Scaling of variability measures in hierarchical demographic data

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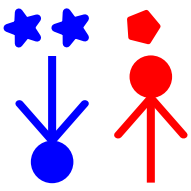
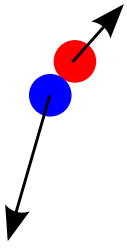
Motivation

Historical context

"**The molecules are like so many individuals**, having the most various states of motion, ..."
(L. Boltzmann (1844–1906))

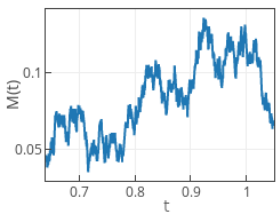


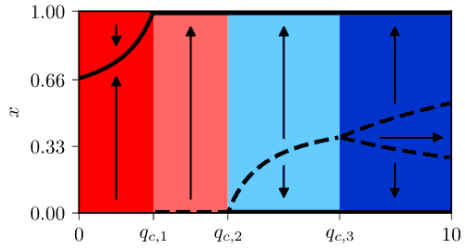


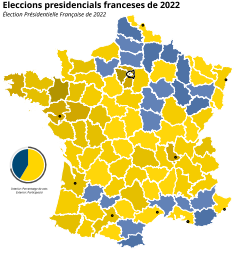
Source: Wiki

Contemporary sociophysics

Most models are temporal, or explore phase transitions, while the data is (usually) spatial.





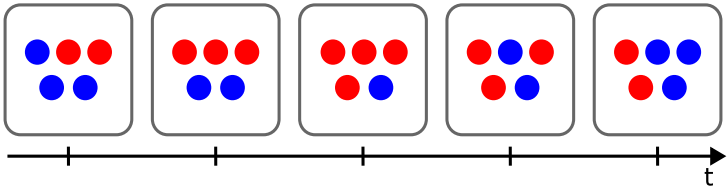


Sources: Physics of Risk, Physics of Risk, Wiki (modified)

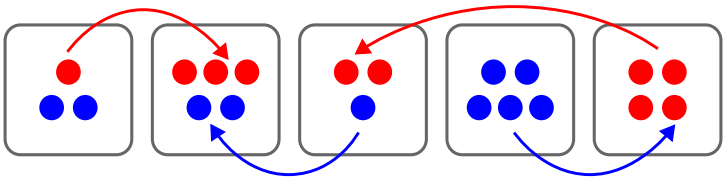
(One of) the question(s)

[Fernandez–Gracia *et al.* (Phys. Rev. Lett., 2014)]

The answer seems to be “no”?



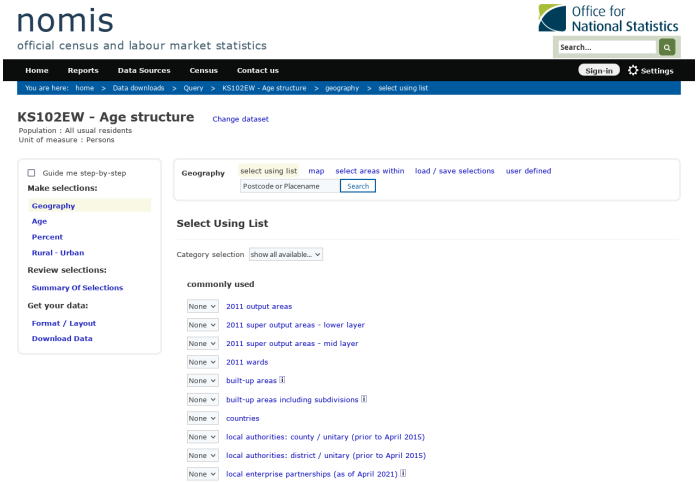
temporal dynamics is (mostly) equivalent to **spatial rearrangement**



[Kononovicius (J. Stat. Mech., 2019)]

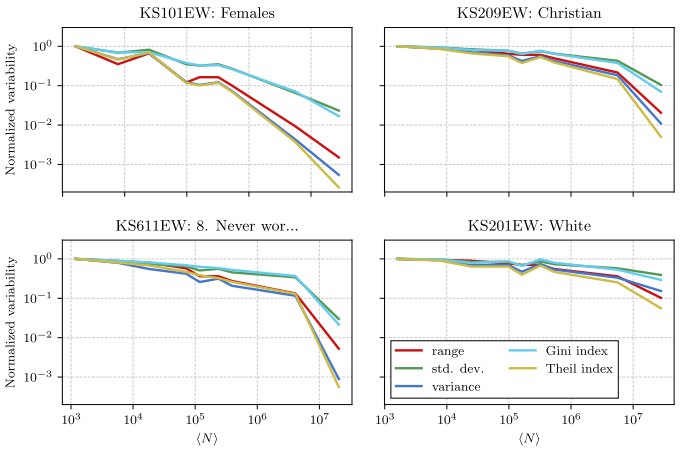

Exploration

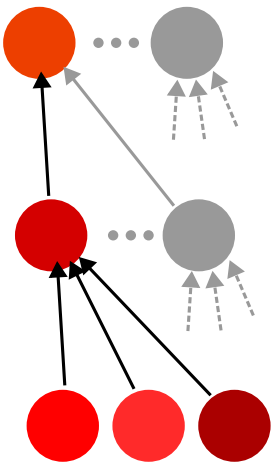
UK 2011 census data set



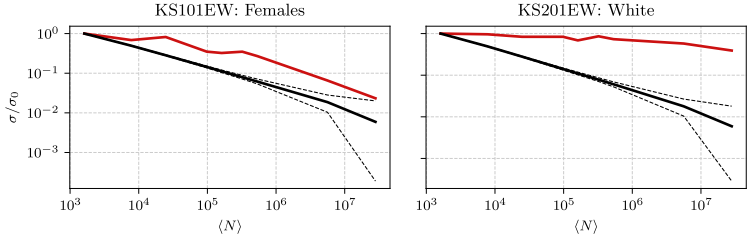
Source: Office for National Statistics (UK)

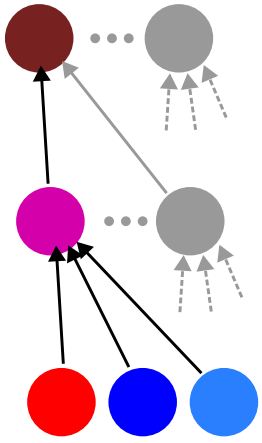
Analyzing hierarchical demographic data





Null model

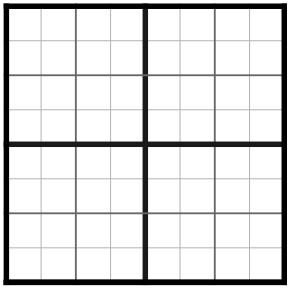


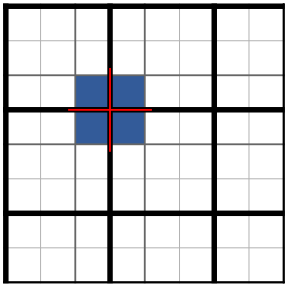


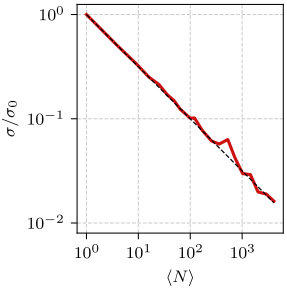
The null model randomizes data at lowest scale by **breaking the spatial relations**, but **keeps data the same**.

For **random data** we would expect $\sigma \sim N^{-\frac{1}{2}}$.

Non–monotonocity is caused by imperfect hierarchy

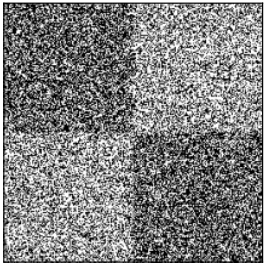


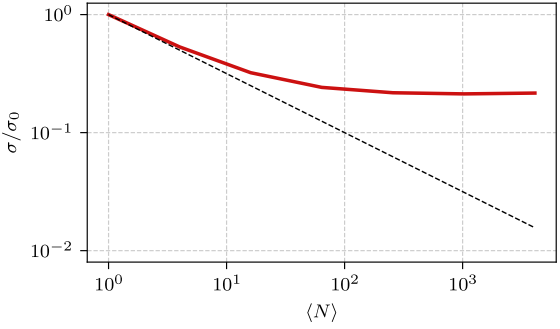




In a perfect hierarchy lowest scale units are always kept “together” (left). In an imperfect hierarchy lowest scale units might be “split” (middle), which generates non–monotonic variability curve (right).

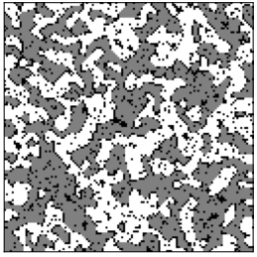
Modeling segregation using random grid model

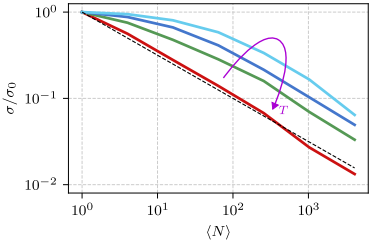


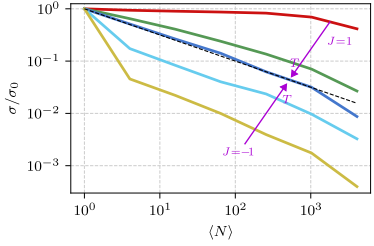


Generated random grid with differing occupation densities (left), and the corresponding variability curve (right).

Modeling segregation using Schelling and Ising models







Variability curves obtained by numerical simulation using Schelling (middle) and Ising (right) models. Different curves correspond to different thresholds (Schelling model) and temperatures (Ising model). State of Schelling model at $T = 0.5$ (cyan curve) is shown on the left.

Thank you!

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