CONTINUING USE OF PRINT-ONLY INFORMATION BY RESEARCHERS: A STUDY OF IMPACT FACTOR AS ONE MEASURE, 1993-2003

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INTRODUCTION

We are living through a period of rapid transition between the formats in which information is delivered. The journals through which most scientific advances are communicated have in the last decade migrated from the printing press to the internet server. One question that has occupied many librarians during this period of change is how electronic journals are shaping the behavior of researchers; this paper seeks to examine whether the proven increase in use of electronic versions of journals as compared to print versions will be reflected in a widely-used bibliometric measure, impact factor, and what can be gleaned from comparing the measures of user studies and impact factor.

The availability of scientific journals online, starting in the 1990s, has led to noticeable changes in the information-seeking behavior of journal readers. Throughout the last decade, numerous studies have shown that among many different groups, ranging from undergraduate students [1, 2] to chemists [3, 4] to veterinary students [5] to physical scientists [6], journal readers are significantly more likely to seek out journal articles from the online environment than they are from print sources – regardless of the relevance of the online material to the research project [7].

INFORMATION-SEEKING BEHAVIOR AND ONLINE JOURNALS

The preference for online versions of journals over print versions is consistent with established paradigms of information-seeking behavior. Classical behavioral theory held that people seek to achieve the best possible outcome from their activities by considering all options and choosing the activity most likely to produce the most desirable outcome; this behavior is called "maximizing." While some people do pursue a maximizing approach to information-seeking and other activities, many others find themselves constrained by limits of available time, mobility, or resources. Herbert Simon reasoned that it is rational for a person to develop an expectation for an outcome that would be satisfactory, and to seek to achieve a satisfactory result within one's boundaries, ignoring those options that would strain time, mobility or resources [8]. This behavior is called "satisficing," and allows for adjustment of expectations as the limitations change [9].

A satisficing approach to information-seeking has been consistently observed in studies, even among less-sophisticated decision makers. For example, Agosto found that teens using the Internet for research exhibit a preference for graphics over text, reliance on known sites, and avoidance of unsummarized content – behaviors which were considered more likely than other search techniques to achieve a satisfactory result within the constraints of limited time and physical endurance for sitting [10]. As well, Tenopir and King have shown that scholarly researchers make choices, sometimes subconsciously, about subscribing to journals based on the relative costs in time and convenience of relying upon library collections [11].

Naturally, then, it is to be expected that researchers will operate according to Simon's "bounded rationality" when choosing a method by which to access scholarly journals. For many, the ease of access from home or office, combined with keyword searching in full-text databases, outweighs poorer quality of presentation of figures and pictures – leading to a heavy favoring of journals available online journals over print journals (as demonstrated in studies by De Groote and Dorsch, and Rogers) [12-14]. A converse example is found in a study by Andrews et al. of rural physicians who prefer using print journals, because a lack of facility with computers leads them to believe that using journals online will be a less effective use of their time [15].

USE OF ONLINE JOURNALS BY HEALTH SCIENCES RESEARCHERS

Health sciences researchers have been eager adopters of online access to journals. In one survey by Curtis et al., a majority of health sciences faculty on one campus were relying primarily upon journals available online as early as 1995 (within just a couple years of being provided personal computer access) [16]. Toward the end of the

decade, a 1998 survey by Morse and Clintworth found that on one campus, journals available online were used about ten times as often as their print counterparts [17].

Health sciences researchers have embraced online journal access more thoroughly than humanities scholars, a trend explained by research examining the differences in searching techniques used by scholars in different disciplines. Talja and Maula defined a difference between directed searching (seeking information directly about a topic of interest, for example in an index) and browsing and chaining (leveraging the citations and bibliographies in known sources to find new sources) [18]. Their research shows that scholars in fields in which directed searching is a more fruitful information-seeking technique rely more heavily on online journals. Health sciences is a field that repays directed searching, particularly with well-developed indexes linked to online journals, such as PubMed and Medline.

One expected consequence of the alignment of bounded rationality with easy access to journals online is the disregard of information that is more difficult to retrieve. As King and Tenopir point out, studies have consistently shown that researchers choosing between two sources of information will usually favor the more accessible source, regardless of the perceived value of the information [7]. In the words of Young and Von Seggern, "users opt for convenience over quality" [19].

WHAT HAPPENS TO THE INFORMATION THAT REMAINS AVAILABLE ONLY IN PRINT?

Although a few studies (such as those by Siebenberg et al. and Sathe et al.) have shown that some scholars persist in preferring print journals [20, 21], the preponderance of evidence shows that researchers – especially those in the health sciences – are much less likely to use journals in print versions than journals online. However, these studies have focused on behavior of researchers within the library's collection.

There is a related question that has not received as much attention: are researchers, despite a change in methods of use of the library's journal collection, still receiving and processing the information published in print-only journals?

One approach to this question is citation analysis. De Groote, Shultz and Doranski collected citations within articles written by faculty members in their institution, using four different years (1993, 1996, 1999, and 2002). Each citation was coded according to whether the article appeared in an online journal, a print-only journal, both, or was not owned by the library. Analysis showed that over the years, the citations to print-only articles did not decrease in comparison to citations to online journals [22].

A parallel approach with a larger pool of citations is the study of changes to impact factor over time. This paper demonstrates one method for studying impact factor as an indicator of scholarly use of published material.

IMPACT FACTOR AS A MEASURE OF JOURNAL READERSHIP

Impact factor is a statistic developed in the 1960s by Irving H. Sher and Eugene Garfield of the Institute for Scientific Information (ISI) [23]. It is "a measure of the frequency with which the 'average article' in a journal has been cited in a particular year or period" [24].

Although the use of impact factor as a measure of journal quality has been questioned (by Garfield himself, among others), [25, 26, 27] it remains a popular tool for collection development and journal selection. For the purposes of this study, impact factor is useful because it reflects actual use of journals; when authors cite a previously published article, it is a demonstration that the article has been accessed. Research by Tsay shows that impact factor is closely correlated with frequency of journal use [28].

Considering the established fact of bounded rationality in information-seeking behavior, and the studies that have shown that users of library-provided journals in the health sciences consistently favor journals available online over print versions, one is led to the question: are researchers still accessing and using material issued only in print?

METHODS

In order to study this question, a group of journals was selected, and the impact factor of each was tracked over the period 1993-2003.

Journal Selection

The journals were divided into seven cohorts. Three were subspecialties of internal medicine: cardiology (represented by 13 journals), gastroenterology (14 journals), and rheumatology (14 journals), and a fourth was a subspecialty of interest to rheumatology: immunology (12 journals). The field of internal medicine is one in which researchers across subspecialties share the same basic training and often collaborate among disciplines. It was of interest to examine citation trends within a fairly similar group of researchers and to compare them with researchers in other fields who do not share the training or research approaches that internists do.

All the journals studied had originally been published in print versions, and later became available online.

For purposes of comparison between internal medicine journals and non-health science journals, the fields of psychology (9 journals) and biology (12 journals) were chosen. These disciplines represent the academic fields (aside from business) in which the largest number of faculty have appointments at colleges and universities in the United States [29], providing a large group of readers and researchers whose information-seeking behavior can be studied. The last cohort consisted of those science journals which registered the highest impact factors out of the entire group of journals surveyed by ISI (10 journals).

Time-frame selection

Within each cohort, the group consisted of those journals that were registered within the top twenty journals (as ranked by impact factor) in each year between 1993 and 2003. 1993 was chosen as a terminus because that is the year that Internet browsers were introduced, ushering in widespread use of online resources [30]. 2003 was the most recent year for which ISI had calculated impact factors at the time the research was completed.

It should be noted, however, that the academic community has not enjoyed universal access to electronic resources throughout this period. Rather, the number journals available in online versions, and the number of libraries providing access to them, has been rising over time. Rich and Rabine performed two studies of access to electronic journals at academic libraries, and found that between 1997 and 2001, libraries overall exhibited a dramatic improvements in the number of full-text journals available and ease of access to them [31, 32].

The increased availability of electronic versions of journals over the time period studied reinforces the demonstrated prejudice against paper journals, as occasions to use paper journals became less frequent.

Impact factor

Impact factors are published in *Journal Citation Reports (Science Edition)* (*JCR*), prepared by ISI. Early editions were published on microfiche, then on CD-ROM. Reports since 1997 are available online [33].

Mathematically, impact factor can be expressed as a fraction (Figure 1).

While this study seeks to examine the effects of electronic availability of journals on citation rates, there are a number of other situations that also are known to affect impact factor. Garfield has shown that papers of a controversial nature that become highly publicized will be cited more frequently than the average paper published in a journal [26]. Research by Sen indicates that "impact factor of a journal tend[s] to increase or decrease (i) with the increase or decrease in the number of standard research journals covered by a database, or (ii) with the substantial change in the composition of content" [34].

On the other hand, studies have shown that impact factor tends to remain relatively stable for a particular journal, exhibiting (for large journals of the type studied in this paper) fluctuation of ± 15% per year [35]. The level of fluctuation is considered acceptable by bibliometricians. Glänzel and Moed find it "not dramatic, so that in practice one or two year old impact factor are sometime used for evaluation purposes where more recent indicators are not available" [36].

Some of this stability is explained by the fact that larger journals are typically more prestigious, so that authors of high-quality (and therefore highly citable) works will continue to publish in those journals, regardless of other influences [37]. However, Christenson and Sigelman have shown that a journal's impact factor can decrease while its perceived prestige remains high [38]. The fact that high-impact journals do not exhibit radical changes in impact factor year-to-year may be an advantage in studying the effect of online availability of journals on citation, as significant changes in access patterns will be more apparent in typically stable journals than in those in which great variation is expected regardless of circumstances.

One caveat about choosing high-impact journals is the fact that not all journals are indexed by ISI. While ISI maintains that its criteria for inclusion in *JCR* – timeliness of publication, editorial content, international diversity, and citation rate – provide "the highest quality, most relevant materials" [39], other researchers consider that journals excluded from *JCR* may have as much value as included journals. Stegmann and Grohmann found that, of a group of dermatology journals excluded from *JCR,* about a third of the titles would rank well within the overall group of included journals, if judged solely by impact factor [40]. Glänzel and Moed point out that the formula for calculating impact factor, which relies on measuring only two years' worth of citations, biases the ranking toward those fields in which most citations occur shortly after publication; those fields in which citation occurs over a longer period exhibit lower impact factors, despite that fact that an article may be cited the same number of times (but over a longer period) [36]. Because life sciences are among those fields in which most citations come soon after publication, impact factor remains a useful measure for examining journal use among physician scientists.

RESULTS

Table 1 includes the complete data set, showing the impact factor for each journal surveyed during each year of the study, along with the percentage change in impact factor from the previous year. The highlighted square indicates the date a journal became available online.

Descriptive analysis of Table 1 reveals no obvious trends of increase or decrease of impact factor in the years before and after a journal became available online.

Another issue of interest is whether the year in which a journal first became available online influenced impact factor. While 1993 saw the first Internet browser, 1998 saw the release of Microsoft's integrated browser [30], as well as the first library portal systems, which integrate the catalog and databases [41]. Because of journal users' reliance on known entities, it is possible that journals that were online when these technologies were introduced would fare better than those which remained print-only until later.

Table 2 shows the average percentage of impact factor change for the group of journals that went online in each year of the study. The percentage change in impact factor is shown for the three years before going online, and the three years following. This information is represented graphically in Figure 2.

Again, the desultory nature of the figures is most noticeable. The percentage change in impact factor shows no trend.

Our analysis of changes in impact factor did not discern a correlation between availability of a journal online and its impact factor.

The lack of association was noticed both within and across the various scientific disciplines studied.

CONCLUSIONS

Although the body of research shows that journal users are definitely relying more upon electronic journals and less upon paper journals in the library's collection, this preference does not seem to be influencing impact factor. The lack of correlation between changes in impact factor and the format of journals over the years 1993-2003 may demonstrate that researchers are making decisions about which journals to cite based on reasons other than format. However, given the many other competing influences on impact factor, it is unclear whether these findings reflect continued strong use of print journals. They do indicate, however, that the online status of a journal is not sufficient to override other considerations by researchers when they choose which material to cite.

While journal use in libraries (particularly in the health sciences) does skew toward journals available online, journal citation shows no such trend. It may be that researchers are accessing information from sources other than the library, which would be one explanation for the divergence between user studies showing increased reliance on journals available online, and this impact factor study with its lack of clear trends.

Some of the sources other than library subscriptions may include personal subscriptions and interlibrary loan. The "invisible college," described by Crane as "a communication network…that links groups of collaborators" [42], is another factor. Most of these researchers communicate frequently with colleagues around the world, and they may receive copies of papers directly from the authors. As well, the old adage that "research begets research" may be at work; in addition to using indexes, the authors may study the references in works of interest to discern other works that may apply to their research.

Of course, the possibility of intellectual fraud exists as well. It is entirely possible that researchers are citing works that they have not accessed, and merely copied citations from indexes or other authors' reference lists.

The most important consideration, however, is that researchers in the health sciences and in other fields, while demonstrating a preference for accessing online journals, continue to cite those sources which are most relevant to their research. This may prove a difficulty for collection development. If selecting the items most often used in the collection, online journals will be chosen; but impact factor study illuminates the fact that the format of a journal does not always outweigh other considerations for researchers seeking material.

Within the next decade, the specific issue of print-versus-electronic journal availability may become moot, at least in those nations with well-developed internet capabilities, as an exceedingly high proportion of journals will become available online. (In fact, the original research plan for this paper had to be modified because no high-impact internal medicine journals remained available only in paper by 2004.) Nonetheless, the issues of access to information in various formats will continue to challenge librarians, particularly in collection development decisions. If the citation patterns studied in this paper are any indication, direct studies of user behavior (such as those which found a strong preference for electronic versions of material over print versions) are not the last word in deciding which types of material to select; other means of determining proper access strategies must also

be considered, and this circumstance will pertain regardless of developments in technology, as no format is ever universally adopted.

Because the results of this study have not reinforced other studies indicating increased preference for journals in electronic versions, some other avenues of study are suggested. It would be useful to discover what value researchers must place on a non-electronic document in order to overcome the obstacles to retrieving it. Also of interest would be a study examining the ways in which non-electronic materials are acquired by researchers, and if collection development policies have any effect on those behaviors. And the issue of bibliographical repetition is of interest – how much weight does a previous citation carry for researchers considering whether to retrieve a non-electronic document?

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Trends in citation were not easily discerned from studying impact factors. The implications for librarians are manifold, particularly in terms of collection development, and it behooves the library community to carefully consider factors other than simple use statistics when judging how best to provide access to information.

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FIGURE 1
Impact factor expressed as a fraction

$$\frac{\text{Number of citations received by the journal in a year (e.g., 1994) to articles published in the two prior years (e.g., 1992 \& 1993)}}{\text{Number of articles published by the journal in the two prior years (e.g., 1992 and 1993)}}$$

Example: Calculation of impact factor for *FASEB Journal* [29]

Cites in 2004 to articles published in 2003 =	3069
Cites in 2004 to articles published in 2002 =	3062
Sum:	6131
Number of articles published in 2003 =	503
Number of articles published in 2002 =	396
Sum:	899

Calculation: $\frac{\text{Cites to recent articles}}{\text{Number of recent articles}} \quad \frac{6131}{899} = \mathbf{6.820}$

TABLE 1

Impact factor and percentage change in impact factor for selected journals, 1993-2003

Under each year, the first column indicates the impact factor for the journal, and the second column indicates the percentage change from the previous year

CARDIOLOGY	1993	1994		1995		1996		1997		1998		1999		2000		2001		2002		2003	
J MOL CELL CARDIOL	3.49	3.01	-13.69%	2.78	-7.58%	2.74	-1.37%	3.26	18.71%	2.72	-16.44%	2.92	7.46%	3.38	15.74%	3.40	0.38%	4.09	20.47%	4.95	21.10%
J THORAC CARDIOV SUR	2.33	2.39	2.62%	2.61	9.29%	2.87	10.07%	3.07	6.75%	2.95	-3.72%	2.99	1.08%	3.06	2.38%	2.82	-7.82%	2.84	0.85%	3.32	16.78%
AM J CARDIOL	2.16	2.25	4.11%	2.24	-0.67%	2.37	6.03%	2.40	1.22%	2.14	-11.03%	2.36	10.48%	2.76	16.98%	2.64	-4.53%	2.33	-11.76%	3.06	31.46%
CARDIOVASC RES	2.09	2.89	38.48%	3.49	20.90%	3.26	-6.61%	2.89	-11.58%	3.00	3.85%	3.09	3.20%	3.78	22.35%	4.55	20.33%	4.69	3.08%	5.16	10.06%
CIRC RES	5.84	6.97	19.28%	8.00	14.79%	7.62	-4.81%	8.44	10.78%	7.99	-5.33%	8.28	3.67%	9.19	11.01%	9.21	0.22%	9.69	5.22%	10.12	4.36%
CIRCULATION	8.99	8.63	-4.00%	8.82	2.18%	9.09	3.08%	9.76	7.35%	9.17	-6.03%	9.90	7.96%	10.89	10.00%	10.52	-3.45%	10.26	-2.49%	11.16	8.86%
J AM COLL CARDIOL	6.34	8.01	26.37%	5.79	-27.70%	5.95	2.68%	6.70	12.71%	7.28	8.62%	7.37	1.18%	7.08	-3.88%	6.37	-10.00%	6.28	-1.51%	7.60	21.04%
TRENDS CARDIOVAS MED	2.10	3.61	72.05%	4.34	20.07%	3.47	-19.94%	3.58	3.11%	2.60	-27.39%	2.33	-10.38%	2.88	23.56%	1.67	-41.99%	3.40	103.41%	4.52	32.97%
AM HEART J	1.54	1.45	-5.77%	1.29	-11.22%	1.86	43.95%	2.40	29.35%	1.85	-22.98%	2.02	9.24%	2.42	19.69%	2.87	18.64%	2.77	-3.66%	3.30	19.35%
EUR HEART J	1.43	1.43	0.14%	1.68	17.87%	1.68	0.00%	2.14	27.05%	3.63	69.91%	3.21	-11.59%	3.84	19.63%	5.15	34.19%	6.13	18.98%	6.00	-2.19%
J HEART LUNG TRANSPL	1.72	1.43	-16.72%	2.00	39.65%	2.46	23.03%	2.65	7.94%	2.85	7.62%	2.44	-14.58%	2.53	3.61%	2.18	-13.74%	1.95	-10.65%	2.84	46.02%
PROG CARDIOVASC DIS	2.16	1.54	-28.80%	1.60	3.77%	2.40	50.13%	3.19	32.93%	2.13	-33.12%	3.23	51.78%	2.38	-26.54%	2.08	-12.63%	1.82	-12.24%	2.18	19.82%
J CARDIOVASC ELECTR		1.55		2.10	35.20%	1.96	-6.85%	1.78	-8.99%	2.08	16.56%	2.11	1.73%	2.79	32.05%	2.98	6.70%	3.11	4.37%	2.69	-13.46%
GASTROENTEROLOGY	1993	1994		1995		1996		1997		1998		1999		2000		2001		2002		2003	
GASTROINTEST ENDOSC	2.44	3.56	46.01%	2.30	-35.61%	4.49	95.82%	2.77	-38.36%	3.53	27.47%	3.23	-8.67%	2.82	-12.56%	2.78	-1.56%	3.04	9.40%	3.33	9.58%
J HEPATOL	2.59	3.15	22.01%	2.78	-11.98%	3.24	16.53%	3.41	5.38%	3.19	-6.45%	3.71	16.18%	3.76	1.51%	4.75	26.30%	4.97	4.72%	5.28	6.21%
ALIMENT PHARM THERAP	1.68	2.11	25.30%	2.04	-3.51%	3.09	51.96%	3.00	-2.91%	3.00	-0.23%	3.06	2.00%	3.49	14.13%	3.90	11.78%	2.98	-23.59%	3.53	18.42%
GASTROENTEROLOGY	5.86	7.25	23.82%	8.20	13.13%	9.33	13.73%	10.25	9.87%	10.33	0.78%	12.18	17.93%	12.25	0.53%	13.02	6.32%	13.44	3.23%	12.72	-5.37%
J PEDIATR GASTR NUTR	0.93	1.08	16.97%	1.24	14.88%	1.52	22.53%	1.29	-15.04%	1.32	1.93%	1.49	12.66%	1.58	6.33%	2.08	31.46%	2.08	0.05%	1.40	-32.53%
HEPATOLOGY	5.07	5.57	9.80%	5.39	-3.18%	6.04	12.02%	5.85	-3.16%	5.62	-3.90%	7.34	30.65%	7.30	-0.54%	8.10	10.84%	9.83	21.36%	9.50	-3.28%
GUT	2.86	2.95	3.22%	3.02	2.47%	4.59	51.84%	4.55	-0.96%	5.11	12.43%	5.75	12.46%	5.39	-6.30%	6.17	14.56%	6.32	2.48%	5.88	-6.96%
NEUROGASTROENT MOTIL				1.36		1.50	10.70%	1.72	14.73%	1.69	-1.69%	1.94	14.42%	2.08	7.49%	2.50	20.13%	2.08	-16.68%	2.50	20.02%
SCAND J GASTROENTERO	1.36	1.48	9.12%	1.53	3.23%	1.72	12.08%	1.64	-4.43%	2.36	43.81%	2.34	-1.02%	1.84	-21.15%	1.83	-0.87%	1.85	1.15%	2.14	15.86%
AM J GASTROENTEROL	1.52	1.86	22.51%	2.18	17.62%	3.18	45.58%	2.34	-26.24%	2.61	11.39%	2.95	12.79%	2.83	-3.77%	3.55	25.23%	3.95	11.38%	4.17	5.54%
LIVER	1.01	1.27	25.57%	1.94	53.12%	1.70	-12.42%	1.35	-20.54%	1.25	-7.56%	1.70	36.46%	1.74	2.11%	1.79	3.16%	2.40	33.95%	2.08	-13.61%
SEMIN LIVER DIS	2.44	2.35	-3.64%	2.39	1.70%	4.15	73.43%	5.67	36.49%	5.00	-11.77%	3.07	-38.56%	6.01	95.70%	6.40	6.49%	5.95	-7.00%	6.52	9.57%
DIS COLON RECTUM	1.38	1.74	26.47%	1.45	-16.62%	2.10	44.83%	1.73	-17.71%	2.14	23.73%	1.93	-9.92%	1.69	-12.25%	2.14	26.75%	2.31	7.75%	2.34	1.52%
GASTROENTEROL CLIN N	1.88	2.29	22.07%	2.68	16.94%	1.58	-41.08%	1.27	-19.77%	1.80	42.50%	1.59	-12.14%	1.77	11.92%	3.21	80.83%	1.54	-52.12%	1.68	9.64%
RHEUMATOLOGY	1993	1994		1995		1996		1997		1998		1999		2000		2001		2002		2003	
ANN RHEUM DIS	1.63	1.92	18.04%	2.64	36.95%	2.12	-19.51%	1.98	-6.46%	2.04	2.97%	1.97	-3.67%	2.44	24.19%	3.19	30.44%	3.59	12.70%	3.83	6.51%
RHEUMATOL INT	1.06	1.34	26.61%	1.19	-11.37%	1.09	-7.76%	0.82	-24.89%	0.80	-2.56%	1.11	38.50%	1.16	4.87%	0.89	-23.15%	1.00	11.98%	1.01	1.30%
LUPUS	1.46	1.29	-11.32%	1.49	15.24%	1.75	17.65%	1.61	-8.10%	1.88	16.57%	1.46	-22.04%	2.51	71.72%	1.88	-25.42%	1.77	-5.39%	1.81	1.92%
SCAND J RHEUMATOL	0.76	1.40	85.07%	1.21	-13.70%	1.27	5.05%	0.86	-32.68%	1.11	29.59%	1.17	5.51%	1.40	19.42%	1.48	6.23%	2.00	34.86%	1.82	-8.95%
Z RHEUMATOL	0.24	0.30	24.69%	0.52	71.29%	0.84	62.24%	0.89	5.94%	0.91	2.24%	0.46	-49.12%	0.73	57.33%	0.77	4.79%	0.96	26.01%	0.53	-44.92%
ARTHRITIS RHEUM	5.50	6.30	14.47%	7.23	14.83%	6.54	-9.62%	6.17	-5.65%	6.77	9.71%	7.05	4.26%	6.84	-3.02%	7.39	8.01%	7.38	-0.14%	7.19	-2.56%
BAILLIERE CLIN RHEUM / BEST PRACT	1.38	0.89	-35.84%	0.52	-41.65%	1.10	113.54%	1.04	-5.43%	1.48	41.86%	1.22	-17.96%	1.44	18.19%	0.79	-45.06%	0.65	-18.12%	1.36	109.91%
BRITISH J RHEUM / RHEUMATOLOGY	2.33	2.01	-13.99%	2.22	10.57%	2.07	-6.59%	2.31	11.49%	2.35	1.95%	2.85	20.86%	3.95	38.80%	3.06	-22.46%	3.25	6.17%	3.76	15.66%
CLIN RHEUMATOL	0.63	0.54	-14.67%	0.56	3.33%	0.48	-13.42%	0.64	31.82%	0.63	-0.78%	0.62	-2.84%	0.72	17.72%	0.84	15.75%	0.98	16.47%	0.85	-12.91%
BULL RHEUM DIS	0.50	0.61	21.00%	0.63	3.80%	0.63	-0.48%	0.34	-45.12%	0.30	-13.41%	0.66	121.21%	1.12	69.71%	0.95	-14.62%	0.52	-45.17%	0.46	-11.49%
CLIN EXP RHEUMATOL	1.59	1.34	-15.60%	0.99	-26.45%	0.93	-6.28%	1.15	24.54%	1.27	10.24%	1.35	6.14%	1.64	21.51%	1.61	-1.47%	1.28	-20.45%	1.92	49.45%
SEMIN ARTHRITIS RHEUM	2.16	1.90	-12.14%	1.71	-9.76%	2.20	28.40%	2.62	19.34%	2.20	-16.17%	2.58	17.20%	3.07	19.02%	3.07	0.00%	2.75	-10.31%	2.60	-5.53%
J RHEUMATOL	1.87	2.28	21.78%	2.24	-1.63%	2.22	-0.98%	2.17	-2.03%	2.21	1.80%	2.88	30.21%	2.91	1.08%	2.59	-10.96%	2.99	15.28%	2.67	-10.48%
RHEUM DIS CLIN N AM	1.33	2.23	67.17%	2.44	9.84%	2.30	-6.10%	1.99	-13.29%	2.18	9.30%	2.06	-5.29%	2.26	9.56%	2.16	-4.47%	3.31	53.71%	2.78	-16.23%

IMMUNOLOGY	1993	1994		1995		1996		1997		1998		1999		2000		2001		2002		2003	
J ALLERGY CLIN IMMUN	3.58	3.57	-0.39%	3.51	-1.65%	3.76	7.04%	3.77	0.37%	4.51	19.63%	4.64	2.84%	4.18	-9.88%	5.51	31.75%	6.28	14.09%	6.83	8.74%
CURR OPIN IMMUNOL	4.64	6.70	44.55%	8.79	31.22%	10.12	15.07%	9.08	-10.28%	11.03	21.47%	11.89	7.81%	12.55	5.57%	13.72	9.36%	12.92	-5.87%	12.12	-6.19%
IMMUNITY				15.35		19.94	29.85%	20.82	4.43%	20.52	-1.45%	20.56	0.22%	21.08	2.53%	18.87	-10.52%	17.47	-7.41%	16.02	-8.31%
IMMUNOL TODAY / TRENDS IN IMMUNOL	19.59	22.05	12.54%	25.23	14.43%	21.94	-13.03%	16.47	-24.96%	15.44	-6.23%	17.13	10.98%	14.95	-12.72%	12.16	-18.70%	15.51	27.56%	18.15	17.06%
J EXP MED	13.69	13.86	1.28%	15.13	9.12%	15.57	2.95%	14.38	-7.63%	15.88	10.41%	15.65	-1.45%	15.24	-2.65%	15.34	0.68%	15.84	3.24%	15.30	-3.38%
AIDS	5.73	5.29	-7.56%	4.88	-7.86%	5.98	22.65%	5.05	-15.59%	6.11	20.97%	6.93	13.46%	8.02	15.68%	6.88	-14.18%	5.98	-13.05%	5.52	-7.72%
ANNU REV IMMUNOL	37.04	39.43	6.45%	49.51	25.57%	47.72	-3.62%	37.80	-20.79%	42.93	13.58%	47.56	10.80%	50.34	5.84%	46.23	-8.16%	54.46	17.78%	52.28	-3.99%
J IMMUNOL	7.07	7.38	4.50%	7.41	0.39%	7.30	-1.57%	6.94	-4.92%	7.17	3.30%	7.15	-0.29%	6.83	-4.35%	7.07	3.38%	7.01	-0.72%	6.70	-4.45%
EUR J IMMUNOL	5.58	5.66	1.56%	6.02	6.20%	5.70	-5.22%	5.26	-7.81%	5.44	3.46%	5.64	3.62%	5.24	-7.01%	4.99	-4.77%	4.83	-3.17%	4.54	-6.13%
ADV IMMUNOL	15.52	15.29	-1.50%	19.00	24.30%	19.21	1.08%	11.58	-39.70%	10.71	-7.49%	9.25	-13.66%	13.80	49.19%	23.08	67.27%	10.49	-54.57%	7.42	-29.20%
IMMUNOL REV	10.09	9.05	-10.27%	5.95	-34.31%	8.02	34.95%	5.95	-25.87%	7.46	25.35%	7.27	-2.49%	5.96	-18.01%	7.00	17.43%	7.41	5.84%	7.05	-4.82%
J LEUKOCYTE BIOL	2.68	2.92	9.10%	3.64	24.45%	4.35	19.48%	3.91	-10.17%	4.26	9.11%	4.28	0.49%	4.34	1.38%	4.52	4.01%	4.13	-8.50%	4.18	1.16%

PSYCHOLOGY	1993	1994		1995		1996		1997		1998		1999		2000		2001		2002		2003	
PSYCHOL REV	6.50	7.19	10.57%	5.06	-29.62%	5.21	3.01%	7.06	35.51%	8.24	16.70%	6.80	-17.43%	6.07	-10.79%	5.76	-5.16%	6.75	17.27%	8.36	23.81%
PSYCHOL BULL	5.20	6.70	28.86%	6.97	4.02%	6.59	-5.38%	6.04	-8.39%	6.35	5.10%	7.79	22.75%	6.91	-11.26%	6.81	-1.53%	7.01	3.00%	8.41	19.88%
ANNU REV PSYCHOL	5.55	6.88	23.98%	6.82	-0.87%	5.44	-20.26%	4.84	-10.99%	6.40	32.10%	7.55	17.98%	5.85	-22.45%	5.98	2.19%	7.90	32.10%	9.90	25.30%
J STUD ALCOHOL	1.52	1.35	-11.14%	1.54	14.09%	1.47	-4.68%	1.71	16.37%	1.89	10.79%	2.77	46.51%	2.01	-27.59%	1.74	-13.37%	1.74	0.35%	2.10	20.71%
PSYCHOL MED	2.66	2.43	-8.64%	2.72	11.59%	2.82	3.68%	3.02	7.18%	3.12	3.55%	3.39	8.48%	3.41	0.68%	3.12	-8.59%	2.78	-10.74%	3.13	12.54%
PSYCHOSOMATICS	1.07	1.17	9.15%	1.32	13.00%	2.13	61.39%	1.71	-19.93%	1.54	-9.72%	1.17	-23.82%	1.56	32.45%	1.93	23.86%	1.84	-4.31%	1.99	8.08%
PSYCHOTHER PSYCHOSOM	0.75	1.06	40.82%	1.05	-1.13%	1.58	50.72%	1.81	14.39%	2.10	16.51%	2.26	7.42%	2.37	5.00%	3.43	44.56%	3.19	-7.03%	3.95	23.87%
PSYCHOPHYSIOLOGY	2.35	2.66	13.20%	2.95	10.87%	2.83	-4.10%	2.77	-1.87%	2.43	-12.33%	3.01	23.60%	3.11	3.33%	3.04	-2.29%	2.67	-11.89%	2.07	-22.74%
PSYCHOSOM MED	2.31	2.81	21.51%	2.91	3.70%	3.03	4.09%	3.09	1.91%	3.05	-1.39%	2.62	-13.85%	3.25	23.70%	2.82	-13.28%	3.22	14.32%	3.69	14.57%

BIOLOGY	1993	1994		1995		1996		1997		1998		1999		2000		2001		2002		2003	
PLANT J	5.39	5.95	10.35%	6.46	8.59%	5.67	-12.26%	5.80	2.44%	5.77	-0.67%	5.09	-11.71%	5.63	10.59%	5.79	2.90%	5.85	1.00%	5.91	1.09%
LIFE SCI	2.38	2.50	5.00%	2.35	-6.20%	2.35	0.30%	2.28	-3.27%	1.94	-14.86%	1.77	-8.42%	1.81	1.92%	1.76	-2.77%	1.82	3.75%	1.94	6.58%
MOL BIOCHEM PARASIT	3.04	3.06	0.69%	2.80	-8.49%	2.64	-5.85%	2.12	-19.55%	2.41	13.57%	2.71	12.36%	2.62	-3.21%	1.76	-32.95%	2.91	65.59%	2.88	-1.00%
BIOL REV	2.66	3.13	17.85%	2.43	-22.37%	3.24	33.51%	3.81	17.51%	3.94	3.41%	5.00	26.87%	6.43	28.66%	5.30	-17.57%	5.73	8.05%	4.93	-14.05%
P ROY SOC LOND B BIO	3.14	2.79	-11.06%	2.59	-7.20%	2.87	10.74%	2.87	0.21%	3.03	5.57%	2.76	-9.17%	3.04	10.24%	3.19	5.10%	3.40	6.39%	3.54	4.36%
PHILOS T ROY SOC B	1.77	2.19	23.87%	2.28	4.16%	2.83	24.16%	2.51	-11.30%	2.89	14.89%	2.65	-8.18%	3.52	32.68%	3.07	-12.80%	3.41	11.22%	3.59	5.16%
BIOESSAYS	5.04	6.02	19.46%	5.58	-7.33%	6.23	11.68%	7.05	13.26%	7.58	7.47%	7.65	0.91%	7.91	3.36%	8.31	5.16%	7.89	-5.12%	6.49	-17.71%
FASEB J	16.63	15.12	-9.13%	13.40	-11.32%	13.77	2.74%	14.63	6.23%	13.86	-5.25%	11.88	-14.29%	9.25	-22.15%	8.82	-4.67%	7.25	-17.75%	7.17	-1.10%
J BIOL RHYTHM	2.47	1.98	-19.74%	2.03	2.47%	1.96	-3.54%	1.98	1.12%	2.37	19.52%	3.70	56.16%	2.87	-22.53%	2.70	-6.00%	3.29	22.15%	4.06	23.36%
BIOSCIENCE	1.81	2.04	13.07%	2.07	1.27%	2.07	0.10%	2.09	1.01%	2.98	42.73%	3.08	3.29%	3.95	28.27%	3.30	-16.62%	3.20	-3.03%	3.27	2.22%
J EXP BIOL	1.59	1.82	14.68%	1.62	-11.15%	1.83	13.11%	1.95	6.51%	2.28	17.25%	2.35	3.06%	1.99	-15.51%	2.48	24.59%	2.42	-2.42%	2.27	-6.08%
Q REV BIOL	3.42	3.63	6.32%	2.08	-42.83%	2.57	23.50%	3.75	46.20%	4.38	16.83%	3.80	-13.26%	3.50	-7.89%	5.59	59.66%	5.20	-6.94%	4.14	-20.33%

HIGH IMPACT JOURNALS	1993	1994		1995		1996		1997		1998		1999		2000		2001		2002		2003	
NAT GENET	19.84	22.57	13.73%	28.54	26.48%	31.47	10.27%	38.85	23.45%	40.36	3.88%	30.69	-23.95%	30.91	0.71%	29.60	-4.24%	26.71	-9.76%	26.49	-0.81%
NEW ENGL J MED	23.73	22.67	-4.44%	22.41	-1.15%	24.83	10.81%	27.77	11.81%	28.66	3.22%	28.86	0.69%	29.51	2.27%	29.07	-1.51%	31.74	9.19%	34.83	9.76%
CELL	37.19	39.19	5.37%	40.48	3.29%	41.00	1.27%	37.30	-9.03%	38.69	3.72%	36.24	-6.32%	32.44	-10.49%	29.22	-9.93%	27.25	-6.73%	26.63	-2.30%
ANNU REV BIOCHEM	37.89	42.17	11.31%	44.41	5.32%	38.97	-12.27%	40.78	4.66%	39.00	-4.37%	37.11	-4.84%	43.43	17.02%	31.64	-27.15%	36.28	14.66%	37.65	3.77%
ANNU REV CELL DEV BI	22.33	27.61	23.61%	30.55	10.66%	20.35	-33.37%	19.00	-6.65%	21.39	12.56%	26.26	22.80%	26.30	0.14%	27.11	3.06%	22.87	-15.63%	22.64	-1.01%
ANNU REV IMMUNOL	37.04	39.43	6.45%	49.51	25.57%	47.72	-3.62%	37.80	-20.79%	42.93	13.58%	47.56	10.80%	50.34	5.84%	46.23	-8.16%	54.46	17.78%	52.28	-3.99%
ANNU REV NEUROSCI	27.63	17.95	-35.02%	29.08	62.00%	33.63	15.62%	21.95	-34.72%	23.02	4.88%	22.61	-1.82%	26.68	18.01%	27.15	1.78%	24.09	-11.27%	30.17	25.22%
NATURE	22.33	25.47	14.06%	27.07	6.31%	28.42	4.96%	27.37	-3.69%	28.83	5.35%	29.49	2.28%	25.81	-12.47%	27.96	8.29%	30.43	8.86%	30.98	1.80%
PHYSIOL REV	14.02	16.29	16.20%	20.55	26.15%	19.39	-5.63%	19.26	-0.67%	23.69	22.99%	23.95	1.12%	27.68	15.55%	30.06	8.61%	26.53	-11.74%	36.83	38.82%
SCIENCE	21.07	22.07	4.71%	21.91	-0.71%	23.61	7.73%	24.68	4.54%	24.39	-1.18%	24.60	0.86%	23.87	-2.94%	23.33	-2.27%	28.96	24.12%	29.78	2.85%

TABLE 2
Average percentage change in impact factor change by year of first online availability

YEAR OF FIRST ONLINE AVAILABILITY	THREE YEARS PRIOR TO ONLINE AVAILABILITY	TWO YEARS PRIOR TO ONLINE AVAILABILITY	ONE YEAR PRIOR TO ONLINE AVAILABILITY	ONE YEAR AFTER ONLINE AVAILABILITY	TWO YEARS AFTER ONLINE AVAILABILITY	THREE YEARS AFTER ONLINE AVAILABILITY
1993				9.97%	0.38%	-1.15%
1994				-9.32%	37.64%	-10.41%
1995			20.80%	0.33%	-3.44%	0.35%
1996		11.00%	7.42%	-0.42%	3.30%	18.05%
1997	5.78%	8.36%	9.04%	7.41%	8.32%	8.89%
1998	9.79%	16.31%	-1.98%	1.15%	10.39%	7.16%
1999	20.16%	9.50%	8.57%	12.59%	-12.50%	-0.90%
2000	-9.83%	6.58%	12.56%	25.52%	-12.63%	-4.41%
2001	3.28%	14.15%	6.53%	-4.47%	6.84%	
2002	11.92%	-5.10%	13.71%	-20.23%	5.58%	

FIGURE 2
Table 2 represented graphically