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

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Oxford University, Nuffield College, 2/14/2019

¹Based on joint work with Aaron Kaufman and Mayya Komisarchik ²GaryKing.org

• Fundamental to Democracy

• Control redistricting \leadsto Define basic units of representation

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 - Required in many other jurisdictions













A simple single compactness dimension that you know when you see



• The dimension is intuitive



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- How to estimate where a new district shape falls on this dimension?



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- Only a consensus measure can constrain advocates



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











Squarish districts more compact than long thin ones



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

Circular districts are most compact

Circular districts are most compact





Measure 2: Reock, District / Bounding Circle Areas Circular districts are most compact



Circular districts are most compact





Circular districts are most compact





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









All travel distances from center should be similar



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

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?



• Existing measures of compactness:

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New Measure: Y-Symmetry, area of symmetric reflection











In both cases, Overlap/Original Area ≈ 0.34

New Measure 2: Number of Visually Significant Corners Computer vision algorithm identifies "objects" in photos

Computer vision algorithm identifies "objects" in photos \rightsquigarrow Fewer corners is more compact

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Both districts have 21 significant corners

Which is more compact?

* - 7 -







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

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- Many more inconsistencies on individual districts

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

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Utterly fails on inter- and intra-coder reliability

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Full Ranking



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

Full Ranking — on line

MOST Compact Here



LEAST Compact Here

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We show: very high reliability

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 - Humans use time-saving heuristics. Would it take you 2 quintillion seconds to rank 20 districts?
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Intercoder Reliability of Pairs

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Intercoder Reliability of Pairs

Paired Comparisons: only slightly better than chance; Pairs implied by ranks: better



Intracoder Reliability of Pairs

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Intracoder Reliability of Pairs

Paired Comparisons: better than chance; Pairs implied by ranks: much better





























So we can measure it. Can we model it?

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- Ensemble of predictive methods: least squares, AdaBoosted decision trees, SVM, random forests...

Predict Test Set from 5 Training Sets

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22/26

Respondents ranging from ordinary citizens to those responsible for redistricting

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Respondents ranging from ordinary citizens to those responsible for redistricting


















Our measure:	COMPACT	noncompact	noncompact	COMPACT
Existing measure:	COMPACT	noncompact	COMPACT	noncompact











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For more information





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