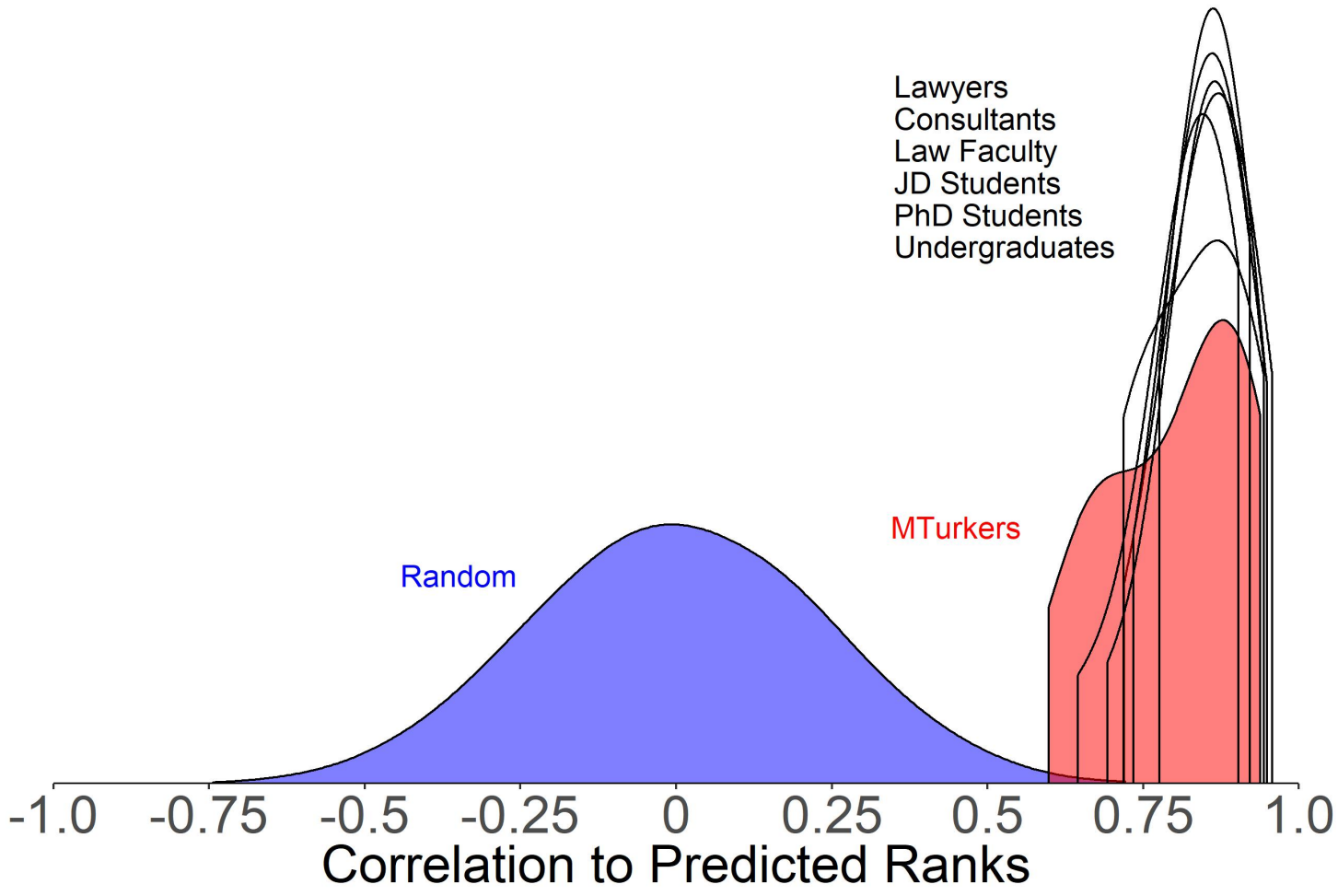

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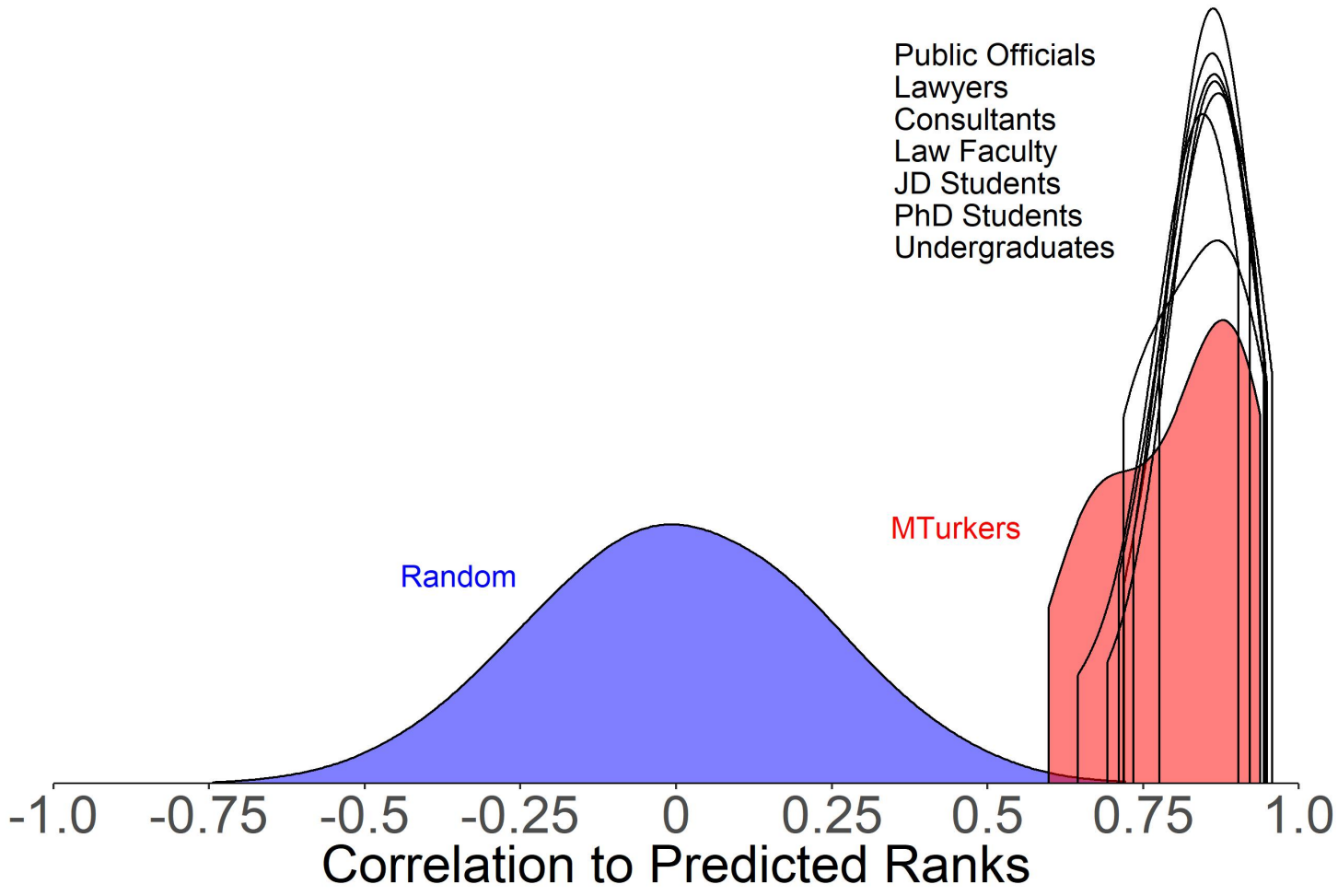

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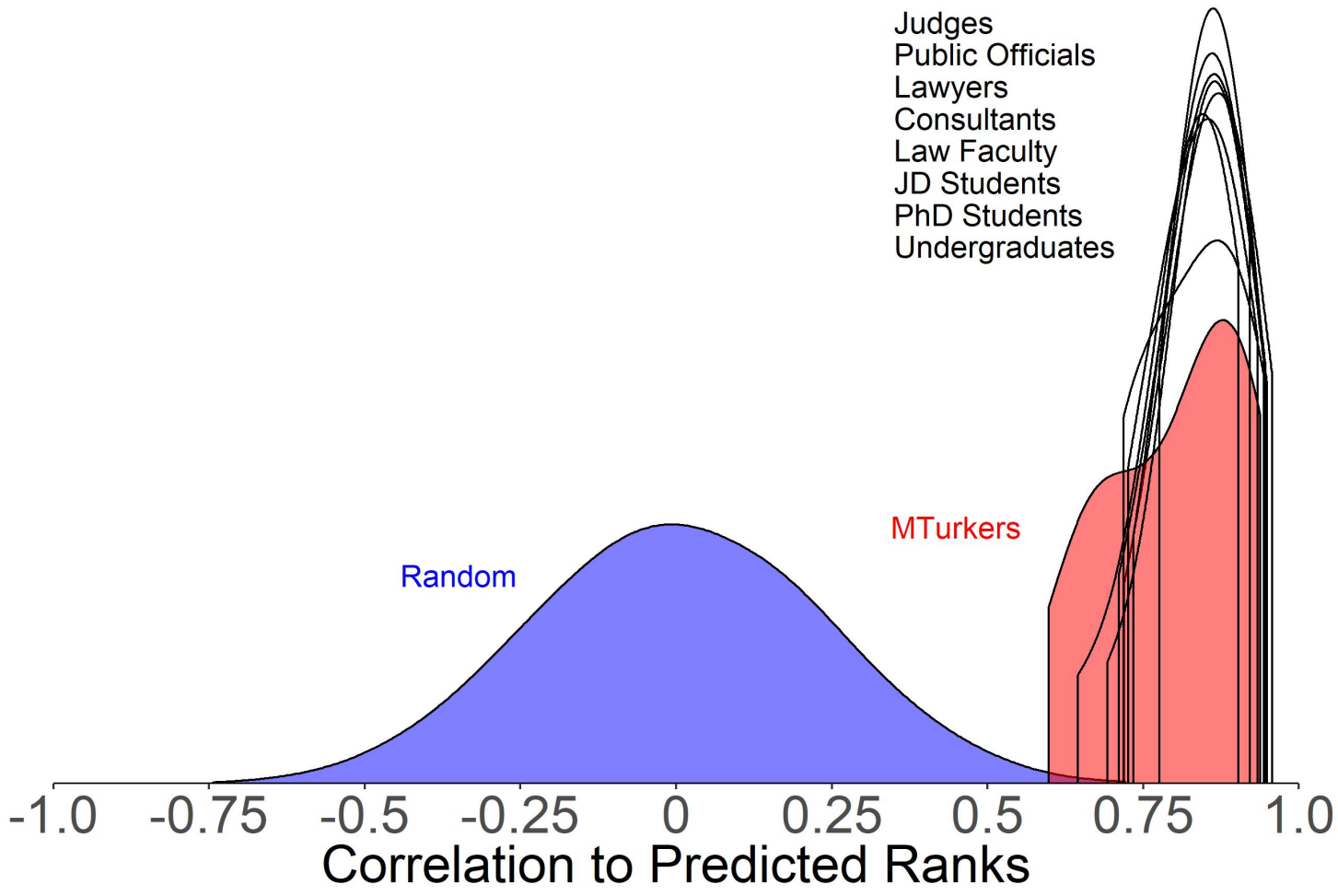

What do you think?

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Our measure:	COMPACT	noncompact	noncompact	COMPACT
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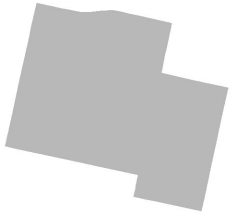
Boyce-Clark				

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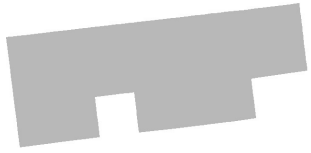
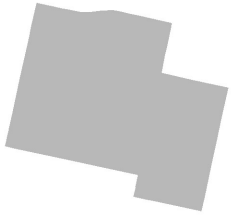
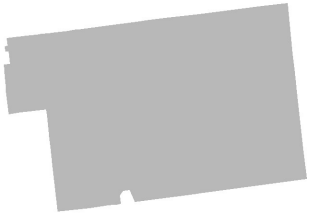
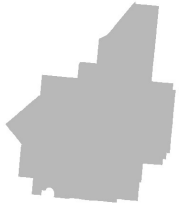
Reock				
Boyce-Clark				
Length/Width				

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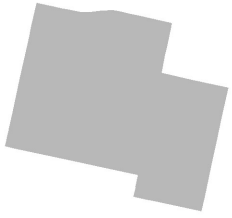
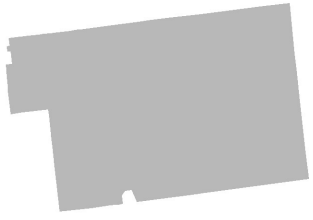
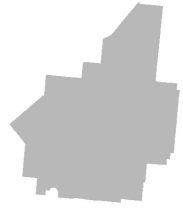
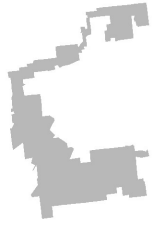
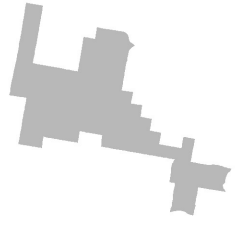
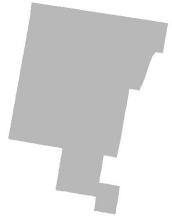
Boyce-Clark				
Length/Width				
X-Symmetry				

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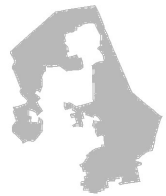
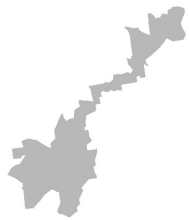
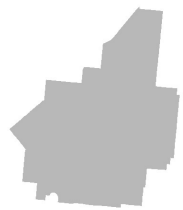
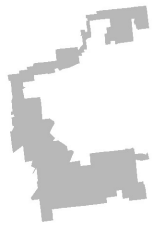
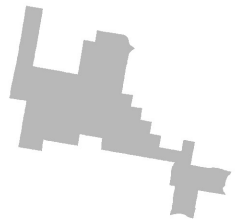
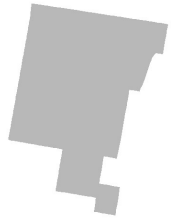
Reock				
Boyce-Clark				
Length/Width				
X-Symmetry				

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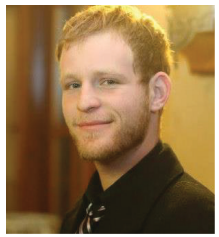
For more information



AaronRKaufman.com

GaryKing.org

MayyaKomisarchik.com

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