

Bibliometrics Citation Analysis

Biblio**metrics**

- Metrics = measuring
 - explaining the world through measurement

Biblio**metrics**

- Biblio = information
 - “series of techniques that seek to quantify the process of written communication.”
(Ikpahindi 1985)

Bibliometrics

- Finding information patterns by
 - analyzing citation patterns
 - analyzing word use frequencies
 - using statistical analysis

Purpose of Bibliometrics

- Quantitative analysis of science and technology performance
- Quantitative analysis of the cognitive and organizational structure of science and technology
- To know how a certain science or technology has evolved in a certain period of time

Informetrics or Infometrics

- The quantitative (mathematical, statistical, probabilistic) study of information and information flow
 - including the modelling of information management and library management

Scientometrics

- The measurement of science
 - not the use of measurement in science
- The quantitative study of scientific communications
- Using bibliometric methods

Cybermetrics

- Bibliometrics, Infometrics, & Scientometrics applied to the Web

Why Bibliometrics

- Technology watch technique
 - compare R&D productivity between two competing technologies
 - provide decision makers with a quick picture of the "state-of-the-art"

Why Bibliometrics

- Analyse R&D trends
 - identify which areas are most active and which are becoming important
 - identify the influences & “cross-fertilizations”
 - useful to the policy makers who are deciding the priority areas in a certain research domain

Some “Laws” of Bibliometrics

Lotka’s Law
Bradford’s Law of Scattering
Zipf’s Law
Narin’s 3 Axioms of Bibliometric Analysis

Lotka’s Law of Authorship

<http://www.is.uiuc.edu/~jdownie/biblio/lotka.html>

The Frequency Distribution of Scientific Productivity

“It would be of interest to determine, if possible, the part which men of different calibre contribute to the progress of science considering first simple volume of production ...”

Lotka, A.J.

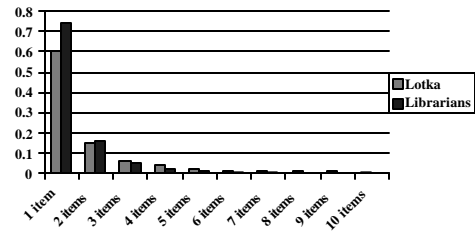
Lotka’s Law

- The number of authors making n contributions to the literature is about $1/n^2$ of those making one
 - 60% of authors make one contribution
 - 15% of authors make two contributions
 - <7% of authors make three contributions
 - <4% of authors make four contributions
 - <2.5% of authors make five contributions
 - 1.25% of authors make six contributions
 - <1% of authors make seven contributions

Lotka's Law

- Out of 1000 authors
 - 608 publish 1 article
 - 152 publish 2 articles
 - 68 publish 3 articles
 - 38 publish 4 articles
 - 24 publish 5 articles
 - 17 publish 6 articles
 - 12 publish 7 articles
- Not exact prediction but holds true overall in most fields

Lotka's Law & Librarians



Bradford's Law of Scattering

<http://www.lis.uiuc.edu/~jdownie/biblio/bradford.html>

- Relevant articles tend to cluster in certain periodicals
 - Lots of articles in each of a few journals
- Relevant articles also tend to scatter among many periodicals
 - Few or single articles scattered among many journals
- That scatter has a predictable shape

Bradford's Law of Scattering

- In any field of interest, relevant journals can be split into three groups
- Each group contributes the same number of relevant articles to citations in the field
- # of 1st group journals = k
- # of 2nd group journals = $k*n$
- # of 3rd group journals = $k*n^2$



The research literature of blubber production

Of the 600 articles cited,

- 200 are from 10 major journals on whale processing
- 200 are from 30 (10 x 3) secondary journals
- 200 are scattered in 90 (10 x 3²) tertiary journals

Bradford's Law is Useful for Collection Development

Zipf's Law of term distribution

<http://www.lis.uiuc.edu/~jdownie/biblio/zipf.html>

- Predicts term distribution in a text
- Rank the words in a text by decreasing frequency
- Multiply frequency by rank
- Result will cluster around a constant for the document

Zipf's Law of term distribution

- In a document of ca. 10,000 words
 - the most frequently used word is “the” at 950 times
 - the 2nd most frequently used word is “a” at 490 times
 - the 3rd most frequently used term is “in” at 340 times
 - ...
 - the 1000th most frequently used term is “fruit” at 1 time

Zipf's Law of term distribution

- Frequency x occurrences = constant
- $1 \times 950 = 950$
- $2 \times 490 = 980$
- $3 \times 340 = 1020$
- ...
- $1000 \times 1 = 1000$
- Constant = 1000 for this document

Uses for Zipfian Distributions

- Can be used in automatic indexing
 - Likelihood of document relevance can be determined to some degree by frequency of terms
 - The most/least frequent terms in a document are not likely to produce relevant retrieval
 - Terms in the middle range of frequency are most likely to produce relevant retrieval



Computational Linguistics

- Simplest definition:
 - Counting words and drawing conclusions
 - Can be done manually, more easily done with computers
- Complexities:
 - Explaining grammar & syntax to a computer
 - Infinite varieties of human expression
 - Multilingual needs

Applications of Computational Linguistics

- Clusterfier <http://ai.iit.nrc.ca/Clustifier/>
 - National Research Council Canada Interactive Information Group
 - Runs a search, e.g. on “Libya”
 - Analyzes the word occurrences in the set of documents retrieved
 - Clusters the documents by use of similar vocabularies

Applications of Computational Linguistics

- Extractor <http://extractor.iit.nrc.ca/cgi-bin/process-url.pl>
 - National Research Council Canada Interactive Information Group
 - Analyzes the vocabulary in a given page to choose important words and phrases
 - Enables further searching based on terms extracted
 - Sample <http://www.sholtmd.com/thobreds.htm>

Narin's 3 Axioms of Bibliometric Analysis

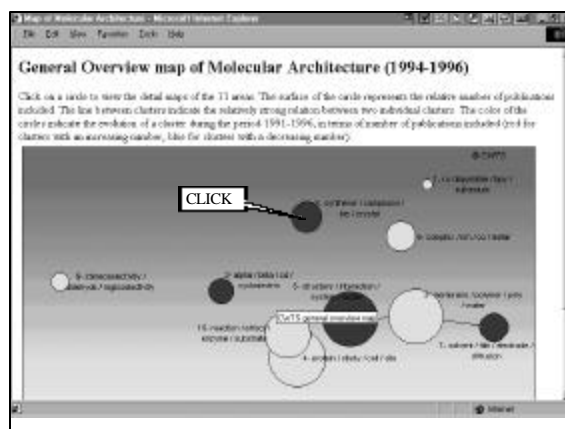
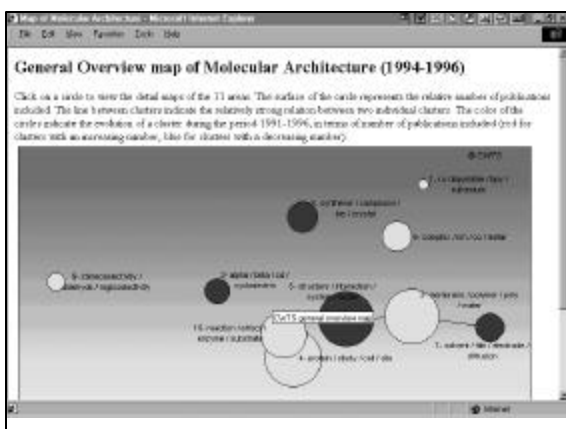
- activity measurement
 - counts of papers provide valid indicators of R&D activity in a subject or at an institute
- impact measurement
 - the number of times papers are cited in provides valid indicators of the impact or importance of the cited papers
- linkage measurement
 - that the citations from paper to paper provide indicators of intellectual linkages between subject areas, organizations, or individuals

What Can Bibliometrics Tell Us?

- To see who cites (influences) whom
 - <http://www.umu.se/inforsk/LIS/index.htm>
- To see changes in a topic over time
 - <http://sahara.fsw.leidenuniv.nl/ed/mlar/map02.html>
 - <http://sahara.fsw.leidenuniv.nl/ed/nframes.html>

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Citation Analysis

- Using citations (footnotes) as the raw data for bibliometric studies
- Who footnotes whom/who is footnoted by whom
- Can be used to assess the influence of an individual on a field of study

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Co-citation

When one document is cited by two other documents, co-citation has occurred.

If A cites 1 and B cites 1, then co-citation of 1 by A and B has occurred.

Bibliographic Coupling

If two documents are cited in another document, bibliographic coupling has occurred.

If A cites 1 and 2, bibliographic coupling of 1 and 2 has occurred in A.

Co-citation/Bibliographic Coupling

“Show me other documents like this one”

- If A cites 1, 2, and 3
- And B cites 1, 2, and 3
- Is document A like document B?
- If C cites 1,2, and 5
- Is document A more like B than C?

Davey Jones. *Dog breath and you.*

FOOTNOTES:

Nathan Hale. *Don't breath on me, Fido.*

Thomas Paine. *Uncommon scents in the mouths of dogs.*

James Monroe. *Your consitutional rights and dog halitosis*

Patrick Henry. *Canine halitosis.*

FOOTNOTES:

Betsy Ross. *Preventing canine plaque.*

Nathan Hale. *Don't breath on me, Fido.*

Thomas Paine. *Uncommon scents in the mouths of dogs.*

Hale is co-cited by Jones and Henry
 Paine is co-cited by Jones and Henry

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Hale and Paine are coupled by Jones
 Hale and Paine are coupled by Henry

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Gee, if I am writing on Dog
 Breath, and both Jones and Henry
 looked at Paine,
 I'd better look at Paine, too.

Co-citation based relevance
 assessment.

Gee, if Jones cited both Hale and
 Paine, they must share some
 similarities. If I need to look at
 one, I probably need to look at
 the other.

Bibliographic coupling based
 relevance assessment.

Cybermetric Use of Bibliographic Coupling

- BIRD: Bibliometric Retrieval of Documents
 – National Research Council Canada-Institute for
 Information Technology.
- Bibliometric-query -by-example search
 engine
- User supplies URLs of pages of interest
- BIRD retrieves similar documents by
 following link/citation paths that pass
 through those given documents

http://ai.iit.nrc.ca/II_public/WebBird/tryIt.html

• “History of Computers

- In this example, BIRD was given a page on
Ada Lovelace, the nineteen century female
 mathematician whose work with Charles
 Babbage resulted in the world's first
 "computer". The BIRD search returned a
 series of sites with information on the early
 history of computing.”

- <http://www.cs.vale.edu/homes/tap/ada-lovelace.html>
- http://ai.iit.nrc.ca/II_public/WebBird/Tests/Miscellaneous/ComputerHistory/res.html

The Citation Indexes

- Institute for Scientific Information
- Science Citation Index (SCI)
- Social Sciences Citation Index (SSCI)
- Arts & Humanities Citation Index (A&HCI)

Web of Science

Institute for Scientific Information

- 1958, Eugene Garfield starts ISI by borrowing \$500 from Household Finance
- Current Contents of Chemical, Pharmacological & Life Sciences is the sole product
- Covers 200 journals in about 32 pages per issue

Institute for Scientific Information

- 1998
- 40th Anniversary
- ISI employs 800 people with offices in 7 countries
- Indexes 8,000+ titles
- In 35 languages

Institute for Scientific Information

- 1961, ISI receives a grant from the National Institutes of Health
- produces experimental *Genetics Citation Index*
 - using citation indexing
 - comprehensive interdisciplinary index
 - from this, citations relating to genetics were extracted.
 - forms 1961 Science Citation Index
 - indexed 613 journals and 1.4 million citations

Citation Indexes

- Index articles from major journals
- Index by what is footnoted
- Search by who footnoted a particular article
- Can be used to search forward chronologically
- Can be used to “measure” science

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**Economics & Business:
Most-Cited Institutions, 1991-2001**

(Ranked by total citations, based on papers and citations recorded in ISI-indexed economics & business journals between 1991 and February 2002.)

Rank	Institution	Papers 1991-2001	Citations
1	Harvard University	1,997	20,965
2	MIT (Mass.) (MIT, 1962-2001) (CONCORDS, 1962)	1,876	17,869
3	University of Chicago	1,232	14,372
4	University of Pennsylvania	1,540	14,265
5	MIT	1,204	12,685

SOURCE: ISI Essential Science Indicators (ESI), a web-based data file reflecting upwards of 7 million citations published in 8,500 ISI-indexed journals over the last decade, covering 22 major fields of science and the social sciences. Users can create citation-based rankings of scientists, papers, journals, nations, and institutions. Available from the ISI Research Access Center.

Hot Paper in Physics

"Superconductivity of 39K in cuprates doped with Bi," by Jun Koganeishi, Hirokazu Hoshizawa, Takahiro Murakami, Yusuke Yamada, and Jun Akimitsu, *Nature*, 410(6824):63-4, 1 March 2001.

(Authors' affiliation: Aoyama-Gakuin University, Tokyo, 20585; ORST, 328-81 Science and Technology Corporation, Sakai, Japan.)

Abstract: In the light of the tremendous progress that has been made in raising the transition temperature of the copper oxide superconductors, it is natural to wonder how high the transition temperature, T_c , can be pushed in other classes of materials. Of interest, the highest reported values of T_c for non-copper-oxide bulk superconductors are 22 K in electron-doped CePrNiO_{10} and 20 K in Ba_2CuO_7 . Here-doped CeO was recently found to be superconducting with a T_c as high as 33 K, although the nature of the superconductivity meant that the superconductivity was confined to the surface of the CeO crystal, rather than probing the bulk. Here we report the discovery of bulk superconductivity in magnesium-dioxide, MgO . Magnetization and resistivity measurements establish a transition temperature of 37 K, which we believe to be the highest yet determined for a non-copper-oxide bulk superconductor.

The above report from early 2001 was cited 55 times in current journal articles indexed in the ISI database by the August 2001. Thanks to that two-month tally, the ISI database has tracked most-cited papers in a field published in the last two years, aside from reviews. At the end of this year, the report will certainly be cited among the most-cited papers published in 2001. Prior to this exact issue, monthly card, citations have accrued as follows:

May-June 2001: 22 citations
March-April 2001: 6

Citer Motivations

From "Bibliometrics and the World-Wide Web" by Don

Turnbull <http://donturn.fis.utoronto.ca/research/bibweb.html>

- paying homage to pioneers
- giving credit for related work (homage to peers)
- identifying methodology, equipment, etc.
- background reading
- correcting one's own work
- correcting the work of others

Citer Motivations

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- criticizing previous work
- substantiating claims
- alerting to forthcoming work
- providing leads to poorly disseminated, poorly indexed, or un-cited work
- authenticating data and classes of fact - physical constants, etc.

Citer Motivations

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- identifying original publications in which an idea or concept was discussed
- identifying an original publication or other work describing an eponymic concept or term (i. e. Hodgkin's Disease)
- disclaiming work or ideas of others (negative claims)
- disputing priority claims of others (negative homage)

Problems in Citation Analysis

- Citing behavior is little understood
- Citer motivations are little acknowledged
- Matthew Effect (Robert K. Merton)
 - "To him who has shall be given, and he shall have abundance: but from him who does not have, even that which he has shall be taken away."
- Obliteration by incorporation

Problems in Citation Analysis

- Ceremonial citing
- Obligatory citing
- Negative citing
- Pied Piper Effect (Kostoff) http://www.udtc.mil/dtic/kostoff_Merweb5.htm
 - everybody follows the Pied Piper
- Gulliver Effect (Geisler) <http://www.staart.edu/workingpapers/technology/index.html>
 - in 3-D filming, the farther apart cameras are placed the larger the image
 - mature writers have greater effect over time simply because of numbers

Problems in Citation Analysis

- Alphabetic Effect (Zuckerman)
- Secondary & Tertiary Citing (Hoerman & Nowicke)
 - The presence of a citation in a reference list that was taken from another reference list, arguably without the citing author’s examining the document being cited

Secondary and Tertiary Citing: A Study of Referencing Behavior in the Literature of Citation Analysis Deriving from the Ortega Hypothesis of Cole and Cole

Heidi Lee Hoerman and
Carole Elizabeth Nowicke

Library Quarterly 65 (October 1995): 415-434

Secondary & Tertiary Citing

- “Lifting”
- “Copying”
- “A form of petty dishonesty ... common in scholarly publishing”
- “Swip[ing] a reference under false pretenses”
- “Plagiarism of other people’s citations without having actually used them”

“A fundamental law of reference giving—*it is unnecessary to have read or even seen the reference yourself before quoting it.*”

David Davies

Evidence of Secondary & Tertiary Citing

- “amusing, and long lasting, miscitation”
- “multiple discrepancies”
 - repetition of errors of detail
- “evolved meaning”
- “directed misregistration”
 - repetition of identical evolved meaning

Ortega Hypothesis

- The work of scientific elites owes much to the work of average scientists
- The works of great men stand on the shoulders of the “little people” who came before
- Jonathan Cole and Stephen Cole tested and rejected the Ortega Hypothesis
 - Cole & Cole conclusion:
elite scientists cite elite scientists

Cole & Cole’s Ortega Hypothesis

“Until recently, historians and philosophers of science have attributed much of the growth of science to the work of the average scientist who, it is suggested, has paved the way with his ‘small’ discoveries for the men of genius—the great discoverers. This hypothesis is boldly asserted in many sources, but perhaps no more clearly than in the words of José Ortega y Gasset.”

Cole & Cole quote Ortega:

“For it is necessary to insist upon this extraordinary but undeniable fact: experimental science has progressed thanks in great part to the work of men astoundingly mediocre, and even less than mediocre. That is to say, modern science, the root and symbol of our civilization, finds a place for the intellectually commonplace man and allows him to work therein with success. In this way the majority of scientists help the general advance of science while shut up in the narrow cell of their laboratory, like the bee in the cell of its hive, or the turnspit of its wheel.”

- J. Cole (1969) cites Ortega
 - introduces textual errors & meaning error
- J. & S. Cole (1972) cites Ortega
 - introduces page number error
- Multiple authors cite Ortega
 - repeat the errors introduced by Cole
- Snizek (1986) cites Ortega
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The missing sentence

“The reason of this lies in what is at the same time the great advantage and the gravest peril of the new science, and of the civilisation directed and represented by it, namely, mechanisation. A fair amount of the things that have to be done in physics or in biology is mechanical work of the mind which can be done by anyone, or almost anyone. For the purpose of innumerable investigations it is possible to divide science into small sections, to enclose oneself in one of these, and to leave out of consideration all the rest. ...

The missing sentence

“... The solidity and exactitude of the methods allows of this temporary but quite real disarticulation of knowledge. The work is done under one of these methods as with a machine, and in order to obtain wuite abundant results it is not even necessary to have rigorous notions of their meanings and foundations.”

Ortega on Scientists

“And now it turns out that the actual scientific man is the prototype of the mass-man. Not by chance, not through the individual failings of each particular man of science, but because science itself—the root and symbol of our civilisation—automatically converts him into mass-man, makes him a primitive, a modern barbarian.”

Ortega on Scientists

“I have said that he was a human product unparalleled in history. The specialist serves as a striking concrete example of the species, making clear to us the radical nature of the novelty. For previously, men could be divided simply into the learned and the ignorant, those more or less one, and those more or less the other. ...

Ortega on Scientists

“... But your specialist cannot be brought in under either of these two categories. He is not learned, for he is formally ignorant of all that does not enter into his specialty; but neither is he ignorant because he is a ‘scientist,’ and ‘knows’ very well his own tiny portion of the universe. ...

Ortega on Scientists

“... We shall have to say that he is a learned ignoramus, which is a very serious matter, as it implies that he is a person who is ignorant, not in the fashion of the ignorant man, but with all the petulance of one who is learned in his own special line.”

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J. & S. Cole (1972) cites Ortega introduces page number error: changes from “110-11” to “84-85”

- J. Cole (1969) cites 1960 W.W. Norton ed., right pages
- J. Cole (1970) cites 1932 W.W. Norton ed., no pages
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- *The Revolt of the Masses*
 - 2 different English translations
 - 5 different publishers
 - Editions by Allen & Unwin, W.W. Norton, and The New American Library
 - Various 141, 144, 190, and 204 pages long
 - Only Norton editions cited in the bibliometric literature
 - Quote is found on 110-11 in the 190-page Norton editions
 - Quote is found on 84-85 in the 144-page 1961 Allen & Unwin edition

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“For it is necessary to insist upon its extraordinary but undeniable fact: experiment in science has progressed thanks in great part to the work of an astonishingly mediocre, and in less than a score. To say that science has not and should not of our civilization, find place for the intellectually common man and to permit him to work therein with success. In the past, the majority of scientists had the general audience of science while shut up in the narrow confines of their laboratory, like the bee in the cell of its hive, or the turnspit of its wheel.”

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From then on, half the authors citing Ortega give the wrong page numbers, citing variously 1932 or 1957 W.W. Norton editions.

Scholarly Interpretations of Ortega

- “only an intellectual elite can lead the unthinking masses in building and maintaining society.”
- “Ortega concludes by demanding that the masses surrender their leadership to the minorities of cultivated men.”
- Ortega “argues for the essential inequality of human beings and for the vital importance of intellectual elites in human history.”



Cole & Cole’s Ortega Hypothesis

“Until recently, historians and philosophers of science have attributed much of the growth of science to the work of the average scientist who, it is suggested, has paved the way with his ‘small’ discoveries for the men of genius—the great discoverers. This hypothesis is boldly asserted in many sources, but perhaps no more clearly than in the words of José Ortega y Gasset.”

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Bibliometricians’ Interpretations of Ortega

- “Ortega seems to be suggesting that average scientists, working on relatively unambitious projects, make minor contributions. But without these lesser discoveries by a mass of scientists, the break-throughs of the truly inspired scientist would not be possible.”
- “Ortega’s ... primary assumption is that utilization of work that is of relatively minor importance is a necessary precondition to the success of more important scientific endeavors.”
- “Ortega seems to be suggesting that the work of the great scientists is built upon a pyramid of small discoveries made by average scientists.”

Citation Patterns for “Ortega Hypothesis”

- Total articles: 26
- Articles citing Ortega y Gasset: 11 (42%)
- Articles citing Cole or Cole & Cole: 14 (53%)
- Articles citing both: 6 (23%)
- Articles citing neither: 7 (27%)

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Those who cited only Ortega or who cite neither have previously cited Cole or Cole & Cole in other works.

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Snizek

- Both quoted and cited Ortega
 - includes Cole’s errors
 - introduces new error

Changes

The Revolt of the Masses

to

The Rebellion of the Masses

Snizek

“Given the extreme care taken by me and others who employ citation analysis as a ‘roughly valid,’ but by no means ‘perfect,’ measure of influence, I find the criticisms of [bibliometric methods by] the MacRoberts to be inappropriate at best, and vacuous and sophomoric at worst. ...”

Snizek

“... In the final analysis, various cannons [sic] of science concerning the reliability and validity of measures, as well as the reproducibility of results must be upheld.”

Ortega: Snizek

“... The solidity and exactitude of the methods allows of this temporary but quite real disarticulation of knowledge. In the final analysis, various cannons [sic] of science concerning the reliability and validity of measures, as well as the reproducibility of results must be upheld.”
The work is done under one of these methods as with a machine, and in order to obtain quite abundant results it is not even necessary to have rigorous notions of their meanings and foundations.”

Ortega:

“... The solidity and exactitude of the methods allows of this temporary but quite real disarticulation of knowledge. The work is done under one of these methods as with a machine, and in order to obtain quite abundant results it is not even necessary to have rigorous notions of their meanings and foundations.”

Ortega:

“... But your specialist cannot be brought in under either of these two categories. He is not learned, for he is formally ignorant of all that does not enter into his specialty; but neither is he ignorant because he is a ‘scientist,’ and ‘knows’ very well his own tiny portion of the universe. ...

- J. Cole (1969) cites Ortega
 - introduces textual errors & meaning error
- J. & S. Cole (1972) cites Ortega
 - introduces page number error
- Multiple authors cite Ortega
 - repeat the errors introduced by Cole
- Snizek (1986) cites Ortega
 - includes page number error
 - introduces title error
- Niederhof & Van Raan (1987)
 - repeats title error introduced by Snizek

**So, did
Niederhof & Van Raan
rely on
Snizek
who relied on
Cole
(who got it wrong in the first place)
to see what Ortega said?**

The Bibliometric Questions:

- If Niederhof & Van Raan never looked at Ortega were they truly influenced by Ortega?
- How often does this occur?
- Is it important?
- Do we need a name for it?

Some relevant terminology that already exists:

- Cognitive conduit
- Obliteration by incorporation

The Questions for Footnoters

- Is it normative to cite an author to whom we directly attribute an idea whether or not we have confirmed that the author actually stated the idea?
- Do you cite the original only?
- Do you cite the cognitive conduit only?
- Do you cite both?

Narin's 3 Axioms of Bibliometric Analysis

- activity measurement
 - counts of papers provide valid indicators of R&D activity in a subject or at an institute
- impact measurement
 - the number of times papers are cited provides valid indicators of the impact or importance of the cited papers
- linkage measurement
 - that the citations from paper to paper provide indicators of intellectual linkages between subject areas, organizations, or individuals

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“Meta-nyms”

from the literature of the Ortega Hypothesis

- “Cannons of science” for Canons of science
- “Ceiling wax” for Sealing wax
- “Belle weather” for Bell wether