# Measuring paradigmaticness

## Soc Stats Reading Group

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# Plan for today

Evans, E., C. Gomez and D. McFarland. 2016. "Measuring paradigmaticness of disciplines using text." *Sociological Science*. http://doi.org/10.15195/v3.a32

- What is a paradigm?
- How should we measure it?
- Evaluating the measure

# Some themes to keep in mind

- Standards for developing measures
- Data selection in measurement work
- Representation vs. operationalization
- Generalizability of measurement

# What is a paradigm?

*Research firmly based upon one or more past scientific achievements, achievements that some particular scientific community acknowledges for a time as supplying the foundation for its further practice. (Kuhn 1962, p. 10)*

# Observable consequences of paradigmaticness

1. Consensus about (or more specifically, commitment to) core ideas, canonical questions, methods of inquiry
2. Rapid "discovery" (i.e. pursuing consensual problems as a mode of knowledge-production)

# How do these relate?

Kuhn: Consensus causes rapid discovery

Collins: Rapid discovery also causes consensus

# Why would we want to measure this?

- Hierarchy of the sciences (paradigmatic divides "soft" from "hard" science)
- Pace and character of "discovery" (Kuhn says paradigmatic = faster)
- Scientific evaluation processes (paradigms imply a mode of evaluating claims)

# Measurement type/level

- Nominal (fields are either paradigmatic or not)
- Ordinal (fields can be ordered as more or less paradigmatic)
- Interval (fields can have paradigmaticness level 1.324, say)

# Prior art

- Citation age (de Solla Price 1970)
  - Rapid discovery entails more recent citations
  - Too dependent on expansion of science? (Do we agree this is a problem?)
- Dissertation length (e.g. Pfeffer and Moore 1980)
  - High consensus increases tacit knowledge, reduces need to reiterate core ideas
- Fractional graph area (e.g. Cleveland 1984)
  - Graphs encode consensual knowledge (aside: I find this counterintuitive)

# Why text?

- Kuhn thinks paradigms are linguistic[1]
- Scientific publications are one of the main venues where scientific field processes play out

[1] This idea is due to Wittgenstein (1958).

# Measuring paradigmaticness

- Consensus: “concentration of disciplinary language in key words that represent the core”
- Rapid discovery: “proportion of distinct terms that persist”
- Stability: “concentration of disciplinary discourse in terms that persist over time”

# Data

- Web of Science, 1991-2011
  - 5% random samples of articles in journals tagged as biology, chemistry, economics, mathematics, physics, political science, psychology, or sociology journals
  - (Is this really a conservative sampling strategy?)

# Consensus

## Definition

$$\text{consensus} =: 1 - \frac{\sum_{w \in d} \left[ p_w \times \log \left( p_w \right) \right]}{\sum_{w \in d} \left[ \frac{1}{V} \times \log \left( \frac{1}{V} \right) \right]}$$

$w$: word
$d$: disciplinary corpus
$p_w$: probability of $w \in d$
$V$: vocabulary size in $d$

Measure of word use concentration over the corpus in a given time window

# Rapid discovery

## Definition

$$\text{rapid discovery } \left(\overrightarrow{d_j}, \overrightarrow{d_{j+1}}\right) =: 1 - \frac{\sum_{w \in d_j, d_{j+1}} \left[tp_{w,d_j} \times tp_{w,d_{j+1}}\right]}{\sqrt{\sum_{w \in d_j} \left(tp_{w,d_j}\right)^2} \times \sqrt{\sum_{w \in d_{j+1}} \left(tp_{w,d_{j+1}}\right)^2}}$$

$j$: time window

$tp_{w,\square}$: is word present in time-windowed vocabulary $\square$?

Essentially, cosine similarity in vocabulary between time periods; high-paradigmaticness (i.e. more rapid discovery) means less similar words between time periods

# Stability

## Definition

$$\text{stability}\left(\overrightarrow{d_j}, \overrightarrow{d_{j+1}}\right) =: \frac{\sum_{w \in d_j, d_{j+}} \left[tf_{w,d_j} \times tf_{w,d_{j+1}}\right]}{\sqrt{\sum_{w \in d_j} \left(tf_{w,d_j}\right)^2} \times \sqrt{\sum_{w \in d_{j+1}} \left(tf_{w,d_{j+1}}\right)^2}}$$

$tf_{w,\square}$: word frequency in time-windowed vocabulary $\square$

Intended to capture use of the *same* words over time

# How does it measure up?

1. Validation
2. Choice of data
3. Conceptual generalizability

# Validation

- Public/academic rankings as ground-truth (?!)
  - What is this picking up?
- Paradigm formation is a historical process
  - In Kuhn's theorization, paradigms form out of scientific *achievements* (can we identify these?)
  - If paradigmaticness varies over time, what are we detecting?

# Choice of data

- Reliance on titles and abstracts (presentation vs. substance?)
  - Scientists try to look comprehensible (Zuckerman 1999)
  - Especially selecting works already categorized as such
- What else could we use?
  - Textbooks (Kuhn 1962; Cole 1983)
  - Conferences (proceedings, verbal discussion)
  - Press releases, media discourse

# Conceptual generalizability

- Is "discovery" a universally meaningful characteristic of fields?
  - There seems to be something different about "discovering" something in physical vs. social science
  - Linguistic innovation as a paradigmatic activity
- Does paradigmaticness look the same in differently structured fields?
  - "Disciplines" constitute a fairly limited range of scientific knowledge work
  - Paradigmaticness is just what the physical sciences do (Kuhn 1962; Isaac 2011)
  - At what level of analysis do paradigms obtain (subfields, topics)?