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

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    - Laptops beat supercomputers!

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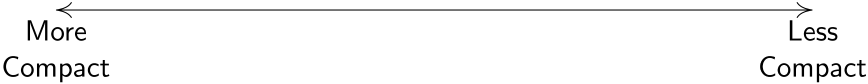

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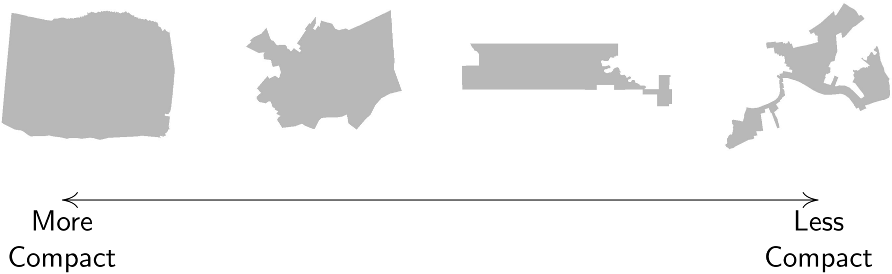

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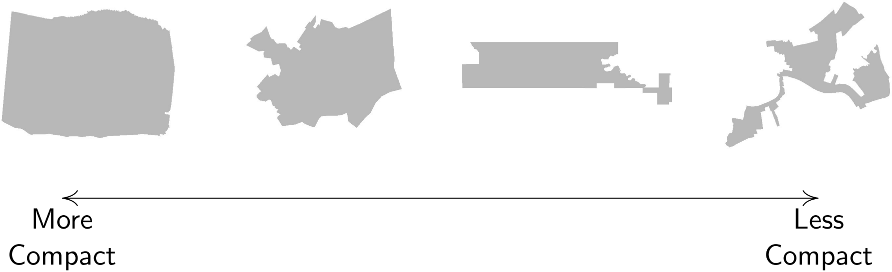

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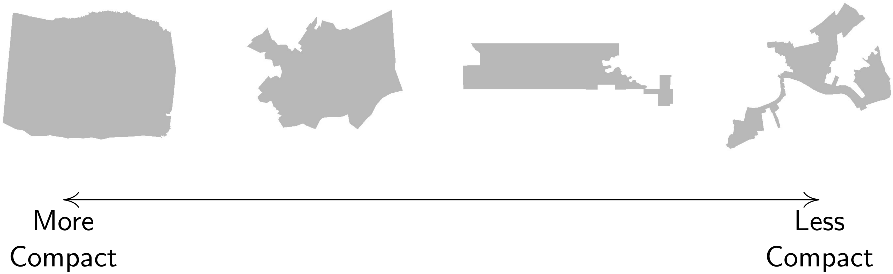

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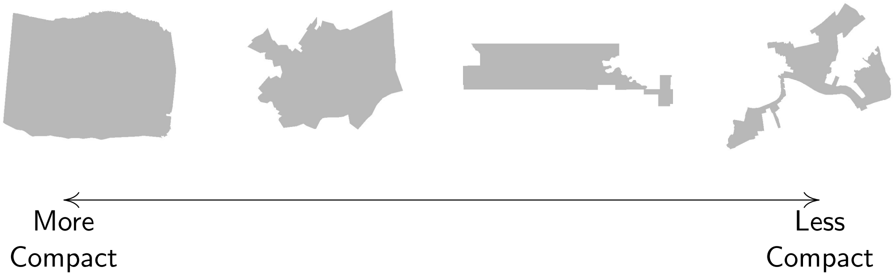

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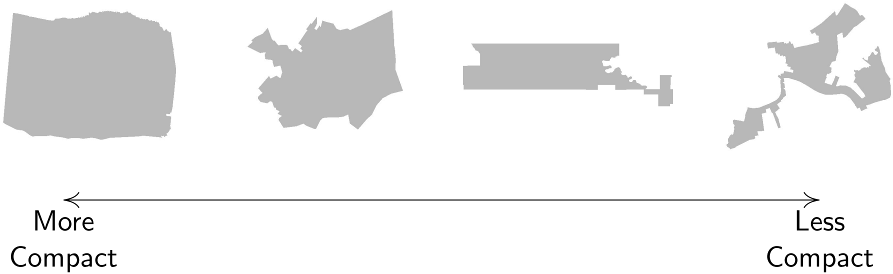

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- $\rightsquigarrow$ Let's start with existing measures by social scientists

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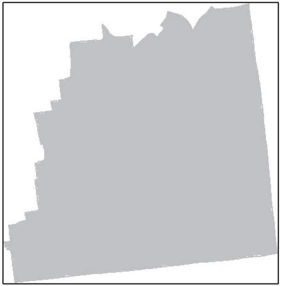

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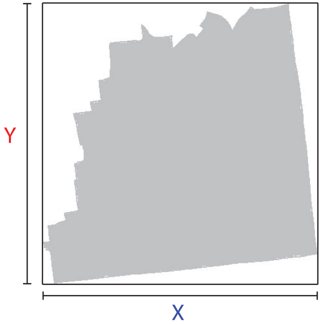

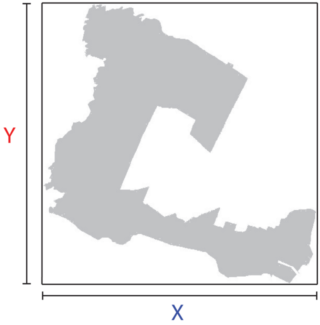

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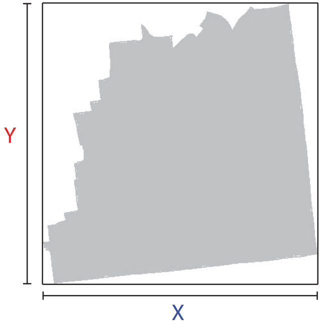
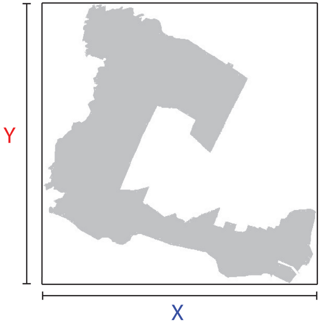
Squarish districts more compact than long thin ones





In both districts: X/Y ≈ 1.30

Measure 2: Reock, District / Bounding Circle Areas

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Circular districts are most compact

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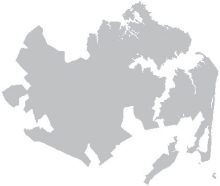

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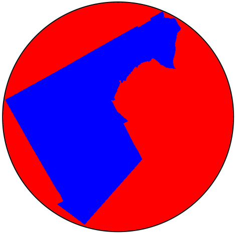

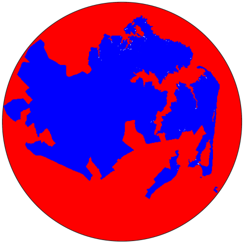

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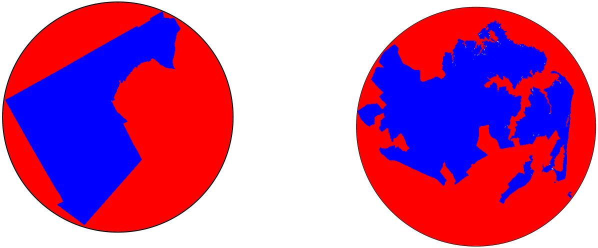

In both cases, $X/(Y + X) \approx 0.37$

Measure 3: Boyce-Clark, Variation in Centroid Deviations

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All travel distances from center should be similar

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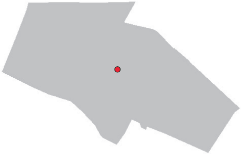

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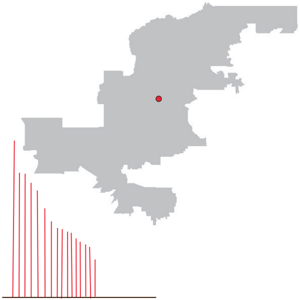

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In both cases, $\mathrm{MAD}(r)/\bar{r} \approx 0.31$

A Brief Rotational Invariance Interlude:

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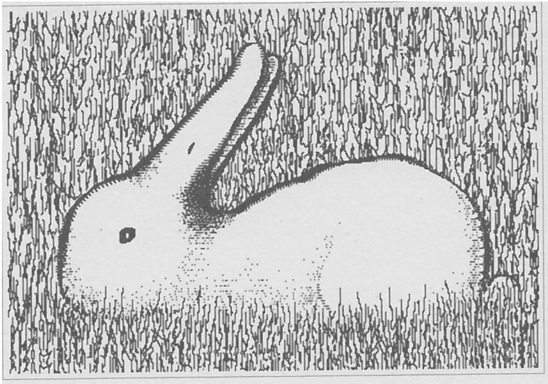
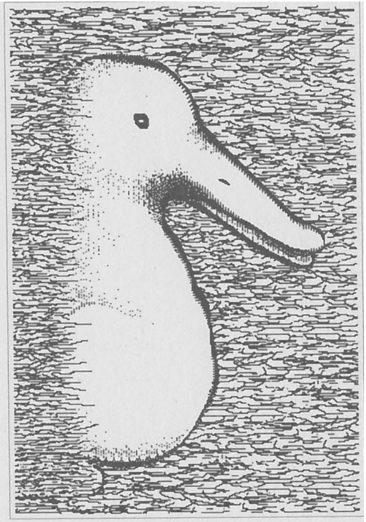
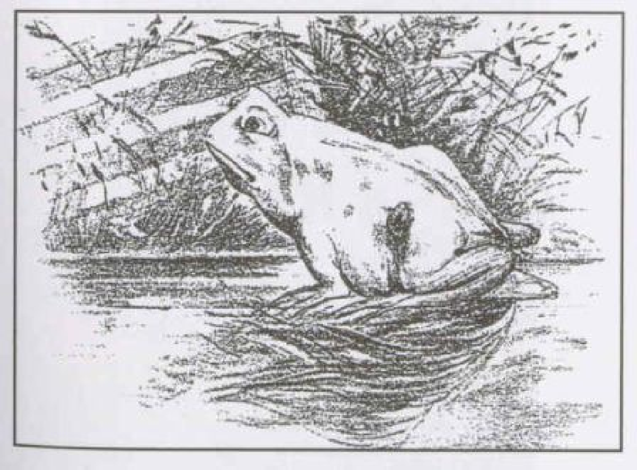
A Brief Interlude on Perception: See the Rabbit?



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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- Existing measures of compactness:

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    - Nearly 100 proposed

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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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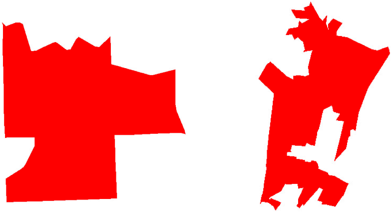

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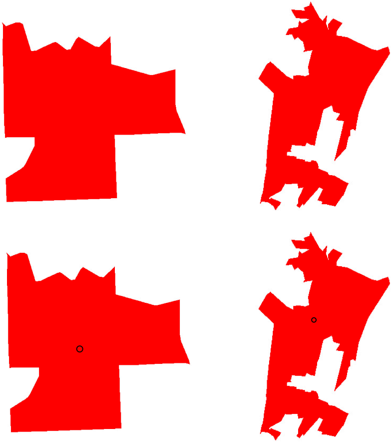

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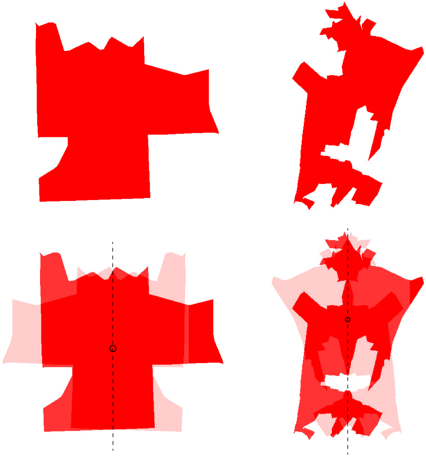

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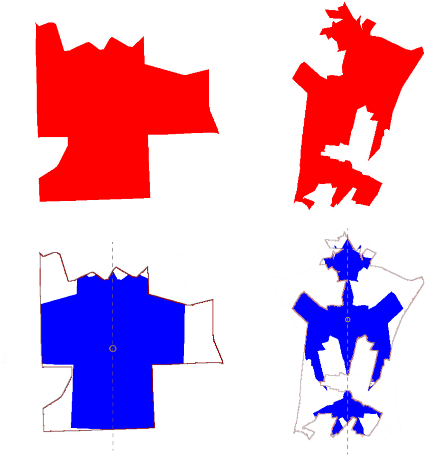

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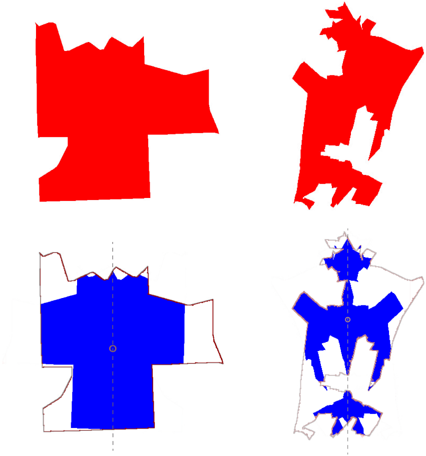

In both cases, Overlap/Original Area ≈ 0.34

New Measure 2: Number of Visually Significant Corners

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Computer vision algorithm identifies "objects" in photos

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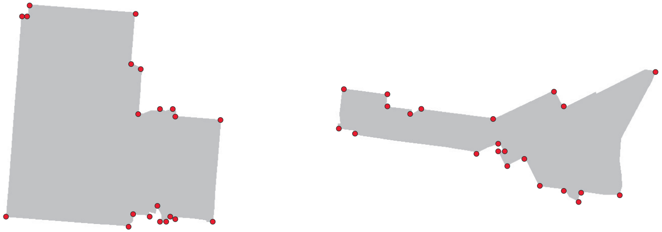

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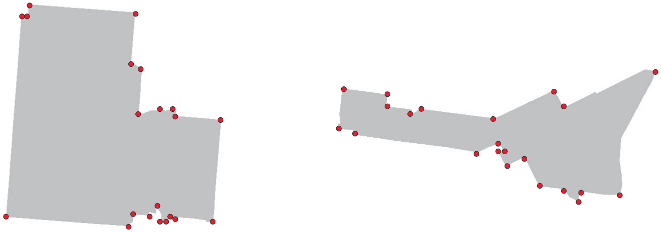
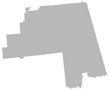
Computer vision algorithm identifies “objects” in photos

⇝ Fewer corners is more compact

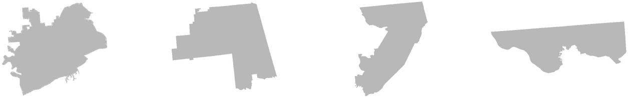


Both districts have 21 significant corners

Which is more compact?

Which is more compact? Depends on the standard!



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		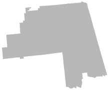		
Convex Hull	4	3	2	1

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		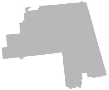		
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		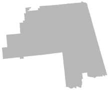		
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		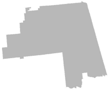		
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		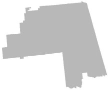		
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		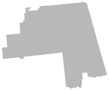		
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		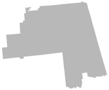		
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		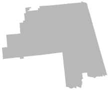		
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		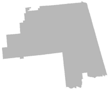		
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		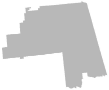		
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		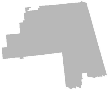		
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		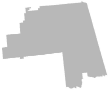		
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- Many more inconsistencies on individual districts

Spanning the Academic–Legal Divide

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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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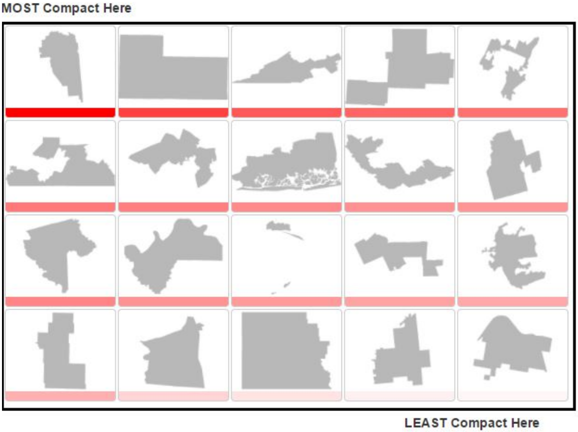
Full Ranking — on line



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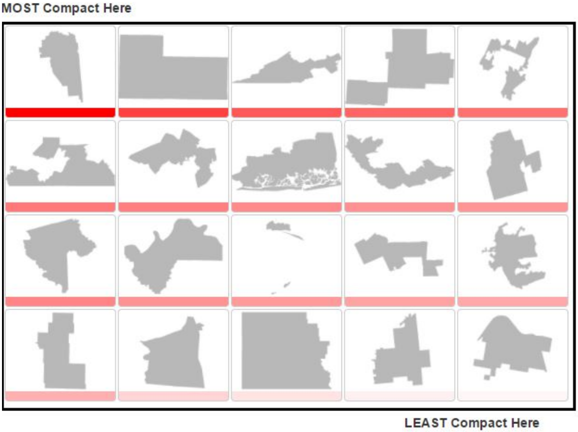

We show: very high reliability

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  - Much easier: $\binom{20}{2} = 190$ pairs v $20! \approx 2$ quintillion ranks

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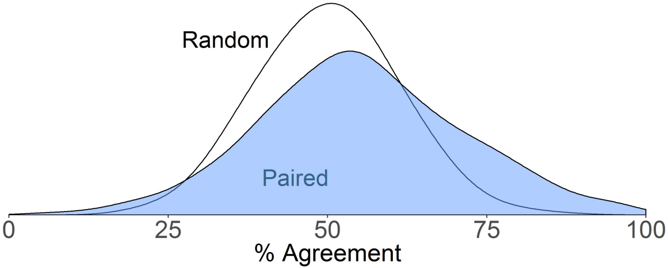
Paired Comparisons: only slightly better than chance;



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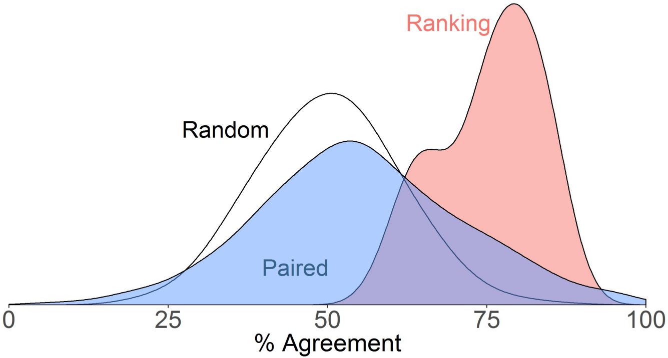

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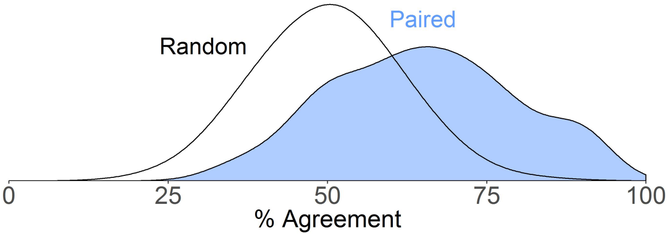

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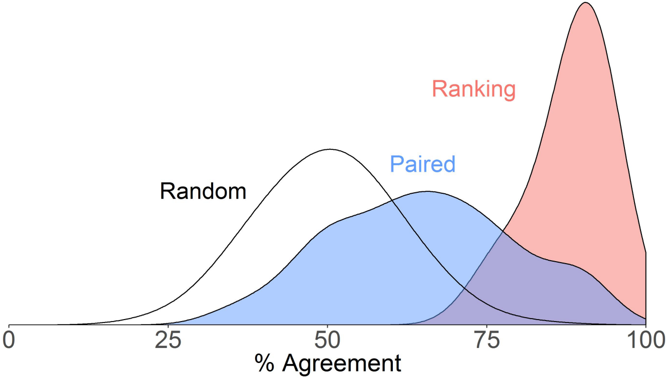

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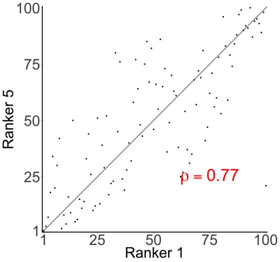

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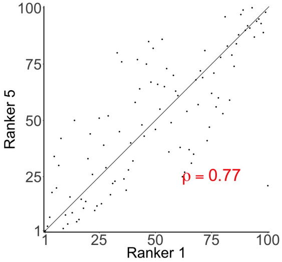

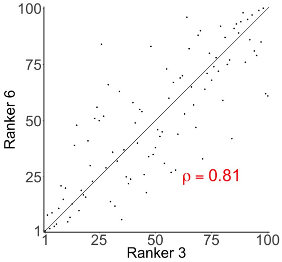

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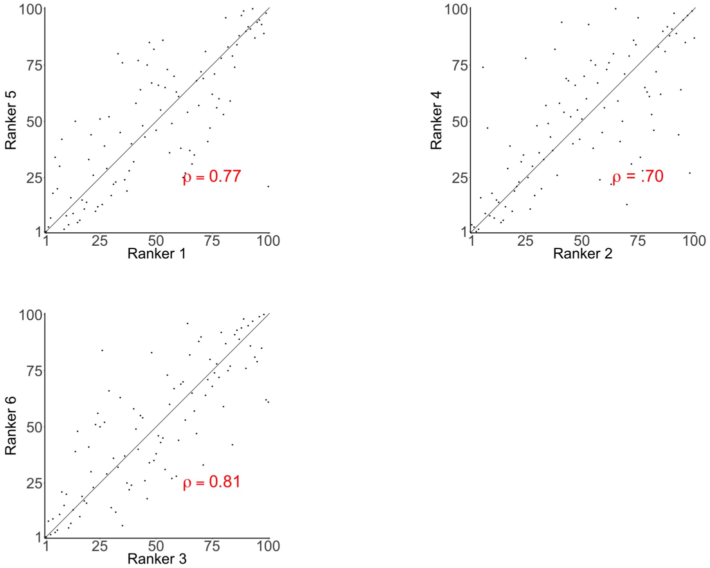

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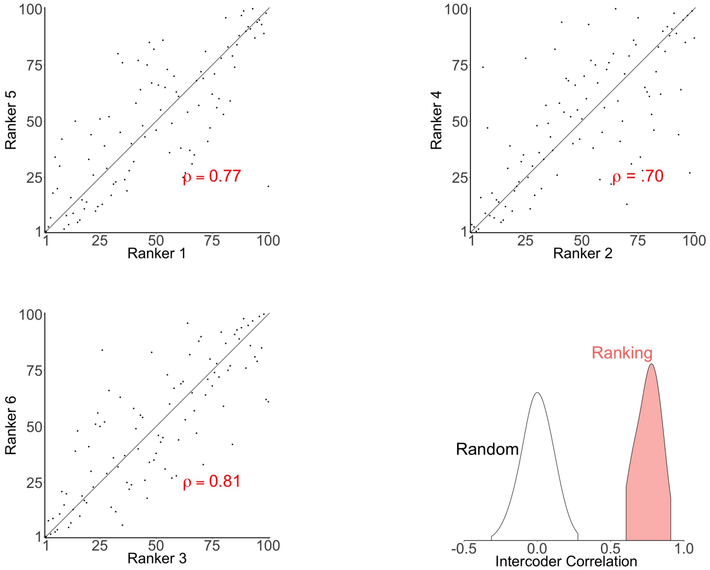

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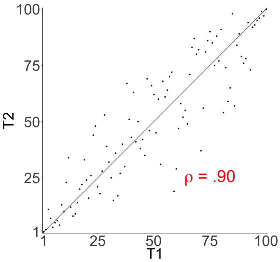

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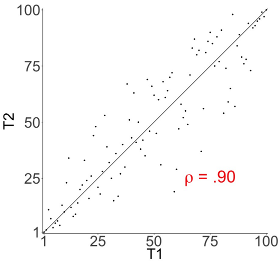

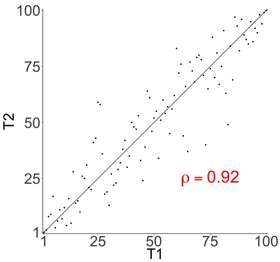

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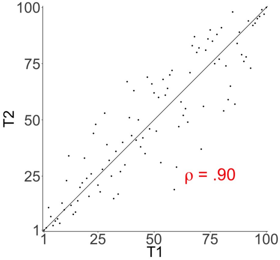

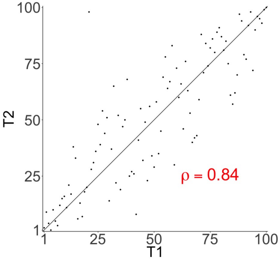

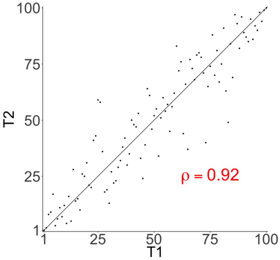

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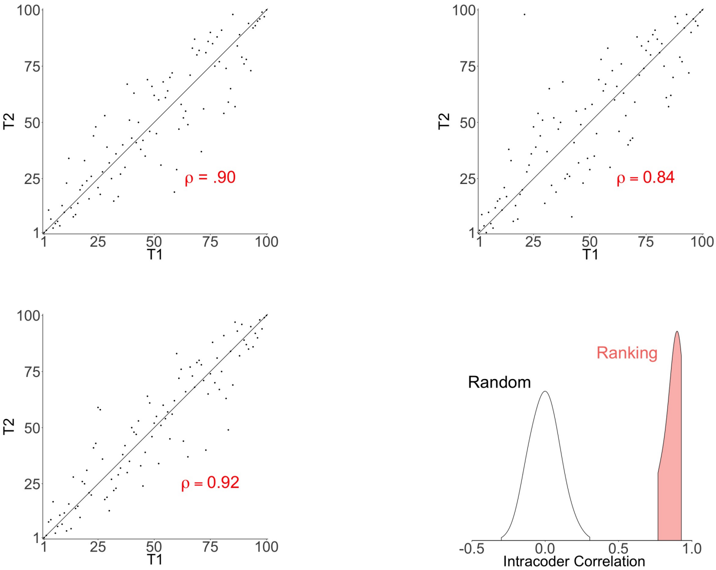

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Goal: Compactness score $= f(\text{shape})$

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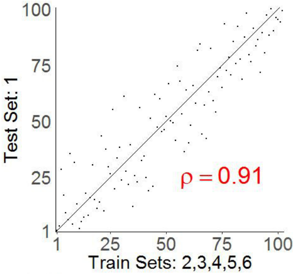

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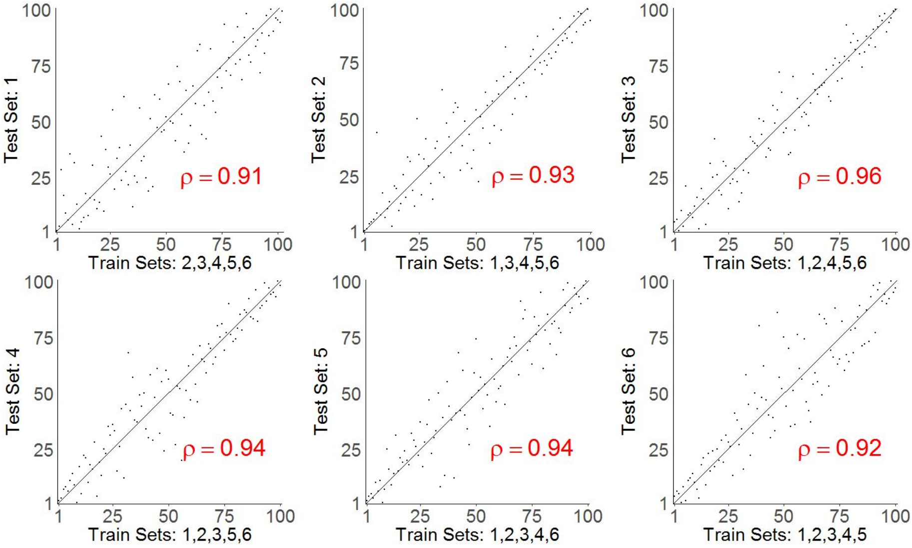

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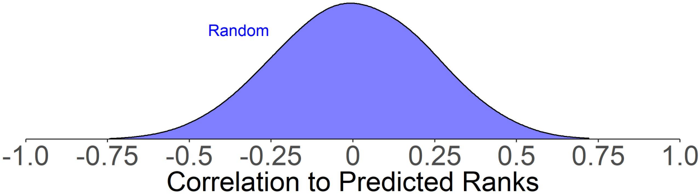

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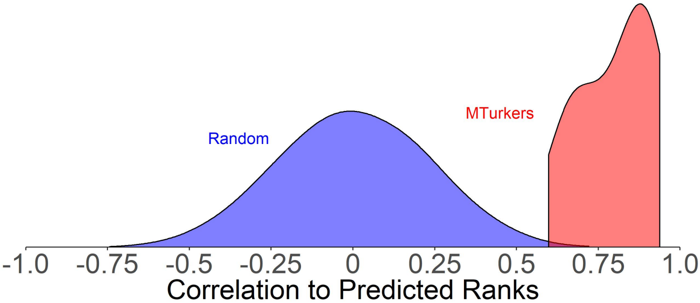

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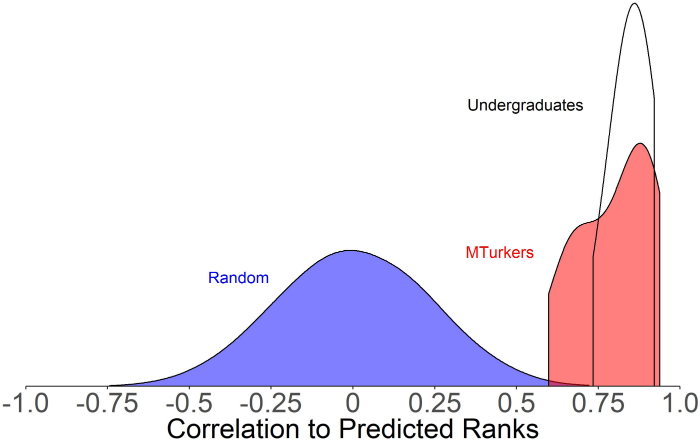

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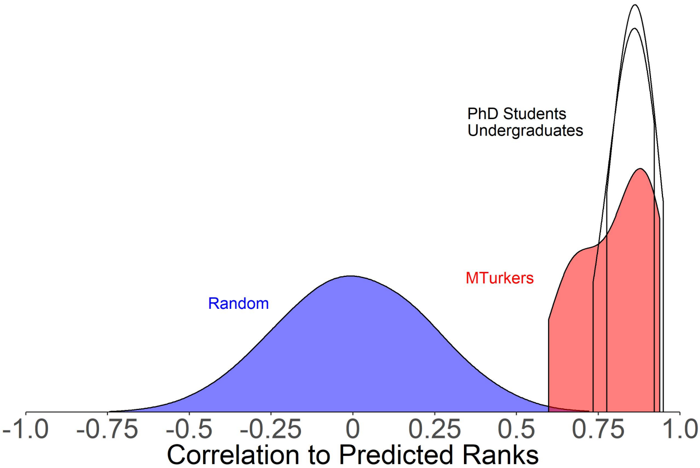

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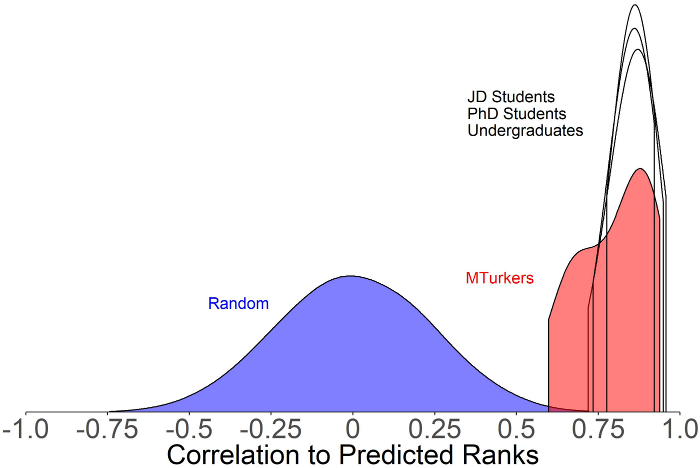

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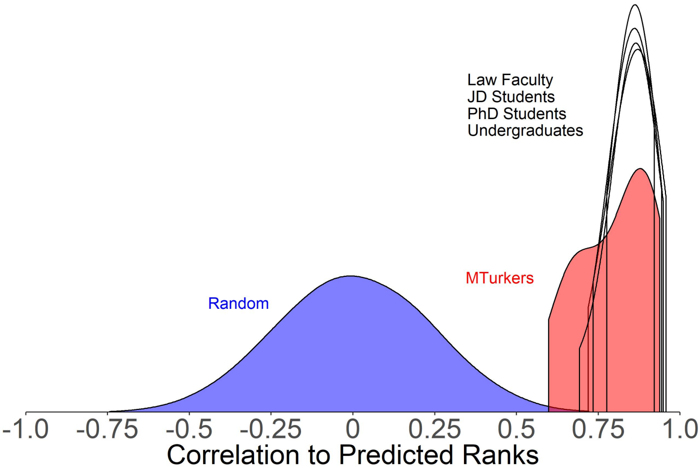

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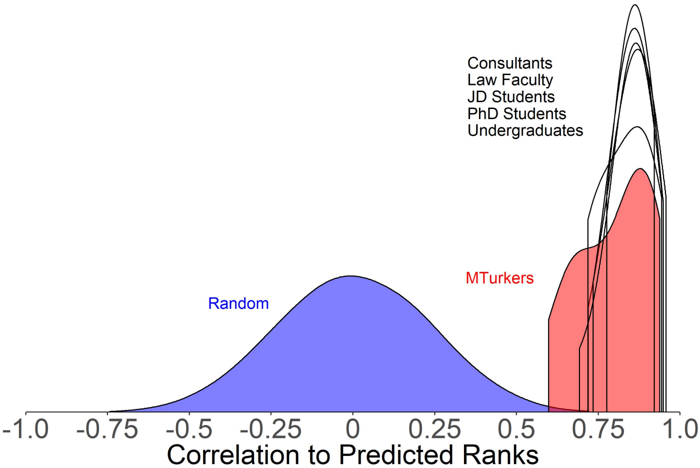

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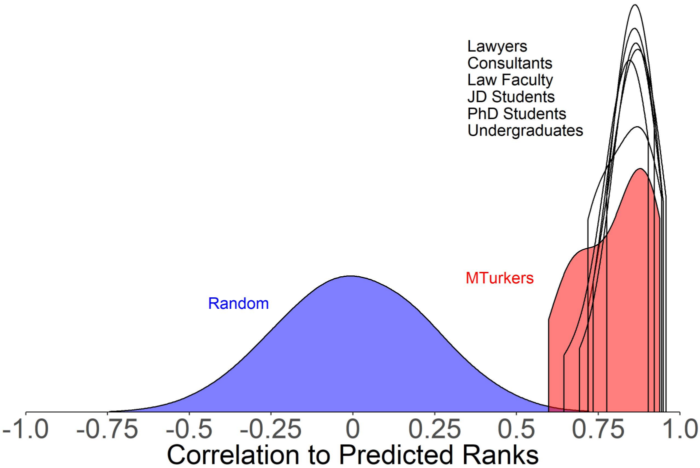

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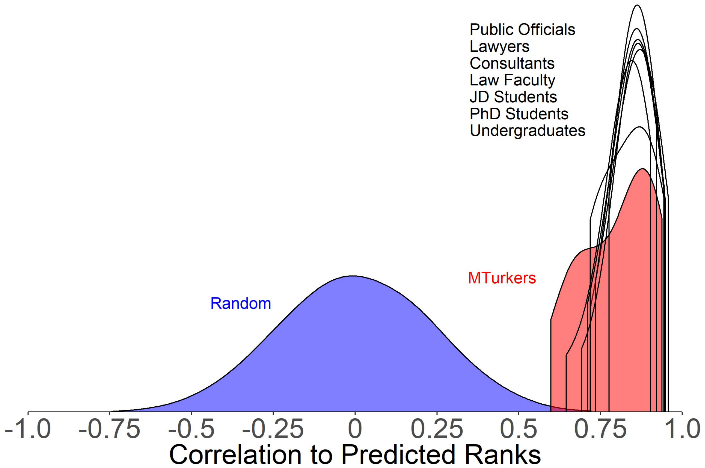

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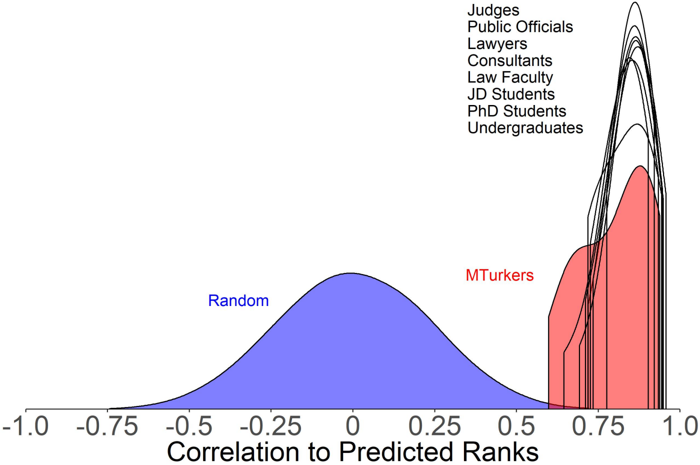

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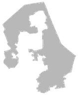
Reock				

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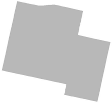
Boyce-Clark				

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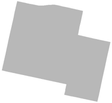
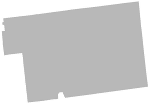
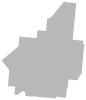
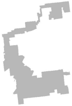
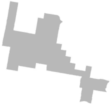
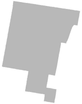
Boyce-Clark				
Length/Width				
X-Symmetry				

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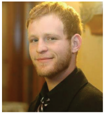
For more information



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