

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 linguistic¹
- Scientific publications are one of the main venues where scientific field processes play out

¹This 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”

- 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

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

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

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

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

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

$tf_{w,\square}$: 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)?