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Practical potentials of Bradford's law: a critical examination of the received view

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Abstract

Purpose – The purpose of this research is to examine the practical potentials of Bradford's law in relation to core-journal identification.

Design/methodology/approach – Literature studies and empirical tests (Bradford analyses).

Findings – Literature studies reveal that the concept of "subject" has never been explicitly addressed in relation to Bradford's law. The results of two empirical tests (Bradford analyses) demonstrate that different operationalizations of the concept of "subject" produce quite different lists of core-journals. Further, an empirical test reveals that Bradford analyses function discriminatorily against minority views.

Practical implications – Bradford analysis can no longer be regarded as an objective and neutral method. The received view on Bradford's law needs to be revised.

Originality/value – The paper questions one of the old dogmas of the field.

Keywords Identification, Information science, Serials, Bibliographies

Paper type Research paper

1. Introduction: Bradford's law

Bradford's law of scattering is often mentioned together with Zipf's law and Lotka's law as one among the three most important bibliometric laws, and is often considered the best model or example of scientific research that is available within library and information science (LIS). Bradford's law states that documents on a given "subject" is distributed (or scattered) according to a certain mathematical function so that a certain growth in papers on a subject requires a certain growth in the number of journals. The numbers of the groups of journals to produce nearly equal numbers of articles is roughly in proportion to 1: n: n^2 ..., where n is called the Bradford multiplier[1]. In other words, Bradford's law states that a small core of, for example, journals have as many papers on a given subject as a much larger number of journals, n, which again has as many papers on the subject as n^2 journals.

Bradford himself provided both a graphical and a verbal formulation of his law that have later been found not to be mathematical equivalent. The exact mathematical function has been subject to much subsequent research, and the very question what a Bradford distribution is has been debated.

Bradford's law has been used as an argument about how to build collections, how to select journals to be indexed in bibliographies, how to measure the coverage of bibliographies, how to solve practical problems related to information seeking and retrieval, and by Bradford himself as an argument for a new way to organize bibliographical work and scientific documentation. According to the received view on Bradford's law[2], this law may consequently help solving many of the practical problems facing the practitioners of our profession. The basic assumption of the advocates of the received view is that Bradford's law functions as a completely neutral and objective method.

We see a number of problems associated with the received view. In this paper we will concentrate on two of these. Our first objection against the received view is that the way one chooses to operationalize the concept of subject, when conducting Bradford analyses, will influence on the results of the very same. Consequently, Bradford's law does not automatically function as a neutral method. On the contrary, the results of utilizing Bradford analysis as a method for identifying the core information sources of any subject, field, or discipline will depend on the way "subject" is operationalized. We will illustrate this to be true by two examples. Our second objection against the received view is that the selection of information sources based on Bradford-distributions tends to favor dominant theories and views while suppressing views other than the mainstream at a given time. Thus, Bradford's law does not function as an objective method either. We will present empirical evidence that illustrate this to be true. However, before going into details with these two objections, we will first provide a very short review of the received view on Bradford's law.

2. The received view
According to the received view there are a number of practical potentials of Bradford's law. B.C. Brookes was among the first to address these potentials. In a short note in *Nature* he wrote that the law "seems to offer the only means discernible at present to reducing the present quantitative untidiness of scientific documentation, information systems and library services to a more orderly state of affairs capable of being rationally and economically planned and organized" (Brookes, 1969, p. 953).

Several commentators have suggested using Bradford's law to solve practical journal collection management problems. The basic idea is to conduct Bradford analyses of journals – i.e. to sort the journals in Bradford zones – and then identify which belong to the core and which does not. Any Bradford analysis involves three steps (Diodato, 1994, pp. 16-17):

(1) identify many or all items (usually articles) published in this field;

(2) list the sources (usually journals) that publish the articles (or items) in rank order beginning with the source that produces the most items; and

(3) while retaining the order of the sources, divide this list into groups (or zones) so that the number of items produced by each group of sources is about the same.

Nisonger (1998, pp. 139-40) argues in his textbook *Management of Serials in Libraries* that the following points are some of the "most obvious potentials" of Bradford analyses:

- selection/deselection;
- defining the core;
- collection evaluation;
- the law of diminishing returns;
- calculation of cost at various coverage; and
- setting priorities among journals.

Other commentators have suggested using Bradford's law to solve practical problems related to information seeking and retrieval. Howard D. White (1981) proposed an automatic option for sorting the output from online searches of journal literature, which he argued would help online users. What he had in mind was a "computerized sorting of hits by the journals in which they appear, and then of journals, high to low, by the number of hits appearing in each" (White, 1981, p. 47). He termed the procedure "Bradfordizing", and argued that "the ability to retrieve items selectively by journal after learning contributing titles and their yields, would seem to be the greatest single advantage of the proposed option" (White, 1981, p. 50). The reason for his optimism is spelled out in the article. According to White (1981) it is easy to imagine situations in which the searcher would want to retrieve hits only in the core journals of a literature. He mentions that it is often troublesome to track down the articles in the tail of a Bradford distribution, and concludes that "one may have the prejudice that items published in the core journals of a subject are generally superior to those scattered over journals in the tail, which is tantamount to believing that journals publishing the most items on a topic also publish the items most worth reading, as a rule" (White, 1981, p. 50)[3]. Perhaps as responses to White's suggestion, the proposed option is today a standard option in the products of most online vendors.

Wallace (1987, p. 45) stated that "any search for reported uses of the results of studies of scatter [...] will probably prove to be fruitless", and that "there seems to be no descriptions of the problems or benefits of actual application of such methods". We have found this to hold true even today. It is still not possible to locate actual reports that describe how Bradford's law has been applied in practical library and information services[4]. The near absence of such reports is hard to comprehend in light of the many suggestions for applications. It is furthermore a bit strange as G. Edward Evans in his primer on collection management writes that:

> Special libraries and information officers make good use of data generated by bibliometric techniques in selecting and maintaining collections of the most needed serials. Bradford's law, Lotka's law, Zipf's law, and citation analysis *have* contributed to the effective operation of special libraries (Evans, 2000, p. 104 [emphasis added]).

Unfortunately, Evans (2000) does not provide any details or references on this[5].

3. The concept of "subject"
Bradford's law is explicitly about the scattering of documents on specific subjects. The meaning of the term "subject" (and related terms such as aboutness, topicality, and theme) as applied in subject indexing, classification and knowledge organization, has been investigated in LIS for about a hundred years. Among the important contributions are Cutter (1904), Wilson (1968), Hutchins (1975, 1977, 1978), Maron

(1977), Miksa (1983), Soergel (1985), and Hjørland (1992, 2001). Since Bradford published his works, there has also been an impressive literature about Bradford's law. However, with few exceptions (Hjørland and Nicolaisen, 2005a; Hood and Wilson, 2001), nobody has tried to outline the consequences of different conceptions of "subject" for Bradford's law. The two lines of research have never really met[6]. This lack of interest is quite peculiar as Bradford's law precisely is about subject scattering. However, until recently, nobody has considered what difference different conceptions of "subject" makes for the outcome of Bradford analyses. Earlier analysts appear to hold what Hjørland (1992, p. 173) terms a "naïve conception of subject", a conception related to the philosophical position of naïve realism. They seem to share the idea that it is rather obvious what subjects are. Consequently, they seem to think, there is no need to dwell much on that concept. Yet, going over the bulk of papers on Bradford's law and related statistical patterns, it is possible to distinguish at least three different ways in which the concept of subject has been operationalized.

3.1 Bradford's conception of "subject"

Let us first examine how Bradford himself perceived of the concept. Unfortunately, Bradford never discussed the meaning of "subject" explicitly. Consequently, we must infer his meaning of the concept indirectly by considering how he used the word. Bradford (1948, p. 110; 1953, p. 148) wrote under the heading "The scattering of articles on a given subject":

> It is, therefore, necessary to examine the extent to which articles on a given subject actually occur in periodicals devoted to quite other subjects: as, for instance, a paper on the mechanism of the heart, contributed to the *Proceedings of Physical Society*, or one on genetics, occurring in an agricultural magazine. Investigation shows that this distribution follows a certain law, which can be deduced both theoretically from the principle of the unity of science and practically from examination of the references.
>
> According to this principle every scientific subject is related, more or less remotely, to every other scientific subject.
>
> It follows that from time to time, a periodical devoted to a special subject may contain an article of interest from the point of view of another subject. In other words, the articles of interest to a specialist must occur not only in the periodicals specializing on his subject, but also, from time to time, in other periodicals, which grow in number as the relation of their fields to that of his subject lessens and the number of articles on his subject in each periodical diminishes.

Bradford's empirical distribution was based on the sources indexed in four years of the current bibliography *Applied Geophysics* and two and a-half years of the current bibliography *Lubrication,* both prepared by the Science Library in London, of which Bradford was the keeper. There is no discussion, however, of how papers were assigned subject descriptors (e.g. classification codes) and how this assignment may have influenced the actual distributions. Indirectly however, we may get a little insight of his thinking about this issue and its consequences for his law. Bradford realized the needs for deep indexing addressed towards specific subject areas. His library, however, could not provide bibliographies with sufficient coverage of the relevant documents. Because the sources were too scattered, no special library could cover all the needed documents, and no compilatory team of a realistic size could manage to scan all the needed sources. Instead Bradford (1953) suggested a two-step procedure. All journals

and other information sources should be indexed by source, not by subject. That is: one team should make a crude indexing of journals one by one. Then other teams of information specialists could make specialized indexing to special purposes[7]. "On the average, a general abstract requires two classification numbers to specify the main subjects of the paper [. . .]. A special abstract, which included every substance mentioned and every piece of apparatus described, might well need as many as twelve classification numbers" (Bradford, 1953, p. 145).

Bradford imagined that 12 classification numbers per document would hardly be worthwhile, as many of these numbers might never be consulted. This is in contrast to present day information retrieval in which every word in documents may be used as subject access point (in full text retrieval), where all references may be used as access points (in citation indexes), and where many kinds of subject access points and retrieval techniques may be applied. Bradford's view reveals a mix of theoretical considerations and practical constraints that probably are typical and harmful in the development of general knowledge in information science.

Concerning indexing and the concept of "subject" the quotation given reveals something about how Bradford looked at things. A comprehensive indexing should list "every substance mentioned and every piece of apparatus described". This is a kind of thinking related to a listing of all "substantive" words. When he suggests that these words should be indexed with the UDC classification, it is not the words, but the concepts (words including synonyms and excluding homonyms) that are indexed. This may therefore be interpreted as indexing of concepts rather than by subjects proper.

A number of subsequent studies have chosen to operationalize the concept of subject in a similar way. A fairly recent example concerns literature on semiconductor research (Ming-Yueh *et al.*, 2000). Using the search command "semiconductor?. de.", the three authors did a Bradford analysis of twenty years of semiconductor literature in the INSPEC database. They argued that by searching the controlled vocabulary they would be able to control for synonyms, nearly synonyms, homographs and related terms. This, they expected, would result in the retrieval of "most of the papers on semiconductors" (Ming-Yueh *et al.*, 2000, p. 492).

3.2 Title words as attributes of subjects

The view that there exists a correspondence between, for example, the title of a document and its actual subject is not uncommon. This operationalization of "subject" was partly employed by von Ungern-Sternberg (2000) in her Bradford analysis of literature on the subject "information seeking". She searched for relevant literature in five different databases using the Dialog information system. The exact search formulation was:

S Information (w)retrieval/de,ti or information (w)seeking/de,ti or Information (w)behavior?/de,ti or information(w)need?/de,ti.

von Ungern-Sternberg (2000, p. 167) explains that "[t]he search was restricted to terms in the descriptor field or in the title to ensure that the topic of the article was information seeking". However, as pointed out by Hjørland and Kyllesbech Nielsen (2001), in some domains titles often express more general claims than are covered by the documents. This presumably results in low search precision. The recall of searches on title words has also been reported to be low. Hodges (1983) tested the effectiveness

of title keywords in retrieval and found that less than 50 percent of the relevant documents were retrieved by words in titles. The results of a study conducted by Peritz (1984) reveals another problem. Peritz (1984) examined the frequency of non-informative titles in LIS journals and sociology journals. She found that non-informative titles totalled 21 percent in LIS and 15 percent in sociology. Her study showed, moreover, that in both fields the non-informative titles were concentrated in a few journals. Thus, a Bradford analysis of a bibliography that has been assembled by searching journal article titles will probably be biased in favour of journals that publish articles with informative titles.

3.3 Citations as subject markers

A third way to operationalize the concept of subject is by means of citation analysis. Faced with the question "what files of scientific periodicals are needed in a college library successfully to prepare the student for advanced work [in the field of chemistry], taking into consideration also those materials necessary for the stimulation and intellectual development of the faculty", Gross and Gross "decided to seek an arbitrary standard of some kind by which to measure the desirability of purchasing a particular journal" (Gross and Gross, 1927, p. 386). In discussing potential procedures, they rejected the method of just sitting down and compiling a list of those journals, which were considered indispensable, because, as they wrote, "such a procedure might prove eminently successful in certain cases, but it seems reasonably certain that often the result would be seasoned too much by the needs, likes and dislikes of the compiler" (Gross and Gross, 1927, p. 386). Instead, they decided to tabulate the references in a single volume of *The Journal of the American Chemical Society* and subsequently to identify the candidate journals by their citation frequencies, i.e. by the number of times they were cited in the sample. According to Gross and Gross this tabulation could be considered statistically and employed to predict the future needs of scientific periodicals.

The Gross's faith in the existence of a free and independent standard that could be utilized for the prediction of future needs and the selection of library materials resembles an empiricist faith in the inductive method. Pure observation of references and their patterns were thought to make a method suitable for the selection of excellence. A method that would lead inevitably to the identification of the paramount of scholarly contributions: "Consideration of the method of investigation here employed will show that we are concerned not merely with the quantity of work published [. . .], but that in reality we are concerned only with the good work, the work which have survived and which has proved of value to the investigators who followed" (Gross, 1927, p. 641). A number of subsequent studies and Bradford analyses have operationalized the concept of subject in similar ways (e.g., Coile, 1952 [subject: Electrical Engineering]; Cave, 1963 [Tropical Agriculture]; Meadows, 1967 [Astronomy]; Donohue, 1972 [Information Science]; Yeon-Kyoung, 1994 [Classification Systems]).

The efficiency of this approach is determined by how well citing documents identifies and cites relevant sources in their reference lists. As pointed out by Hjørland and Kyllesbech Nielsen (2001), the method presupposes that scientific literature is neither unrelated to other research and literature nor simply redundant. It also presupposes that authors do not cite on purely formal or presentational grounds. But

most importantly, it presupposes that authors are not biased when selecting their sources but give even consideration to papers that argue both for and against their own view. This last assumption contradicts both qualitative and quantitative research on the citing behavior of scientists. Delamont (1989) conducted a qualitative study of citation patterns between schools of researchers studying social mobility in Britain. In her study she was able to demonstrate systematic neglect by each school of the work of the others. Her article is loaded with examples showing the failure of leading scholars to address the work of others. She concludes, in fact, that this is the most striking feature on the literature on social mobility. Inspired by Hjørland (2002), Nicolaisen (2004) conducted a structural bibliometric analysis of citations between 16 leading psychological journals representing four different research traditions. The results of his empirical study indicate that authors from different research traditions tend to use and cite sources that share their own basic views while ignoring contradicting perspectives. As observed by Delamont (1989, p. 335), "[t]he most devastating way of demonstrating that another scholar is not part of the in-crowd is to leave them out of debate all together – to render them invisible". And as noted by Meadows (1974, p. 45), "[i]f incorrect results stand in the way of the further development of a subject, or if they contradict work in which someone else has a vested interest, then it may become necessary to launch a frontal attack [. . .]. Otherwise, it generally takes less time and energy to bypass erroneous material, and simply allow it to fade into obscurity". Thus, disagreement has probably very little influence on the distribution of references and citations. As noted by Cole and Cole (1974, p. 33), "[p]apers which are trivial and receive critical citations will not accumulate large numbers of citations". This is, of course, a generalization. Garfield (1989, p. 10), however, claims it is one he has found to apply in most cases. Yet there are important exceptions. The famous article on cold fusion from 1989, for instance. Meadows (1998) found that this article had been cited several hundred times, mostly by researchers who disputed its results. Reiterating the essentials of his 1974 argument, Meadows (1998, p. 90) concluded that "[s]uch citation depends on the importance of the topic: questionable articles dealing with less important topics are likely to be ignored rather than cited".

4. Neutrality

We have previously identified three kinds of scattering[8] (Hjørland and Nicolaisen, 2005a, p. 103):

(1) *Lexical scattering*. The scattering of words in texts and in collections of texts.

(2) *Semantic scattering*. The scattering of concepts in texts and in collections of texts.

(3) *Subject scattering*. The scattering of items useful to a given task or problem.

These three kinds of scattering are not completely independent of each other. Previous research has shown that there are some internal relations between them – they do overlap to some extent depending on the domain of study. The overlap between semantic scattering and subject scattering (operationalized by citation relations) has, however, been reported to be quite low. Pao (1984) was among the first to suggest that descriptor and citation retrieval are likely to produce quite different search results. She examined the results of 10 searches (on a medical subject) using both descriptors and citations for retrieving relevant documents from a proprietary database. The result of

her study demonstrated a "surprisingly low overlap" (Pao, 1984, p. 136). In a later study, Pao and Fu (1985) found that 12 percent of a document set on sulfur dioxide air pollution was retrievable both from MEDLINE and by citation searches. McCain (1989) reported a comparable low overlap (10 percent) in her study of descriptor retrieval versus citation retrieval in the field of biomedicine. Green (2000) compared citation searching with the use of standard bibliographic tools in the humanities and found an even lower overlap. Only 5 percent of the retrieved items were found by both search tactics. The overlap between lexical scattering and semantic scattering is probably somewhat higher. Miller (1971) compared the retrieval efficiency of MEDLARS titles and index terms and found that title words retrieved close to 40 percent of the relevant documents retrieved by index terms, and that index terms retrieved close to 55 percent of the relevant documents retrieved by title words. Olive *et al.* (1973) did a similar study of retrieval effectiveness in *Nuclear Science Abstracts*. They found that both index term searching and title words searching missed many relevant documents retrieved by the other. Index terms retrieved 58 percent of the relevant documents retrieved by title words. The converse relationship was only 51 percent.

What difference do different conceptions of "subject" have for the outcome of Bradford analyses? It seems reasonable to assume that depending on how the concept of subject is being operationalized (e.g., descriptors, title words, references), different results will emerge. Yet, it need not be so. Relevant documents retrieved by any search procedure (e.g., by descriptors, title words or references) could be distributed equally among the same set of journals. If this is the case, different conceptions of "subject" should have little or no influence on the results of Bradford analyses. A Bradford analysis conducted using title words for searching relevant documents would thus identify the same core journals (journals in the first Bradford zone) as other analyses based on descriptor searches or citation searches (etc.). In order to test our assumption that the outcome of any Bradford analysis will be heavily affected by the way the subject is operationalized, we conducted three Bradford analyses of two different subjects:

(1) Anorexia nervosa; and

(2) Virology.

The methods employed for the three Bradford analyses and the results of the same are described below.

4.1 Anorexia nervosa

Anorexia nervosa is an eating disorder characterized by voluntary starvation. It is a complex disease that probably involves both psychological and physiological components. However, the causes of anorexia nervosa are not entirely agreed upon. We decided to take a closer look at the psychological side of the disease and chose the database *PsycInfo* and the journal *International Journal of Eating Disorders* as data collections for three Bradford analyses:

(1) Articles published during the years 2000-2004 and retrieved in *PsycInfo* by a search for "anorexia" in the title and/or abstract fields.

(2) Articles published in the same period and retrieved in *PsycInfo* by a search for "anorexia nervosa" in the descriptor field.

(3) Items cited in articles published in *International Journal of Eating Disorders* during the years 2000-2004. The search was limited to citing articles with the term "anorexia" in the title and/or abstract.

Table I lists the journals in the first Bradford zone. The table reveals that the three different operationalizations of "anorexia nervosa" identify different collections of journals in the first zone. As seen in Table II, the total overlap is just 5.9 percent.

4.3 Virology
Virology is the study of viruses and their properties. We chose the database *BIOSIS Previews* and the journal *Journal of Virology* as data collections for three Bradford analyses:

(1) Articles published during the years 2000-2004 and retrieved in *BIOSIS Previews* by a search for "virology" in the title and/or abstract fields.

(2) Articles published in the same period and retrieved in *BIOSIS Previews* by a search for "virology" in the descriptor field.

(3) Items cited in articles published in *Journal of Virology* during the years 2000-2004.

Table III lists the journals in the first Bradford zone. The table reveals that the three different conceptions of "virology" identify different collections of journals in the first zone. As seen in Table IV, the total overlap is just 17.6 percent.

These results clearly show that Bradford analyses are heavily affected by the way the subject is operationalized. A Bradford analysis conducted using title and abstract words for searching relevant documents does not identify the same core journals (journals in the first Bradford zone) as other analyses based on descriptor searches or citation searches. The three different operationalizations lead, in fact, to the identification of very different collections of core-journals.

5. Objectivity

Andersen (2000) presents the results of a survey of 788 Danish researchers from the social sciences. The researchers had been asked to assess the most influential researchers and journals of their fields. The results display a pluralistic picture and only a moderate degree of consensus among the researchers. Except for one exceptional case (legal science), the percentage of researchers mentioning the same journal as one of the three most important ones was found to be 25 percent or less. Andersen (2000, p. 689) thus concludes that "although a set of common journals can function as a medium of communication, thus making visible the reputation of research results and researchers, this function is weak, at least in the Danish social sciences". Yet, the same pluralistic picture and moderate degree of consensus may possibly characterize much larger parts of the social sciences. The cognitive school has dominated American psychology (and thus also international psychology) since the early 1970s. Before that time behaviorism was the dominant school in psychology (Robins *et al.*, 1999). However, historians of psychology have found that cognitive approaches may be tracked long back in the history of psychology. Greenwood (1991), for instance, identified sources of cognitive psychology in the hey-days of behaviorism, often in more remote psychological journals. It is reasonable to expect, that if

Table I.
Journals in the first Bradford zone according to three operationalizations of the subject (anorexia nervosa)

Title and abstract	Descriptor	References
American Journal of Psychiatry	Eating and Weight Disorders	Acta Psychiatrica Scandinavica
Eating and Weight Disorders	Eating Behaviors	American Journal of Clinical Nutrition
Eating Behaviors	European Eating Disorders Review	American Journal of Psychiatry
Eating Disorders: The Journal of Treatment	International Journal of Eating Disorders	Archives of General Psychiatry
European Eating Disorders Review	International Journal of Law and Psychiatry	Biological Psychiatry
International Journal of Eating Disorders	Molecular Psychiatry	British Journal of Psychiatry
International Journal of Law and Psychiatry	Psychiatria Polska	British Medical Journal
Molecular Psychiatry		Clinical Psychology Review
Physiology & Behavior		Comprehensive Psychiatry
Psychiatria Polska		European Eating Disorders Review
Seishin Igaku (Clinical Psychiatry)		International Journal of Eating Disorders
		JAMA – Journal of The American Medical Association
		Journal of Abnormal Psychology
		Journal of Clinical Endocrinology and Metabolism
		Journal of Clinical Psychiatry
		Journal of Consulting and Clinical Psychology
		Journal of Nervous and Mental Disease
		Journal of Psychiatric Research
		Journal of Psychosomatic Research
		Journal of The American Academy of Child and Adolescent Psychiatry
		Lancet
		New England Journal of Medicine
		Psychiatric Clinics of North America
		Psychiatry Research – Neuroimaging
		Psychological Medicine
		Psychosomatic Medicine

Bradford's law had been applied to select psychology journals to libraries around 1930, then the result would have been that journals with an exclusive behavioral orientation would have been too strongly represented and that journals more open towards, for example, the cognitive approach, would have been too weakly represented. Consequently, there is no reason to believe that the assumptions about universalism and objectivity underlying the application of Bradford's law can be combined with the demands on pluralism, which may be expected from libraries and information systems. In other words: The application of Bradford's law to the selection of information sources is probably not an objective method, but may possibly turn out to function discriminatorily against minority views[9]. To test whether this is the case, we searched *Social SciSearch* and identified four collections of data. The first collection consisted of 536 articles from 2004 that cited at least one of four leading psychoanalytical journals[10]. The second collection consisted of 2,784 articles from 2004 that cited at least one of four leading behaviorist journals[11]. The third collection

	%
Title and abstract/descriptor	63.6
Title and abstract/references	8.8
Descriptor/references	6.5
Title and abstract/descriptor/references	5.9

Table II.
Overlaps (anorexia nervosa)

Title and abstract	Descriptor	References
Journal of General Virology	Archives of Virology	Cell
Journal of Medical Virology	Journal of General Virology	Embo Journal
Journal of Virological Methods	Journal of Medical Virology	Journal of Biological Chemistry
Journal of Virology	Journal of Virology	Journal of Experimental Medicine
Virus Research	Virology	Journal of General Virology
Virology		Journal of Immunology
		Journal of Virology
		Molecular and Cellular Biology
		Nature
		Nucleic Acids Research
		Proceedings of The National Academy of Sciences of The United States of America
		Science
		Virology

Table III.
Journals in the first Bradford zone according to three operationalizations of the subject (virology)

	%
Title and abstract/descriptor	57.1
Title and abstract/references	18.8
Descriptor/references	21.0
Title and abstract/descriptor/references	17.6

Table IV.
Overlaps (virology)

consisted of 3.868 articles from 2004 that cited at least one of four leading cognitive journals[12]. The fourth collection consisted of 6,987 articles from 2004 that cited at least one of these 12 journals. We did Bradford analyses on these four collections and thus identified four collections of core journals (journals in the first Bradford zone) (see Table V).

The results of the four Bradford analyses reveal that Bradford's law does function discriminatorily against minority views. The Bradford analysis of all 12 leading journals identifies ALL of the cognitive core-journals, but only 45 percent of the behavioral core-journals and just 50 percent of the psychoanalytic. One could ask[13] whether this is really "discrimination". Do not the results simply reflect "the contemporary view"? This is, for instance, close to how Cole and Cole (1973, p. 24) used to argue for their utilization of citation analysis:

> Current citations are not a measure of the absolute quality of work, they are an adequate measure of the quality of work socially defined.

Yet, we should not forget that our choices always have consequences. Thus, if one chooses to rely solely on the result of a Bradford analysis and thus to go exclusively with the majority view when selecting journals for a library collection, it is definitely an act of discrimination against the overlooked and disregarded minority views.

6. Conclusion
In this paper we have put forward serious arguments against the received view on Bradford's law. The fact that it is difficult to find any examples of its actual use in practice may be an indication that such problems have intuitively been foreseen.

What is a subject for one person need not be the same subject for another. The best way to generalize views about subjects is probably to consider different theoretical views or epistemologies regarding that subject. A pure mechanical view of selection must consequently be replaced by a reflective view in which the selector must justify the selection. Hjørland (1992) proposed that "subjects" are the informative or epistemological potentials of documents. The purpose of subject analysis and indexing is to make some documents retrievable in relation to some purposes. A subject analysis is always preliminary because you cannot in advance predict what kinds of use will be made of a document. The whole issue is theory-dependent. For example, nobody could predict that the subject "energy resource" was adequate to uranium before radioactivity was discovered. In the same way will the potential usefulness of documents be dependent on theoretical developments in the user community. The implication is that dynamic kinds of subject assignments[14] have better possibilities to adapt to changing needs by the users compared to fixed indexing systems like descriptors and library classifications.

The implication for Bradford analyses is that subject analysis is very relative and depending on subject knowledge. No kind of mechanical operationalizations of subject analysis (say: by title, descriptor, or citations) can be said to be the best one in all cases. What is the best way to operationalize subject analysis is simply depending on the specific query as well as the standard of the available subject access points.

This insight introduces a major subjective element in Bradford analyses. The claimed objectivity of the method is thus based on a subjective factor. Because the

Psychoanalytic core-journals	Behavioral core-journals	Cognitive core-journals	Psychological core-journals
International Journal of Psychoanalysis	Addictive Behaviors	Applied Cognitive Psychology	Acta Psychologica
Journal of The American Psychoanalytic Association	Behavior Analyst	Behavior Research Methods	Applied Cognitive Psychology
Psyche-Zeitschrift für Psychoanalyse und Ihre Anwendungen	Behavior Modification	Instruments & Computers	Behavior Research Methods
Psychoanalytic Inquiry	Behavior Therapy	Brain and Cognition	Instruments & Computers
Psychoanalytic Psychology	Behavioural Processes	Brain and Language	Behavior Therapy
Psychoanalytic Quarterly	Behavioural Interventions	Cognition	Behaviour Research and Therapy
	Behaviour Research and Therapy	European Journal of Cognitive Psychology	Behavioural Processes
	Behavioural and Cognitive Psychotherapy	Journal of Cognitive Neuroscience	Brain and Cognition
	Cognition & Emotion	Journal of Experimental Psychology-Human Perception and performance	Brain and Language
	Cognitive and Behavioral Practice	Journal of Experimental Psychology	Cognition
	Cognitive Therapy and Research	–Learning, Memory and Cognition	Cognition & Emotion
	Depression and Anxiety	Journal of Memory and Language	Child Development
	International Journal of Eating Disorders	Memory	Cognitive and Behavioral Practice
	Journal of Abnormal Psychology	Memory & Cognition	Cognitive Neuropsychology
	Journal of Affective Disorders	Neuropsychologia	Cognitive Science
	Journal of Anxiety Disorders	Neuropsychology	Cognitive Therapy and Research
	Journal of Applied Behavior Analysis	Perception	Developmental Psychology
	Journal of Behavior Therapy and Experimental Psychiatry	Perception & Psychophysics	Developmental Science
	Journal of Child Psychology and Psychiatry	Perceptual and Motor Skills	European Journal of Cognitive Psychology
	Journal of Clinical Child and Adolescent Psychology	Psychological Science	International Journal of Psychoanalysis
	Journal of Clinical Psychiatry	Psychology and Aging	Journal of Abnormal Psychology
	Journal of Clinical Psychology	Psychonomic Bulletin & Review	Journal of Anxiety Disorders
	Journal of Consulting and Clinical Psychology	Quarterly Journal of Experimental Psychology Section A –Human Experimental Psychology	Journal of Applied Behavior Analysis
	Journal of Nervous and Mental Disease	Visual Cognition	Journal of Child Psychology and Psychiatry
	Journal of Positive Behavior Interventions		Journal of Clinical Psychology
	Journal of Psychopathology and Behavioral Assessment		Journal of Cognitive Neuroscience
	Journal of Psychosomatic Research		Journal of Consulting and Clinical Psychology
			Journal of Experimental Child Psychology

Table V.
Journals in the first
Bradford zone according
to three
operationalizations of the
subject (Psychology)

Psychoanalytic core-journals	Behavioral core-journals	Cognitive core-journals	Psychological core-journals
	Journal of The American Academy of Child and Adolescent Psychiatry		Journal of Experimental Psychology – Human Perception and Performance
	Journal of the Experimental Analysis of Behavior		Journal of Experimental Psychology – Learning Memory and Cognition
	Journal of Traumatic Stress		Journal of Memory and Language
	Learning & Behavior		Journal of Personality and Social Psychology
	Memory		Journal of The American Psychoanalytic Association
	Pain		Journal of the Experimental Analysis of Behavior
	Personality and Individual Differences		Memory
	Psych		Memory & Cognition
	Psychiatry Research		Neuroimage
	Psychological Record		Neuropsychologia
	Psychological Reports		Neuropsychology
	Research in Developmental Disabilities		Perception
			Perception & Psychophysics
			Perceptual and Motor Skills
			Personality and Individual Differences
			Psychoanalytic Psychology
			Psychological Record
			Psychological Reports
			Psychological Science
			Psychology and Aging
			Psychonomic Bulletin & Review
			Quarterly Journal of Experimental Psychology Section A – Human Experimental Psychology
			Visual Cognition

discussion of this subjective factor has never been raised in relation to Bradford analyses, their claimed neutrality and objectivity are based on a myth.

One common practice in research libraries is to have subject specialists selecting the journals. This praxis represents a view that is based on assumptions that differ from the use of Bradford analyses. Still, one may ask how research in LIS could contribute to make the selection better motivated? Our answer is that investigations such as the one by Andersen (2000) that study researchers' attitudes toward journals and compare patterns across disciplines and across national borders and compare such opinions with the rankings from citation databases provide the most valuable information for the selection of journals which can be obtained from research.

Notes

1. Bradford believed n to be constant in the different zones ($n^1 = n^2 = n$); Results reported by Rao (1998) indicates, however, that Bradford's assumption was wrong: Bradford multipliers vary from zone to zone.

2. The received view on Bradford's law is the view put forward by the majority of textbooks (see, e.g. Evans, 2000; Nisonger, 1998).

3. This prejudice is probably quite common. Sandstrom (2001, p. 584), for instance, argues: Knowing how the core is constructed and integrated with other research concerns makes it easier for scholars to track down necessary information.

4. One exception is the ISI databases. The ISI journal selection process is claimed to be based in part on Bradford analyses. Yet, the relative contribution of this method is not reported (http://scientific.thomson.com/knowtrend/essays/selectionofmaterial/journalselection/).

5. One of the referees argued that the reason why it is hard to find detailed applications of Bradford's law in practice is because it has long been recognized as great fun in theory, but not to be taken too seriously by practitioners. This, however, is not the impression one receives from reading the literature on Bradford's law. Besides the already mentioned sources, one needs only consult last years' volume of *Scientometrics* to see that the contemporary view on Bradford's law is actually the received view. The article by Kumar Patra and Chand (2005, p. 590) argues, for instance, that [b]ecause of increasing cost of information resources in today's library and information centers, a typical Bradford analysis can suggest the journals to be procured in a library collection. In fact, the authors claim (p. 583) to have used Bradford's law to identify the core journals of Indian Biotechnology. Thus, we find it hard to agree with the anonymous referee about Bradford's law having long been recognized as being of limited applicability in practice. The same referee argued that Bradford's law was devised in the context of science, and is most useful in that context. The main reason is that a given area of science nearly always has a theoretical framework accepted by the great majority of its practitioners. The same is not generally true either of the social sciences or of the humanities. However, Bradford's law has been examined in both the social sciences and the humanities (e.g., Donohue, 1972; Heine, 1998; von Ungern-Sternberg, 2000; Yeon-Kyoung, 1994). Bradford's law in relation to questions concerning theoretical frameworks accepted by the majority has, as far as we know, never been examined or discussed. The view that science is governed by degrees of theoretical consensus is, by the way, a post-positivist view raised – in different ways – by, for instance, Thomas Kuhn and Karl Popper. Such epistemological discussions are in our view very important but have unfortunately been rather neglected in LIS. That is actually partly why we launched *The Epistemological Lifeboat* (Hjørland and Nicolaisen, 2005b).

6. Umstätter (2005) has claimed in a German e-only journal published at the Department of Library and Information Science/Humboldt-University Berlin by a student editorial team

that we (Hjørland and Nicolaisen, 2005a) are wrong: "Am Schluss sei noch darauf hingewiesen, dass die Aussage" nobody have thus far tried to outline the consequences of different conceptions of "subjects" for Bradford's law "die wichtige Diskussion vieler Rechercheure über Relevanz, Precision, Recall, Noise und Pertinenz völlig vernachlässigt". However, Umstätter failed to document his claim. He failed to produce proper evidence that these concepts have been regarded in relation to consequences for Bradford's law. We seriously doubt the existence of such documentation.

7. In our opinion Bradford's suggestion is unrealistic and based on a too simplified view of subject matter. It is not possible to make screening procedures of this kind. It is impossible to screen documents in relation to user needs, and it is not possible to screen user requirements in relation to subject classes or descriptors. Based on the second author's experience as a practicing academic librarian, our view is that such screenings are most often harmful (see Hjørland, 1997, p. 155 n4). However, we know of no investigations that have made serious inquiries into this problem. The problem falls outside the scope of this article.

8. The idea about different kinds of scattering occurred when the second author served as referee for a paper by Hood and Wilson (2001). This paper examines – in the tradition from Bradford (1934) – the distribution of bibliographic records in online bibliographic databases using 14 different search topics, searched in the Dialog information system. The second author's suggestion to the two authors was that these 14 questions represented different kinds of questions and thus different kinds of scattering. This was subsequently acknowledged by Hood and Wilson (2001, p. 1253-4).

9. This is especially interesting in the case reported because this view later developed to a majority view. If journals open to the cognitive view had been deselected due to the application of Bradford's law, this could perhaps have made it more difficult for this view to develop.

10. *International Journal of Psychoanalysis*, *Psychoanalytic Quarterly*, *Journal of the American Psychoanalytic Association* and *Contemporary Psychoanalysis* was identified as leading psychoanalytic journals by Robins *et al.* (1999, p. 121) in their empirical analysis of trends in psychology.

11. *Journal of the Experimental Analysis of Behavior*, *Behavior Research and Therapy*, *Journal of Applied Behavior Analysis* and *Behaviour Therapy* was identified as leading behavioral journals by Robins *et al.* (1999, p. 121) in their empirical analysis of trends in psychology.

12. *Cognitive Psychology*, *Cognition*, *Memory and Cognition* and *Journal of Experimental Psychology: Learning, Memory, and Cognition* was identified as leading cognitive journals by Robins *et al.* (1999, p. 121) in their empirical analysis of trends in psychology.

13. As one of the anonymous referees in fact did.

14. Dynamic assignments of subject indicators are possible using bibliometric methods like, for example, co-citation analysis. Such methods have other drawbacks not to be discussed here. The point at this place is that kinds of dynamic subject assignments – other things being equal – are to be preferred compared to static kinds of subject assignments.

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