

How to Measure Legislative District Compactness If You Only Know it When You See it¹

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¹Based on joint work with Aaron Kaufman and Mayya Komisarchik

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Redistricting Defines Democracy — & Needs Fixing

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The Political Science Discipline & Redistricting

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- Political science contributions to the real world

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 - Required in many other jurisdictions

Compactness According to the Law

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A simple single compactness dimension that you know when you see

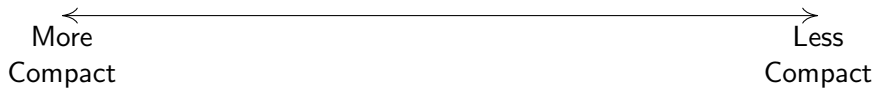
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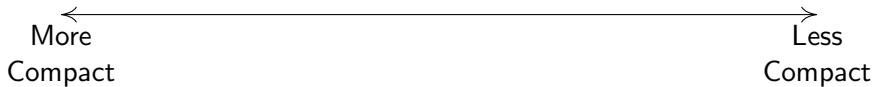
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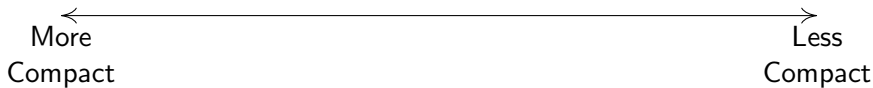


←
More
Compact

→
Less
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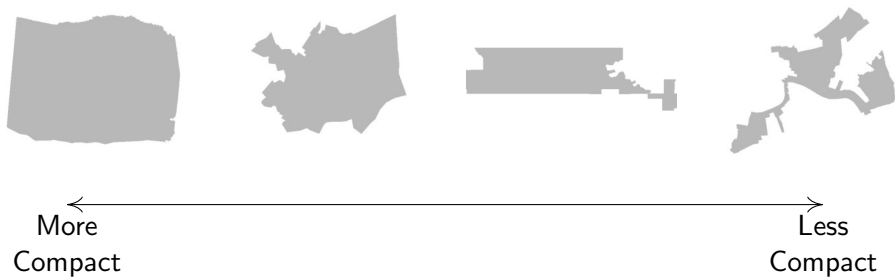
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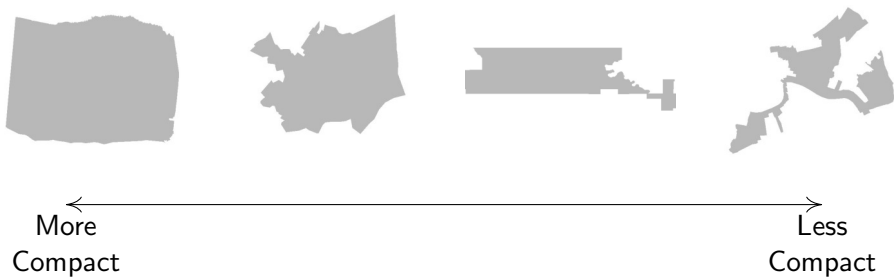
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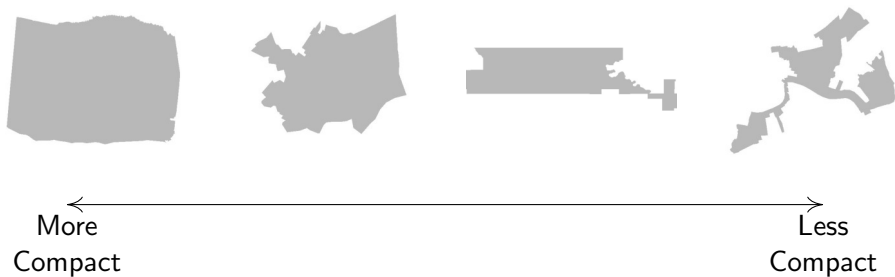
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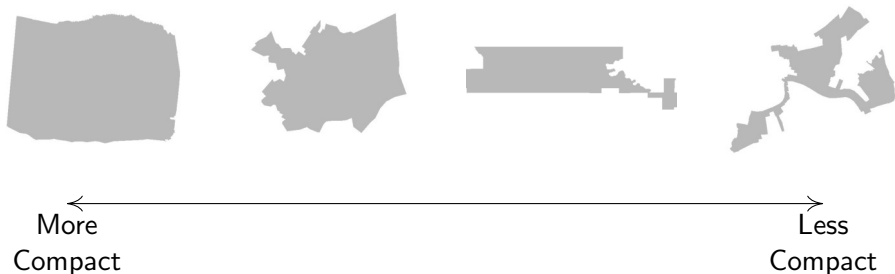
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- **↪ Let's start with existing measures by social scientists**

Measure 1: Length/Width Ratio of Min Bounding Box

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Squarish districts more compact than long thin ones

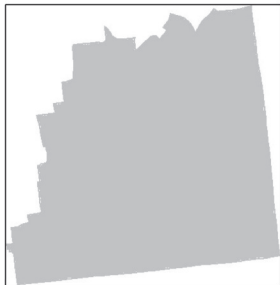
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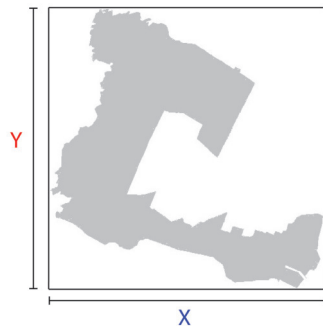
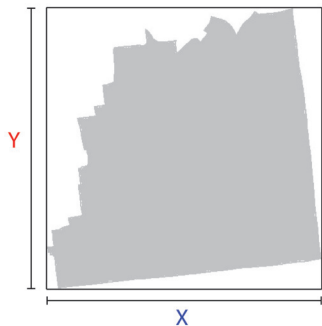
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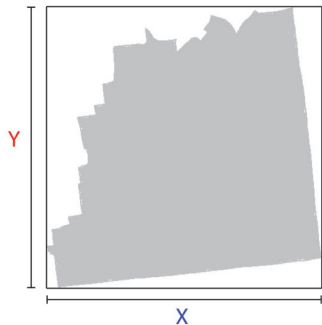
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In both districts: $X/Y \approx 1.30$

Measure 2: Reock, District / Bounding Circle Areas

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Circular districts are most compact

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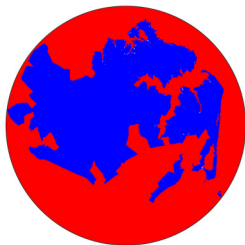
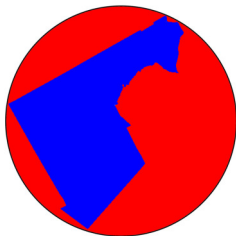
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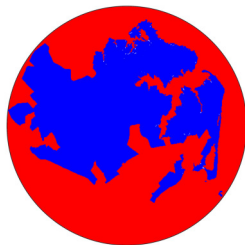
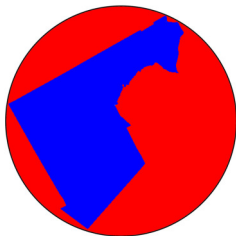
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In both cases, $X/(Y + X) \approx 0.37$

Measure 3: Boyce-Clark, Variation in Centroid Deviations

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All travel distances from center should be similar

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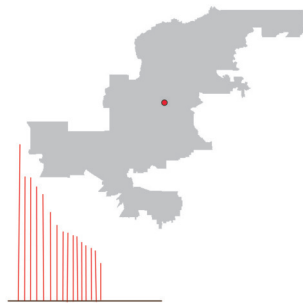
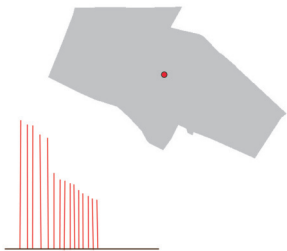
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In both cases, $MAD(r)/\bar{r} \approx 0.31$

A Brief Rotational Invariance Interlude:

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Can you Name this Celebrity?

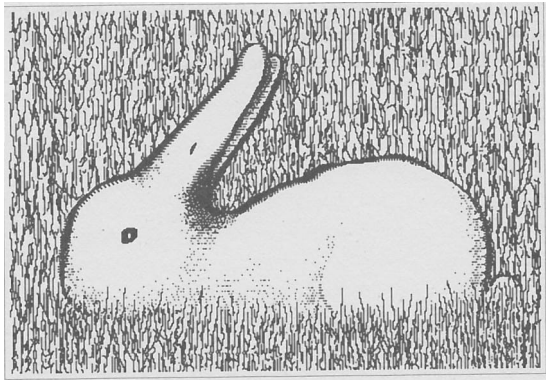
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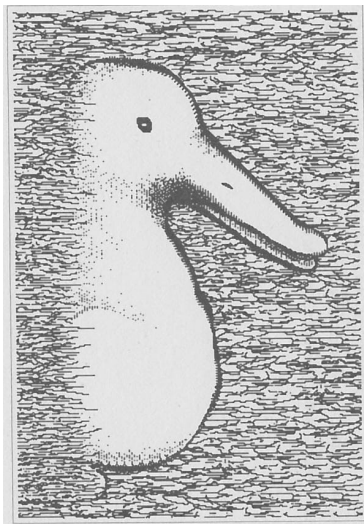
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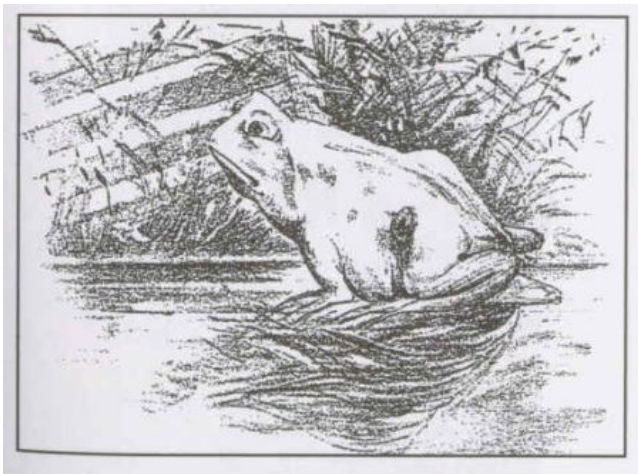
A Brief Interlude on Perception: See the Rabbit?



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?



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- \rightsquigarrow Measuring “you know it when you see it”: No rotational invariance

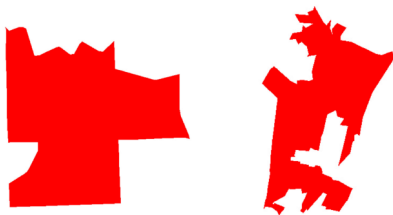
New Measure: Y-Symmetry, area of symmetric reflection

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Symmetric figures (circles, squares) are more compact

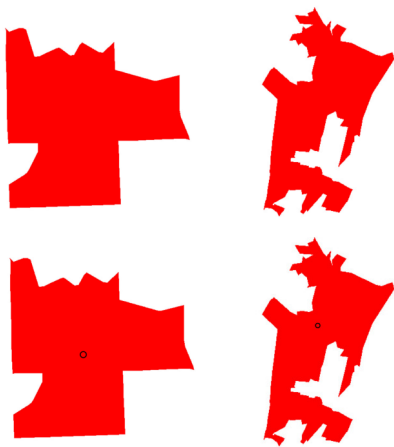
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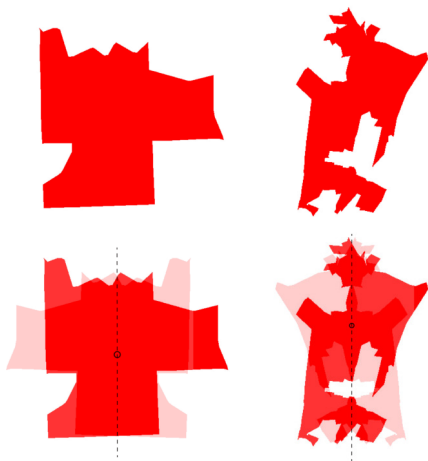
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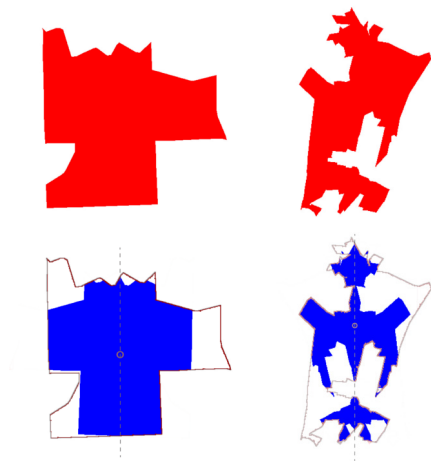
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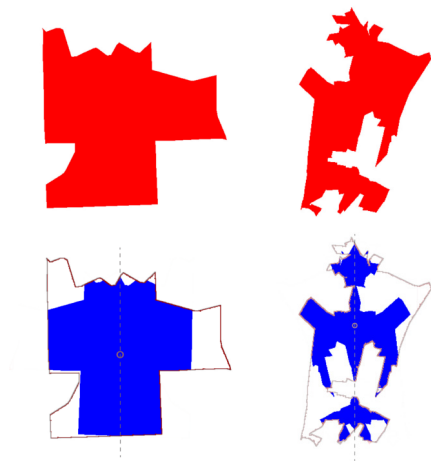
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In both cases, $\text{Overlap} / \text{Original Area} \approx 0.34$

New Measure 2: Number of Visually Significant Corners

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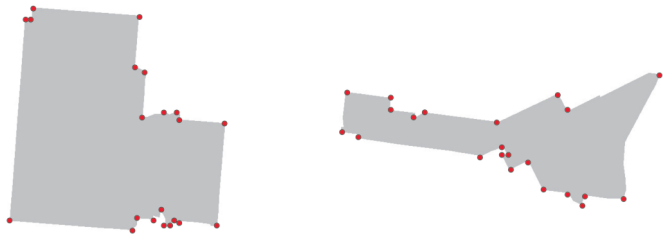
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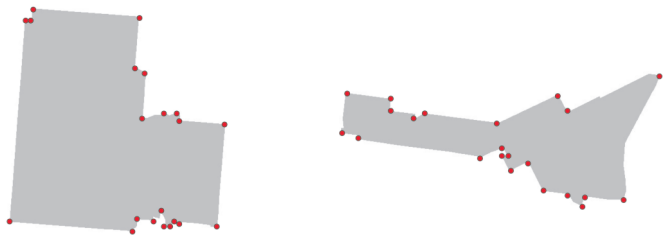
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Computer vision algorithm identifies “objects” in photos

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Both districts have 21 significant corners

Which is more compact?



Which is more compact? Depends on the standard!



Which is more compact? Depends on the standard!



Convex Hull

4

3

2

1

Which is more compact? Depends on the standard!



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3

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4

1

2

3

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| | | | | |
|---------------|---|---|---|---|
| Convex Hull | 4 | 3 | 2 | 1 |
| Reock | 1 | 2 | 3 | 4 |
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| Boyce-Clark | 2 | 3 | 1 | 4 |

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- 7 measures;

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- **Many more inconsistencies on individual districts**

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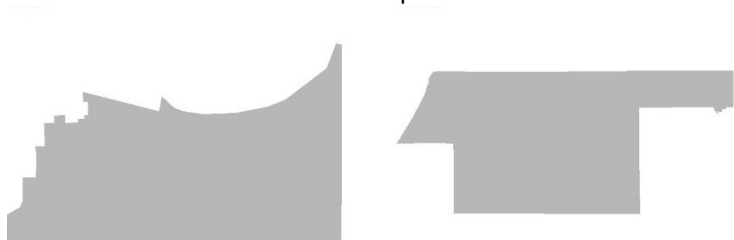
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Utterly fails on inter- and intra-coder reliability

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Full Ranking

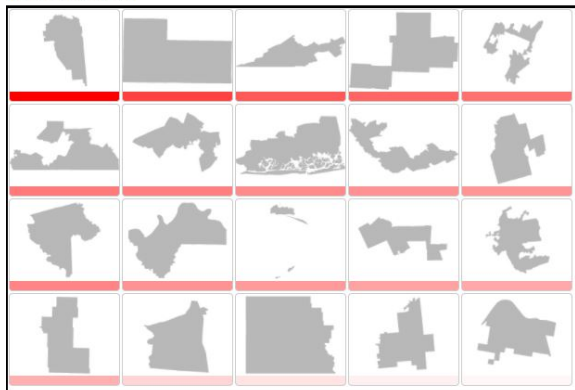


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Full Ranking — on line

MOST Compact Here



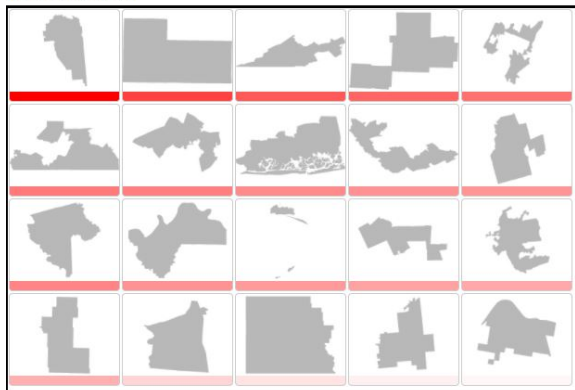
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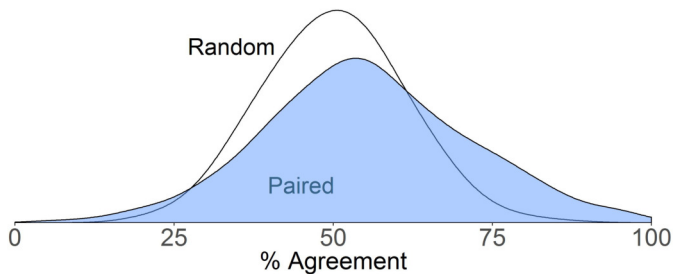
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Ranking: all evaluations on **one dimension** of user's choice

Intercoder Reliability of Pairs

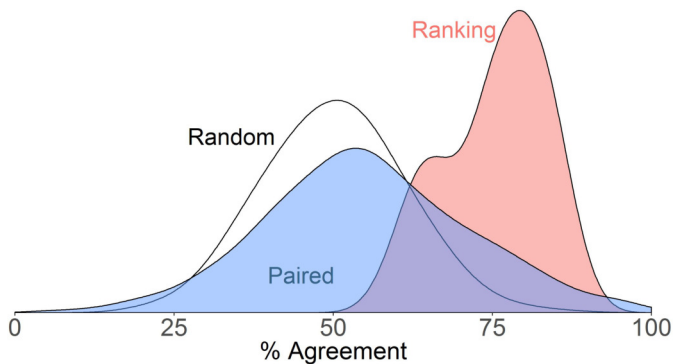
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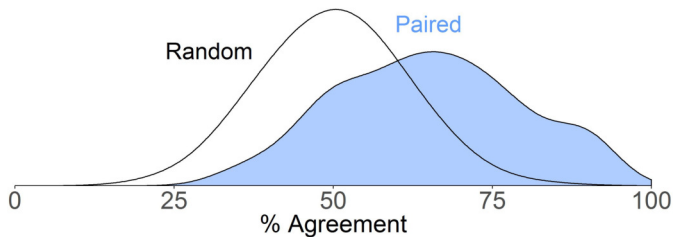
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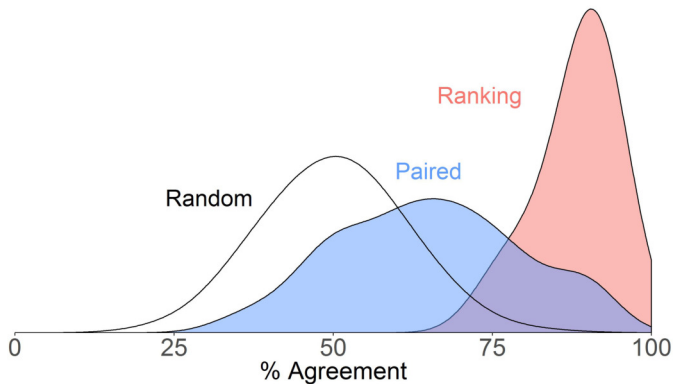
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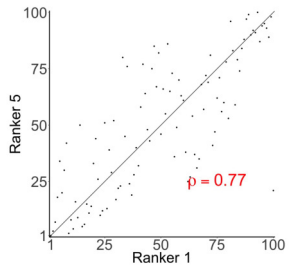


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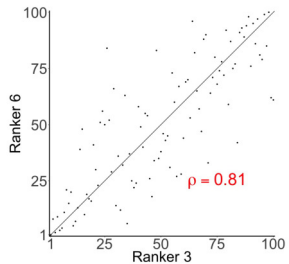
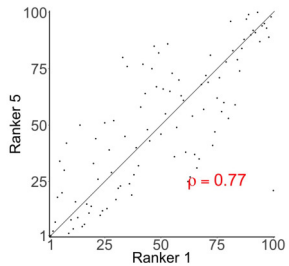
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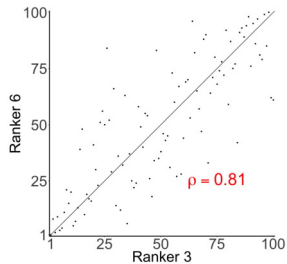
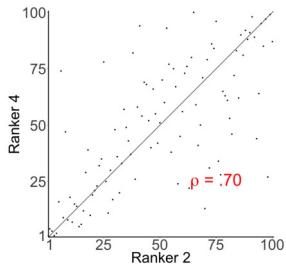
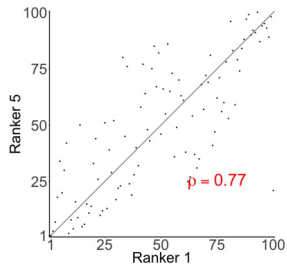
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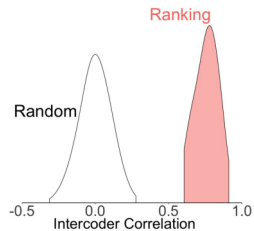
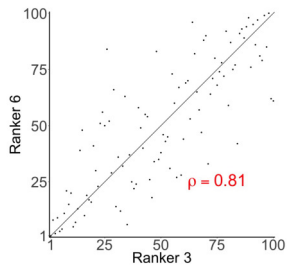
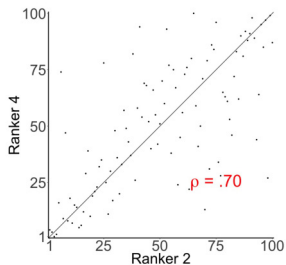
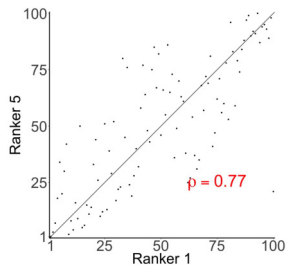
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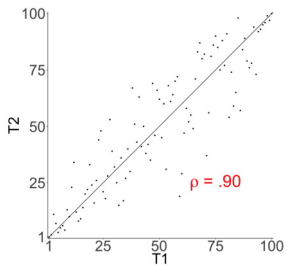
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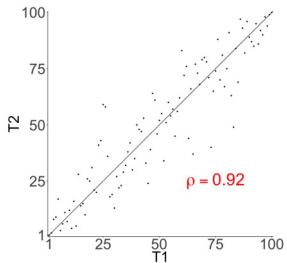
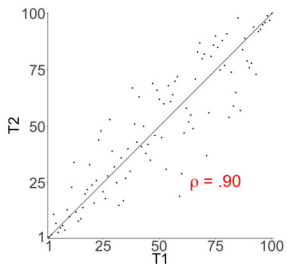
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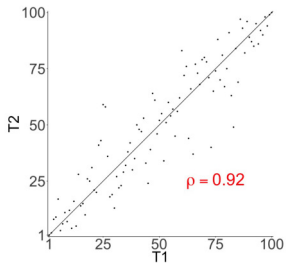
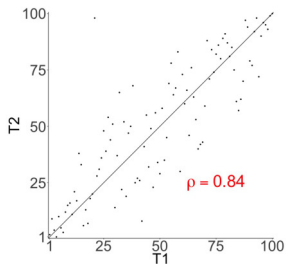
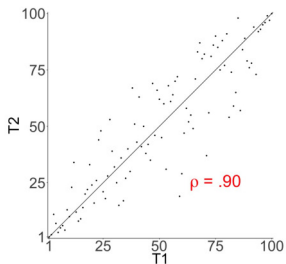
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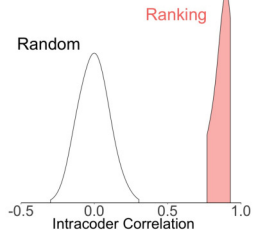
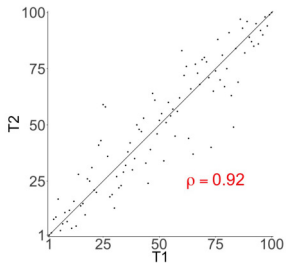
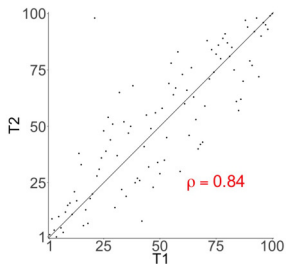
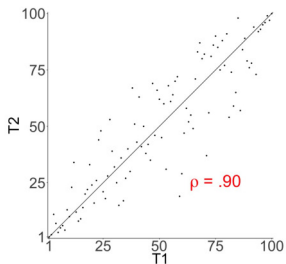
Intracoder Reliability on Ranks



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 - (Not a description of any one existing measure)

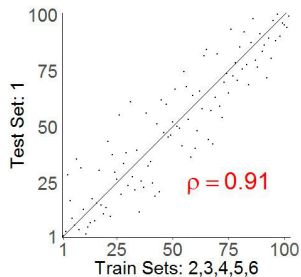
Model Validation: 6-Fold Cross-validation

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Predict Test Set from 5 Training Sets

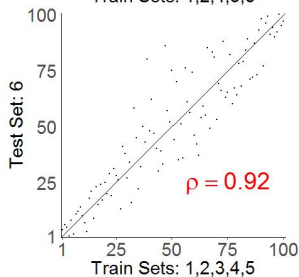
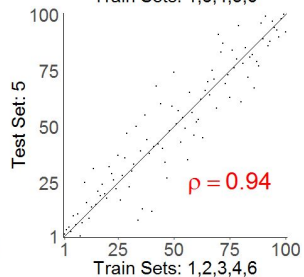
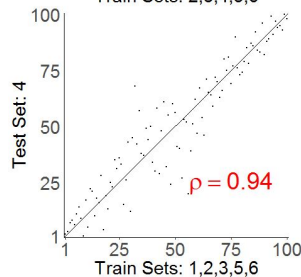
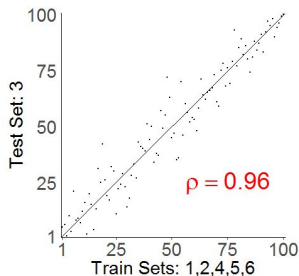
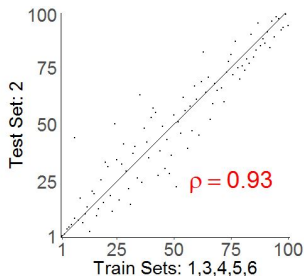
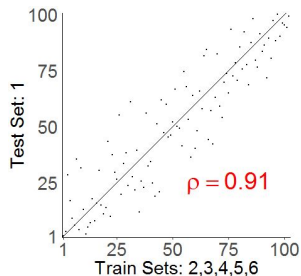
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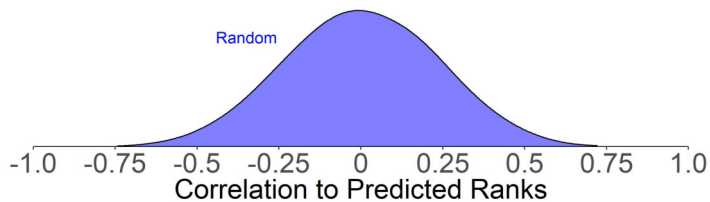
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Respondents ranging from ordinary citizens to those responsible for redistricting

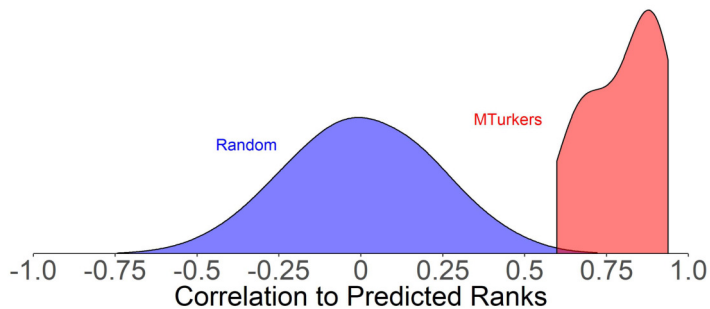
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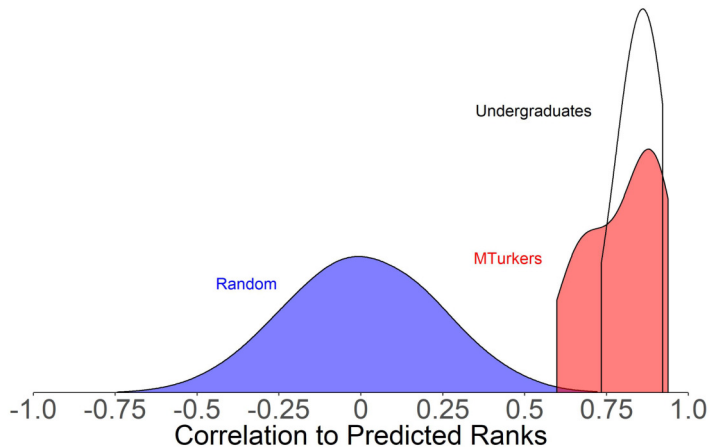
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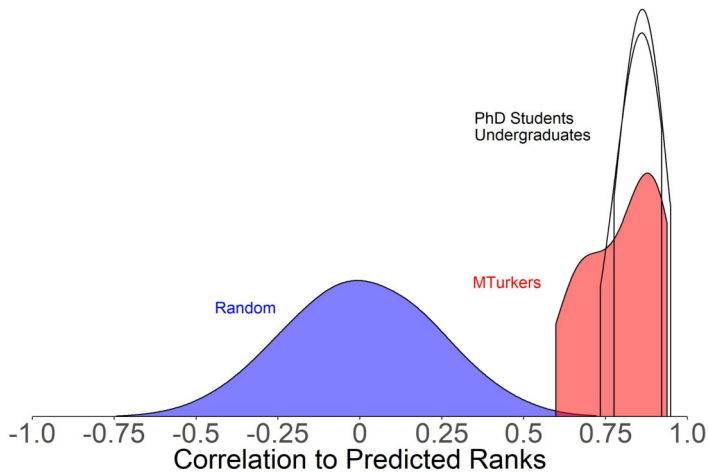
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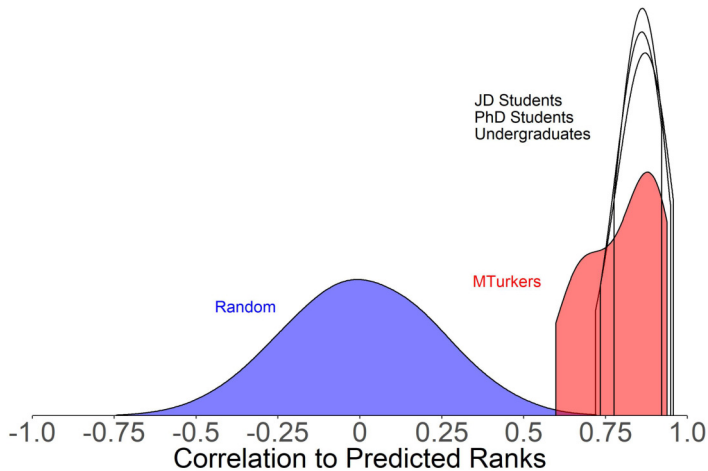
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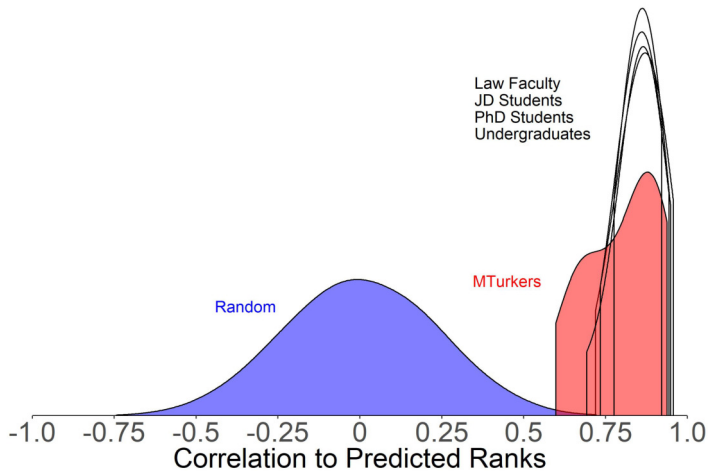
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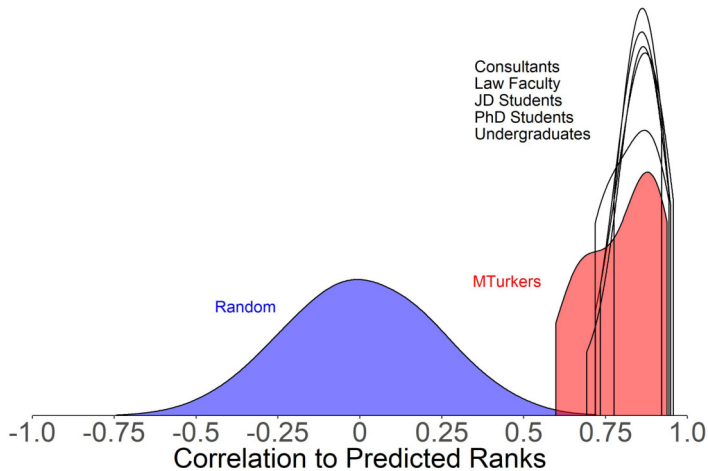
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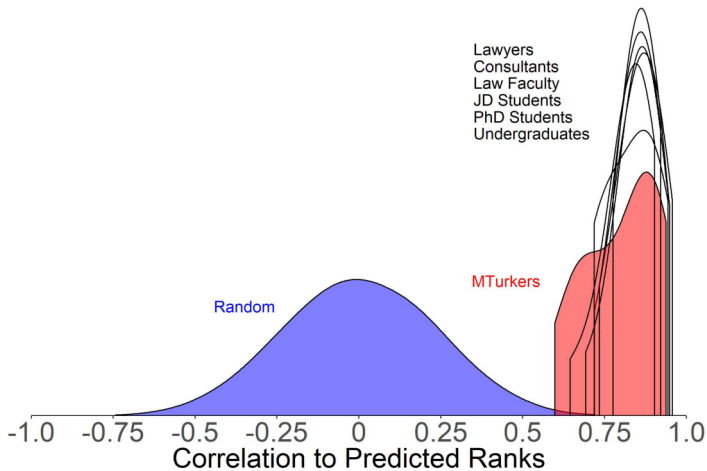
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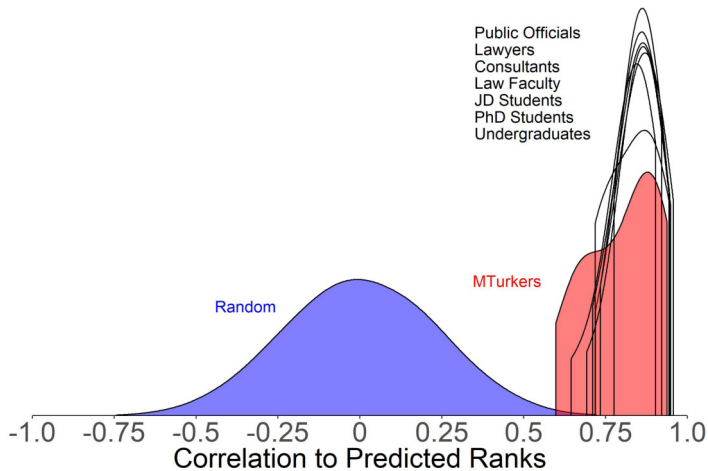
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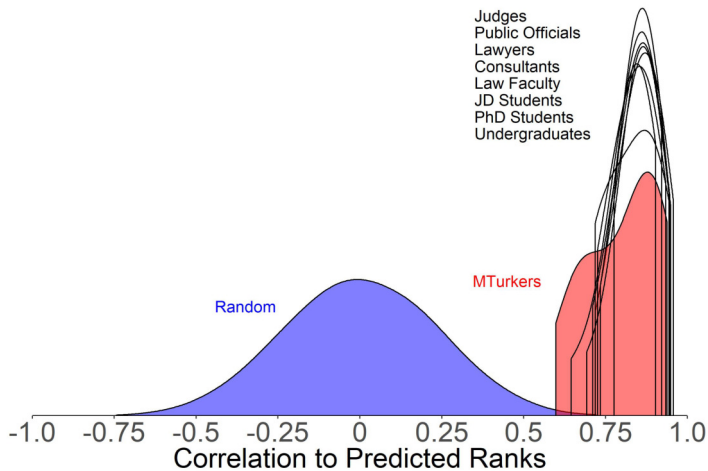
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|-------------------|---------|------------|------------|------------|
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For more information



AaronRKaufman.com



GaryKing.org



MayyaKomisarchik.com

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