

## The Languages of Science Revisited: English (Only) Spoken Here?

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Language use in scientific publication has been frequently discussed in *Current Contents*® and *The Scientist*®.<sup>1-6</sup> Drawing on ISI®'s database of journal articles and references indexed in the *Science Citation Index*® (*SCI*®), these studies have consistently shown that English is by far the primary language of international research. Typically, English-language articles have accounted for about 70-85 percent of the *SCI* files over the last 15 years, depending on whether cover-to-cover translation journals were included. They also have been cited about three or four times as often as *SCI*-indexed articles in German, French, Russian, Japanese, and other languages.

While language use in science is a complex issue, it can be summed up in two basic questions: Who writes in what languages and who cites what languages? Our studies to date have focused on answering the first question by examining the distribution of ISI-indexed articles by language and by nation. Of course, ISI's data can also be used to examine the second question, by ranking nations in order of their citations to ISI-indexed articles in English and other languages.

Such an analysis has not been undertaken before, mainly because of the considerable time and effort required to process the millions of items involved. But the incentive to do so was recently provided by Richard D. Lambert, director of the National Foreign Language Center of Johns Hopkins University, Washington, DC, and editor of the *Annals of the American Academy of Political and Social Science* (AAPSS). He was planning a special issue of the *Annals* on the topic of foreign language use and

training in business, engineering, and government. At his invitation my colleague Al Welljams-Dorof and I contributed a citation perspective on language use in the scientific literature. The article is preprinted here and will appear in the September 1990 issue of the *Annals*.<sup>7</sup> Other articles in this special issue are shown in Table 1 to give an idea of the subjects covered.

The present study was based on about 900,000 articles indexed by ISI in 1984 and about 3,000,000 citations they received from 1984 through 1988. As indicated above, and not surprisingly, English-language articles represented 85 percent of the total. Also, their impact of 3.7 was at least four times that of articles in Russian (0.9), German (0.6), French (0.5), and Japanese (0.5).

The data showed that many nations could be considered "unilingual" in the sense that English was almost the exclusive language of communication, accounting for over 90 percent of their 1984 output. They included the US, the UK, Canada, and Australia as well as India, Sweden, and The Netherlands. In contrast, "bilingual" nations such as France, the Federal Republic of Germany, Spain, and Italy published both in English and in their respective native languages. However, looking instead at what languages are cited by various nations, almost all seemed to be unilingual—of their 1984-1988 citations to ISI-indexed 1984 articles, over 90 percent cited English-language publications.

I should point out that the *Annals* is celebrating its centennial in 1990. A bimonthly scholarly journal on public issues and public policy, the *Annals* began publication in 1890, a few months after the AAPSS

**Table 1: Contents of the September 1990 issue of *Annals of the American Academy of Political and Social Science* on "Foreign Language in the Workplace."**

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was established in Philadelphia to promote the progress of political and social science. The AAPSS currently has about 11,000 members.

This reminds me again that we have not yet done a citation survey of social-sciences journals. Previous essays have identified the most-cited authors,<sup>8</sup> articles,<sup>9,10</sup> and books<sup>11</sup> in the *Social Sciences Citation Index*<sup>®</sup> (*SSCI*<sup>®</sup>). Later this year we will conduct a comprehensive analysis of *SSCI*-

indexed journals to identify the most significant journals of the social sciences. In addition, we plan to update our earlier analyses of the most significant science journals, which were originally published in *Science*<sup>12</sup> in 1972 and *Nature* in 1976.<sup>13</sup>

\* \* \* \* \*

*My thanks to Al Welljams-Dorof for his help in the preparation of this essay.*

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## Language Use in International Research: A Citation Analysis

By EUGENE GARFIELD and ALFRED WELLJAMS-DOROF

**ABSTRACT:** The fact that English is the internationally accepted language of research communication raises the issue of a language barrier in two senses. First, those whose native language is not English risk being unaware of—and overlooked by—mainstream international research unless they learn to read, write, and publish in English. Second, native English-speaking researchers risk being ignorant of significant findings reported in foreign languages, especially the Japanese and Russian literature, unless they become proficient in at least one other language. The Institute for Scientific Information (ISI) data base is used to answer three basic questions bearing on this issue: (1) who writes in what languages; (2) who cites what languages; and (3) who cites what nations.

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**NOTE:** Authors citing data from this article are requested to acknowledge the source and the Institute for Scientific Information, Philadelphia.

FEW would argue with the claim that English is the lingua franca of international science. Previous studies by the Institute for Scientific Information (ISI) have demonstrated that most of the world's scientific literature is written and published in English and that the English-language literature is by far the most cited.<sup>1</sup>

The ISI data base offers unique perspectives on language use in the research literature. Each year it monitors thousands of journals for three major indexes to the research literature: *Science Citation Index (SCI)*; *Social Sciences Citation Index (SSCI)*; and *Arts & Humanities Citation Index (A&HCI)*.

Full bibliographic data are entered for every indexed source item; source items include original research articles, literature reviews, letters, notes, editorials, book reviews, and other items. These data include authors' names, institutions, and addresses; source-item title; journal title, volume, issue, year, and page numbers; language of publication; and other information.

All cited references are also indexed, which provides innovative capabilities for literature analysis and retrieval. These unique citation data have been used to develop quantitative indicators for bibliometric analysis of the research literature. In-

creasingly, the ISI data base is being utilized by policymakers and analysts for comparative evaluation of multinational scientific performance.

Previous ISI studies of language use have reported on the publication output of different nations in various languages and on their respective impacts, or the average number of citations received over a given time period. ISI has now developed a citation-based method to reveal interlingual and international links in the scientific literature. The data presented here identify not just who writes in what languages but also who cites what languages and what nations.

#### METHODS AND DEFINITIONS

The year 1984 was selected as a base year for analysis. The ISI file for that year allows us to track citations to 1984 source items over a five-year period, from 1984 through 1988. The analysis includes nearly 900,000 source items from 6100 journals indexed in the 1984 *SCI*, *SSCI*, and *A&HCI*. These source items received almost 3 million citations from 1984 to 1988. Book citations have been purposefully omitted from this analysis.

The nationality of a source item is defined here by the institutional affiliation of the first author. If a U.S. address is listed, the source item is credited to the United States, even if the first author is a British or French citizen, for example, or if he or she is a visiting researcher from another country working at a U.S. lab while on sabbatical or other leaves of absence.

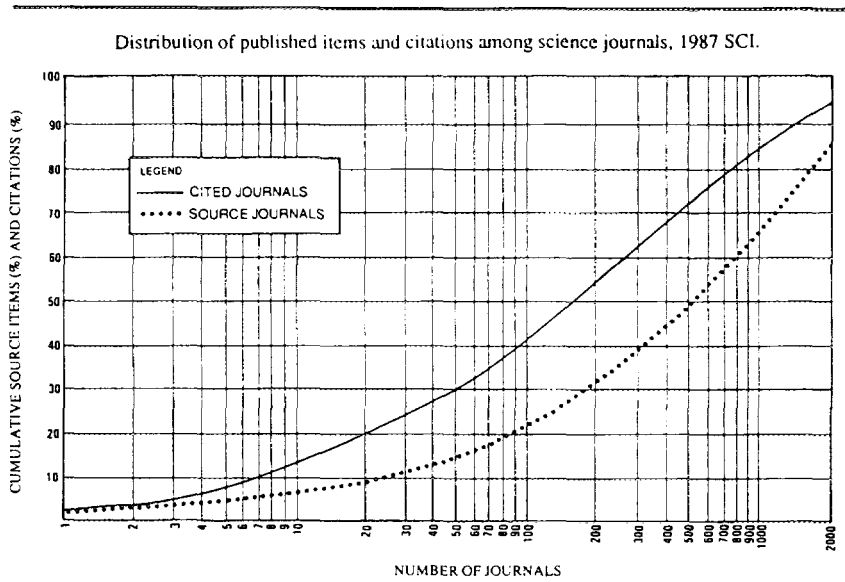
Also, this definition does not account for multinational collaborations—source items by researchers based in different nations. This may be a shortcoming in particular specialties, such as high-energy physics. Cur-

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FIGURE 1

DISTRIBUTION OF PUBLISHED ITEMS AND CITATIONS AMONG SCIENCE JOURNALS, 1987 SCI



rently, the number of such source items is small. Their overall number is growing, however, accounting for about 4.4 percent of 570,000 source items indexed in the 1984 *SCI*, compared to 2.4 percent in the 1975 *SCI*.

Obviously, ISI-covered journals are only a sample of the international scientific literature, not an inventory of the entire universe. But we are confident they represent the major international research publications.

ISI data indicate that a relatively small proportion of the world's journals account for the majority of source items and citations. This is illustrated in Figure 1, which presents the distribution of source items and citations in the 1987 *SCI* file. The dotted line shows that 500 journals

published about half of all source items that year. Only 200 journals received over 50 percent of the references cited in 1987, indicated by the solid line. ISI's coverage of more than 6000 journals goes well beyond what is necessary to capture the core of the international research literature.

### THREE BASIC QUESTIONS

In this article, the ISI data base will be used to answer three questions bearing on the issue of language use in science.

The first is, who writes in what languages? This will be answered by examining the number and impact of source items from a particular nation

TABLE 1

**LANGUAGE DISTRIBUTION OF 1984 ISI SOURCE ITEMS,  
LISTING THE TOP 15 LANGUAGES OF PUBLICATION BY TOTAL ITEMS**

Language	Items		Citations, 1984-88		Cited Items	Total Impact	Cited Impact
	Number	% of Total	Number	% of Total			
English	759,753	84.7	2,841,591	97.4	362,602	3.74	7.84
German	43,533	4.9	27,745	1.0	9,989	0.64	2.78
French	35,050	3.9	17,081	0.6	6,707	0.49	2.55
Russian	30,578	3.4	26,284	0.9	11,238	0.86	2.34
Spanish	7,161	0.8	945	—	549	0.13	1.72
Japanese	5,743	0.6	2,809	0.1	1,354	0.49	2.07
Italian	5,626	0.6	201	—	156	0.04	1.29
Czech	1,847	0.2	449	—	295	0.24	1.52
Dutch	1,206	0.1	100	—	52	0.08	1.92
Portuguese	1,096	0.1	176	—	125	0.16	1.41
Swedish	780	0.1	12	—	10	0.02	1.20
Polish	710	0.1	163	—	114	0.23	1.43
Hungarian	686	0.1	178	—	102	0.26	1.75
Chinese	682	0.1	219	—	131	0.32	1.67
Ukrainian	622	0.1	169	—	100	0.27	1.69
16 other languages	1,667	0.2	136	—	87	0.08	1.56
Total	896,740	100.0	2,918,258	100.0	393,611	3.25	7.41

that were in English, German, French, Russian, Spanish, Japanese, and other major languages of publication in the 1984 ISI data base.

Second, who cites what languages? This will be examined by identifying the nationality of source items citing the literatures of various languages.

Finally, who cites what nations? Interlingual citation data may indicate a nation's awareness of research reported in various languages. For example, it will be shown that the ISI-covered Japanese- and Russian-language literature is cited primarily by source items from Japan or the USSR. This is not to say, however, that the scientific world is largely unaware of research from Japan or the USSR. International citation links will be examined to indicate the extent of a nation's awareness of literature from other countries.

**LANGUAGE AND  
AUTHOR DISTRIBUTION**

Table 1 presents the top 15 languages in the 1984 ISI data base, ranked by total number of source items. English clearly predominates, with about 760,000, or 85 percent of the total, written in English. Of these, 362,602, or 48 percent, were cited over 2.8 million times from 1984 to 1988. Dividing citations by total source items gives a five-year total impact of 3.74 citations, which is more than four times greater than that of other languages shown in Table 1. Dividing instead by cited source items gives a cited impact of 7.84, at least three times higher than that of other languages.

Thirty other languages are represented in the 1984 ISI data base, accounting for 15 percent of all source items. German is the second most

frequent language of publication, with 43,500 source items, or 5 percent of the total. French is third with 35,000 source items, or 4 percent. German has the second highest cited impact, 2.78, followed by French, 2.55. While Russian-language source items in the ISI data base rank fourth in sheer numbers, they rank second on total impact, with 0.9 citations per source item.

Table 2 presents the top 17 nations in the 1984 ISI data base, ranked by number of source items. Source items with first authors based at U.S. institutions lead the list, accounting for 42 percent of the 722,295 addressed source items. The United Kingdom, with 9.3 percent, is second, followed by West Germany, 5.7 percent; the USSR, 5.6 percent; and Japan, 5.5 percent.

Switzerland's source items rank first in total impact (5.89) and cited impact (10.28). While Sweden shows the second highest total impact (5.81), its cited impact of 8.42 is third after that of the United States (9.28). The Netherlands comes in third and fourth in total (5.13) and cited impact (7.98), respectively, followed by the United Kingdom at 4.14 and 7.69.

About 175,000 source items did not list an address. These include editorials, correction notes, commemorations, obituaries, and other anonymous source items. Their impact is rather low compared to that of all ISI items.

#### WHO WRITES IN WHAT LANGUAGES?

One measure of a nation's language use is the number of source items it produces in various languages. Table 3 lists nations by the number of source items written in English, German, French, Russian, Spanish, and Japanese. Also shown are the proportions that these numbers rep-

resent of a given nation's and language's total source items and the impact of the source items.

Not surprisingly, the leading nations within each language are the native speakers, nations in which the language is spoken. For example, over half of the English-language source items were written by first authors from the United States, the United Kingdom, Canada, and Australia. West and East Germany account for 49.8 percent of all German-language items. France takes 43.2 percent of all French source items while the Soviet Union, with 98.9 percent of the Russian-language items, and Japan with 98.8 percent of the Japanese-language items, are virtually the only nations writing in Russian and Japanese, respectively.

Regardless of its native language, a nation's English-language publications have the highest impact. For example, 59 percent of West Germany's 41,000 source items were in English and 41 percent in German. Its English-language publications had a cited impact of 8.87 and a total impact of 5.83, compared to 3.08 and 1.16, respectively, for German. Switzerland's exceptional citation record, discussed earlier, is even better in English. Its cited impact of 11.71 and total impact of 7.67 are well above the second-ranked United States, at 9.29 and 4.95, respectively.

#### UNILINGUAL AND BILINGUAL NATIONS

English is virtually the exclusive language of publication for the United States, the United Kingdom, and Australia. This is shown in the fourth column of data in Table 3: the percentage of a nation's total 1984 source items that were in English. Over 99.5 percent of U.S., U.K.,

TABLE 2  
**NATIONAL DISTRIBUTION OF 1984 ISI SOURCE ITEMS,  
 LISTING 17 COUNTRIES WITH AT LEAST 6000 ITEMS**

Nation	Items		Citations, 1984-88		Cited Items	Total Impact	Cited Impact
	Number	% of addressed items	Number	% of addressed items			
United States	303,613	42.0	1,495,949	51.6	161,126	4.93	9.28
United Kingdom	67,439	9.3	279,260	9.6	36,295	4.14	7.69
Federal Republic of Germany	41,147	5.7	160,682	5.5	22,240	3.91	7.22
USSR	40,295	5.6	43,325	1.5	14,327	1.07	3.02
Japan	39,840	5.5	162,842	5.6	25,343	4.09	6.43
Canada	32,181	4.5	120,950	4.2	17,775	3.76	6.80
France	31,621	4.4	119,516	4.1	17,184	3.78	6.96
Italy	15,421	2.1	48,089	1.7	8,740	3.12	5.50
Australia	15,058	2.1	57,643	2.0	8,873	3.83	6.50
India	14,346	2.0	19,586	0.7	6,755	1.37	2.90
Netherlands	11,136	1.5	57,145	2.0	7,162	5.13	7.98
Sweden	9,662	1.3	56,090	1.9	6,660	5.81	8.42
Switzerland	8,316	1.2	48,941	1.7	4,760	5.89	10.28
German Democratic Republic	7,055	1.0	10,520	0.4	3,000	1.49	3.51
Israel	6,734	0.9	26,704	0.9	4,109	3.97	6.50
Spain	6,231	0.9	15,026	0.5	3,094	2.41	4.86
Belgium	6,002	0.8	22,896	0.8	3,370	3.81	6.79
149 other nations	66,198	9.2	152,354	5.3	33,203	2.30	4.59
Addressed source items	722,295	80.5*	2,896,888	99.3*	384,016	4.01	7.54
Unaddressed source items	174,445	19.5*	21,370	0.7*	9,595	0.12	2.23
Grand total	896,740	100.0*	2,918,258	100.0*	393,611	3.25	7.41

\*Percentage of grand total, not of addressed items.

and Australian source items were in English.

These nations are essentially unilingual in the sense that they write almost only in English and their foreign language publication is comparatively insignificant. The same is true of ISI-indexed publications from Sweden (97.6 percent are in English), Canada and the Netherlands (96.5 percent for both countries), and Japan (91.8 percent).

For West Germany, France, and Italy, English represents a smaller but still majority share of total source items. In each case, the second language of publication is the native language. Added together, English-lan-

guage and native-language items amount to 99 percent of the total. Thus these nations are bilingual in the sense that they are proficient in two written scientific languages, English and their own.

#### WHO CITES WHAT LANGUAGES

Another indicator of language use is the frequency of citation of foreign language literature. Table 4 presents the nations that most often cited source items written in English, German, French, Russian, Spanish, and Japanese, in order of citations.

Again, within each language the lead citing nations are native speakers.



TABLE 3  
 WHO WRITES IN WHAT LANGUAGES, LISTING NATIONS IN ORDER OF  
 THEIR PUBLICATIONS IN THE TOP SIX LANGUAGES IN THE 1984 ISI DATA BASE

Source Language				% of a		
Author		Citations,	% of	Nation's Total	Total	Cited
Nation	Items	1984-88	Total Items	Items in a	Impact	Impact
				Given Language		
English	759,753	2,841,591	100.0		3.74	7.84
United States	302,225		39.8	99.5	4.95	9.29
United Kingdom	67,232		8.8	99.7	4.15	7.70
Japan	36,571		4.8	91.8	4.38	6.65
Canada	31,040		4.1	96.5	3.88	6.86
Federal Republic of Germany	24,231		3.2	58.9	5.83	8.87
France	16,301		2.1	51.6	6.45	8.93
Australia	15,017		2.0	99.7	3.84	6.50
India	14,320		1.9	99.8	1.37	2.70
USSR	13,980		1.8	34.7	1.25	4.46
Italy	13,547		1.8	87.9	3.53	5.59
Netherlands	10,751		1.4	96.5	5.30	8.05
Sweden	9,432		1.2	97.6	5.94	8.46
152 other nations	205,106		27.0			
German	43,533	27,745	100.0		0.64	2.78
Federal Republic of Germany	16,737		38.4	40.7	1.16	3.08
German Demo- cratic Republic	4,902		11.3	69.5	0.74	2.34
Austria	1,799		4.1	44.7	0.69	2.25
Switzerland	1,632		3.7	19.6	0.03	1.62
United States	400		0.9	—	0.36	2.51
63 other nations	18,063		41.5			
French	35,050	17,081	100.0		0.49	2.55
France	15,156		43.2	47.9	0.94	2.66
Canada	1,049		3.0	3.3	0.37	2.06
Belgium	976		2.8	16.3	0.60	2.12
Switzerland	554		1.6	6.7	0.65	2.26
United States	406		1.2	—	0.33	2.60
86 other nations	16,909		48.2			
Russian	30,578	26,284	100.0		0.86	2.34
USSR	30,247		98.9	75.1	1.10	2.34
Bulgaria	104		0.3	7.9	0.34	1.67
German Demo- cratic Republic	47		0.2	0.7	0.19	1.27
United States	27		0.1	—	0.30	1.33
Hungary	17		0.1	0.5	0.47	1.60
Federal Republic of Germany	13		—	—	0.31	4.00
Poland	10		—	0.2	0.90	2.25
23 other nations	113		0.4			
Spanish	7,161	945	100.0		0.13	1.72
Spain	2,044		28.5	32.8	0.26	1.81
Chile	632		8.8	55.3	0.22	1.86
Argentina	550		7.7	28.6	0.17	1.63
United States	415		5.8	0.1	0.05	1.18
Mexico	166		2.3	15.1	0.20	1.62
Venezuela	129		1.8	24.0	0.20	1.18

TABLE 3 Continued

Source Language Author Nation	Items	Citations, 1984-88	% of Total Items	% of a Nation's Total Items in a Given Language	Total Impact	Cited Impact
Brazil	68		1.0	2.3	0.18	1.71
34 other nations	3,157		44.1			
Japanese	5,743	2,809	100.0		0.49	2.07
Japan	5,671		98.8	7.9	0.83	2.15
People's Republic of China	29		0.5	1.0	0.24	1.75
Taiwan	17		0.3	2.1	0.00	0.00
Italy	12		0.2	0.1	0.00	0.00
5 other nations	14		0.2			

Over 60 percent of all citations received by English-language source items were from U.S., U.K., Canadian, and Australian citing papers. The two Germanies account for 60 percent of all citations to German-language source items, and France for 54 percent of French citations. Source items in Russian and Japanese are cited primarily by the native-language producers, the USSR (82 percent) and Japan (76 percent), respectively.

The fourth column of data in Table 4 shows that, except for the USSR, English-language source items received over 90 percent of every listed nation's total citations. This is to be expected, given that English-language source items amount to 85 percent of the 1984 ISI data base. The data simply reinforce the axiom that English is the internationally accepted language for research communication.

#### UNIVERSAL UNILINGUALISM?

The data in Table 4 indicate that most nations are essentially unilingual in the sense that they almost exclusively cite source items written in English. But it is important to stress that, while the percentage of citations to non-English-language items may seem insignificantly small, the absolute number amounts to an im-

portant share of each language's total citations. For example, just 0.2 percent of U.S. citations were to German-language source items, but these 2100 citations are 7.6 percent of the total for German. West Germany cited English-language source items 92 percent of the time, but the 7.8 percent of West German items that cited German-language source items constitute half of the language's total.

The United States and the United Kingdom usually are among the top three nations citing the literatures in German, French, Russian, and Japanese, trailing only the respective native-language nations. Together they account on average for about 10 percent of all citations received by these languages. The exception is Russian, where U.S. and U.K. citations are just 3 percent of its total citations.

#### WHO CITES WHAT NATIONS?

The language-use data presented here raise an interesting question: How international is science? The data on Japanese-language and Russian-language source items show that they are solely produced and cited by Japan and the USSR. But these interlingual links only indirectly touch on the question of science's internationality. An answer

TABLE 4  
 WHO CITES WHAT LANGUAGES, LISTING NATIONS IN ORDER OF CITATIONS TO  
 LITERATURE PUBLISHED IN THE TOP SIX LANGUAGES OF THE 1984 ISI DATA BASE

Source Language				% of a Nation's		
Citing Nation	Items	Citations, 1984-88	% of Total Citations	Citations of Items Written in a Given Language	Total Impact	Cited Impact
English	759,753	2,841,591	100.0		3.74	7.84
United States		1,294,461	45.6	99.6	1.70	5.25
United Kingdom		258,466	9.1	99.2	0.34	2.24
Japan		171,761	6.0	98.3	0.23	2.62
Federal Republic of Germany		162,586	5.7	91.9	0.21	2.39
Canada		136,204	4.8	99.3	0.18	2.03
France		135,084	4.8	93.2	0.18	2.24
Italy		64,927	2.3	98.8	0.09	1.92
Australia		61,755	2.2	99.5	0.08	1.84
Netherlands		60,965	2.1	99.0	0.08	1.93
Sweden		54,002	1.9	99.1	0.07	2.01
USSR		44,351	1.6	66.5	0.06	9.68
Switzerland		43,624	1.5	96.4	0.06	1.91
Israel		27,525	1.0	99.5	0.04	1.65
152 other nations		325,880	11.5			
German	43,533	27,745	100.0		0.64	2.78
Federal Republic of Germany		13,757	49.6	7.8	0.32	2.38
German Democratic Republic		2,979	10.7	17.9	0.07	1.87
United States		2,102	7.6	0.2	0.05	1.52
Switzerland		1,216	4.4	2.7	0.03	1.62
Austria		1,077	3.9	7.7	0.02	1.48
United Kingdom		1,049	3.8	0.4	0.02	1.20
USSR		454	1.6	0.7	0.01	1.22
Japan		448	1.6	0.3	0.01	1.67
France		402	1.4	0.3	0.01	1.25
Netherlands		379	1.4	0.6	0.01	1.34
Canada		297	1.1	0.2	0.01	1.37
58 other nations		3,585	12.9			
French	35,050	17,081	100.0		0.49	2.55
France		9,263	54.2	6.4	0.26	2.11
United States		1,774	10.4	0.1	0.05	1.43
United Kingdom		642	3.8	0.3	0.02	1.23
Canada		566	3.3	0.4	0.02	1.43
Belgium		539	3.2	2.0	0.02	1.45
Federal Republic of Germany		458	2.7	0.3	0.01	1.27
Italy		394	2.3	0.6	0.01	1.32
Switzerland		390	2.3	0.9	0.01	1.30
Japan		323	1.9	0.2	0.01	1.44
USSR		257	1.5	0.4	0.01	1.19
Spain		235	1.4	0.9	0.01	1.32
Netherlands		178	1.0	0.3	0.01	1.16
87 other nations		2,062	12.1			
Russian	30,578	26,284	100.0		0.86	2.34
USSR		21,414	81.5	32.1	0.70	2.21
United States		564	2.1	----	0.02	1.19

TABLE 4 Continued

Source Language Citing Nation	Items	Citations, 1984-88	% of Total Citations	% of a Nation's Citations of Items Written in a Given Language	Total Impact	Cited Impact
United Kingdom		244	0.9			
44 other nations		4,062	15.5	0.1	0.01	1.04
Spanish	7,161	945	100.0		0.13	1.72
Spain		388	41.1	1.5	0.05	1.78
Chile		123	13.0	4.4	0.02	1.64
United States		91	9.6	—	0.01	1.17
Argentina		85	9.0	1.4	0.01	1.49
28 other nations		258	27.3			
Japanese	5,743	2,809	100.0		0.49	2.07
Japan		2,139	76.1	1.2	0.37	1.84
United States		256	9.1	—	0.04	1.21
United Kingdom		77	2.7	—	0.01	1.60
Canada		53	1.9	—	0.01	1.15
Federal Republic of Germany		33	1.2	—	0.01	1.18
USSR		29	1.0	—	0.01	1.04
France		28	1.0	—	0.01	1.12
29 other nations		194	6.9			

requires knowing which nations have most frequently cited the literature of other nations. Table 5 presents this information, listing countries in order of their citations to source items authored in the United States, the United Kingdom, the Federal Republic of Germany, Japan, the USSR, Canada, and France.

Not surprisingly, each nation is its own most frequent citer. For example, of the 1.5 million citations received by U.S. source items, 63 percent were from other U.S. source items—the self-cited rate. These amounted to 72 percent of all citations from U.S. source items—the self-citing rate. The United Kingdom cited itself about 38 percent of the time, and this represents 41 percent of all citations from U.K. source items. West Germany's self-cited rate is 39 percent, and its self-citing rate is 35 percent. For Japan, the rates are 47 percent and 43 percent, and for the USSR, 67 percent and 44 percent.

At first glance, these data seem to indicate that U.S. source items are

perhaps less aware of the international literature compared to other leading nations, in the sense that a smaller proportion of its citations—28 percent—refers to non-U.S. literature. A different perspective is obtained, however, when self-citing rates in Table 5 are compared to each nation's proportionate share of all 1984-88 ISI citations, shown in Table 2.

The 1.5 million citations received by U.S. source items represent 51.6 percent of all ISI citations to addressed source items. All things being equal, U.S. source items would be expected to receive an equivalent percentage of the United States' total citations. Instead, they received 72.4 percent of all citations from U.S. source items. Dividing actual by expected citations received gives a value of 1.4—that is, the United States cites itself 1.4 times more than the ISI mean of citations to the United States. In comparison, the United Kingdom's self-citing rate of 40.6 percent is 4.2 times greater than the 9.6 percent share of all ISI cita-

TABLE 5  
WHO CITES WHAT NATIONS, LISTING CITING NATIONS IN ORDER OF  
CITATIONS TO VARIOUS NATIONS' LITERATURES, 1984-88 ISI DATA BASE

Cited Nation Citing Nation	Items	Citations, 1984-88	% Cited	% Citing	Total Impact	Cited Impact
United States	303,613	1,495,949	100.0		4.93	9.28
United States		940,976	62.9	72.4	3.10	6.48
United Kingdom		84,278	5.6	32.4	0.28	1.96
Federal Republic of Germany		59,965	4.0	33.9	0.20	2.13
Canada		57,576	3.8	42.0	0.19	1.84
Japan		56,408	3.8	32.3	0.19	2.30
France		52,210	3.5	36.0	0.17	2.04
Italy		23,710	1.6	36.1	0.08	1.76
Australia		21,456	1.4	34.6	0.07	1.57
Netherlands		21,300	1.4	34.6	0.07	1.64
Sweden		17,546	1.2	32.2	0.06	1.66
Switzerland		17,386	1.2	38.4	0.06	1.72
USSR		16,026	1.1	24.0	0.05	1.57
134 other nations		127,112	8.5			
United Kingdom	67,439	279,260	100.0		4.14	7.69
United Kingdom		105,747	37.9	40.6	1.57	3.17
United States		73,624	26.4	5.7	0.95	3.98
France		10,498	3.8	7.2	0.19	2.72
Federal Republic of Germany		12,271	4.4	6.9	0.16	2.04
Canada		9,969	3.6	7.3	0.13	1.69
Japan		8,820	3.2	5.1	0.11	2.10
Australia		6,462	2.3	10.4	0.08	1.61
Italy		5,233	1.9	8.0	0.08	1.72
Netherlands		5,072	1.8	8.2	0.08	1.60
Sweden		4,696	1.7	8.6	0.07	1.72
Switzerland		3,616	1.3	8.0	0.05	1.71
USSR		3,203	1.1	4.8	0.05	1.55
107 other nations		30,049	10.8			
Federal Republic of Germany	41,147	160,682	100.0		3.91	7.22
Federal Republic of Germany		62,077	38.6	35.1	1.51	3.60
United States		39,539	24.6	3.0	0.96	3.98
United Kingdom		9,433	5.9	3.6	0.19	1.80
Japan		6,584	4.1	3.8	0.16	2.06
France		6,576	4.1	4.5	0.16	1.94
Canada		4,180	2.6	3.1	0.10	1.71
USSR		3,015	1.9	4.5	0.06	1.55
Switzerland		2,888	1.8	6.4	0.07	1.66
Italy		2,785	1.7	4.2	0.07	1.64
Netherlands		2,765	1.7	4.5	0.07	1.63
Sweden		1,995	1.2	3.7	0.05	1.65
Australia		1,971	1.2	3.2	0.05	1.58
98 other nations		16,874	10.5			
Japan	39,840	162,842	100.0		4.09	6.43
Japan		75,681	46.5	43.3	1.90	3.72
United States		37,909	23.3	2.9	0.95	3.25
United Kingdom		7,602	4.7	2.9	0.17	1.64
Federal Republic of Germany		6,384	3.9	3.6	0.16	1.81

TABLE 5 Continued

Cited Nation Citing Nation	Items	Citations, 1984-88	% Cited	% Citing	Total Impact	Cited Impact
France		5,656	3.5	3.9	0.14	1.73
Canada		4,004	2.5	2.9	0.10	1.58
USSR		2,732	1.7	4.1	0.06	1.40
Italy		2,398	1.5	3.7	0.06	1.57
Netherlands		2,010	1.2	3.3	0.05	1.47
Sweden		1,567	1.0	2.9	0.04	1.54
81 other nations		16,899	10.4			
USSR	40,295	43,325	100.0		1.07	3.02
USSR		29,067	67.1	43.6	0.72	2.36
United States		3,978	9.2	0.3	0.10	2.26
Japan		1,060	2.4	0.6	0.03	1.71
Federal Republic of Germany		1,029	2.4	0.6	0.03	1.76
United Kingdom		931	2.1	0.4	0.02	1.36
France		919	2.1	0.6	0.02	2.12
57 other nations		6,341	14.6			
Canada	32,181	120,950	100.0		3.76	6.80
Canada		40,604	33.6	26.6	1.26	3.22
United States		39,183	32.4	3.0	1.22	3.66
United Kingdom		7,823	6.5	3.0	0.24	1.74
Federal Republic of Germany		4,144	3.4	2.3	0.13	1.77
France		4,086	3.4	2.8	0.13	1.74
Japan		4,040	3.3	2.8	0.13	1.93
Australia		2,147	1.8	3.5	0.07	1.48
Netherlands		1,721	1.4	2.8	0.05	1.48
Italy		1,653	1.4	2.5	0.05	1.52
Sweden		1,609	1.3	3.0	0.05	1.48
Switzerland		1,181	1.0	2.6	0.04	1.54
USSR		1,173	1.0	1.8	0.04	1.38
93 other nations		11,586	9.6			
France	31,621	119,516	100.0		3.78	6.96
France		44,655	37.4	30.8	1.41	3.40
United States		29,794	24.9	2.3	0.94	3.87
United Kingdom		7,360	6.2	2.8	0.23	1.87
Federal Republic of Germany		5,760	4.8	3.3	0.18	1.98
Japan		4,736	4.0	2.7	0.15	1.97
Italy		2,699	2.3	4.1	0.09	1.68
USSR		2,084	1.7	3.1	0.07	1.48
Netherlands		1,950	1.6	3.2	0.06	1.68
Switzerland		1,754	1.5	3.9	0.06	1.56
Australia		1,504	1.3	2.4	0.05	1.55
Sweden		1,456	1.2	2.7	0.05	1.53
Belgium		1,253	1.0	4.7	0.04	1.42
Spain		1,155	1.0	4.6	0.04	1.46
100 other nations		9,861	8.3			

tions it received. The ratio for West Germany is 6.3; for Japan, 7.7; and 29.1 for the USSR. The higher the ratio, the greater the disparity between a nation's citation of its litera-

ture and the world's citation of that nation's literature.

In this light, the USSR again stands out as a country whose literature has a restricted circulation. Of

all citations to ISI-covered USSR source items, 67 percent are from other USSR-produced source items. As usual, the United States is the second citing nation. But the United States accounts for only about 10 percent of all citations to the USSR, compared to its average of about 25 percent of all citations to the United Kingdom, the Federal Republic of Germany, Japan, and France. The reason is that the United States and all other citing nations are citing the 39 percent of the ISI-covered Soviet literature published in English. No Western nations show meaningful awareness of Russian-language Soviet research.

To a lesser extent, the same is true of Japan. From a citation perspective, Japan is more like the Western nations than the USSR. As we have seen, no Western nations cite Japan's Japanese-language source items to a significant extent. But these items amount to only 8 percent of Japan's ISI-covered literature. Its predominant English-language output is what the world cites. The data in Table 5 show high international awareness of Japan's source items: they are cited about as often as those from West Germany, France, Canada, and other leading nations.

#### SUMMARY AND CONCLUSION

The data presented here document the predominance of English as the primary language of international research. More source items are published in English by both native and nonnative speakers than any other language, and they have the highest impact. Also, most major scientific nations, regardless of their native language or languages, cite the

English-language literature almost exclusively.

In most non-English languages represented in the ISI data base, especially Japanese and Russian, the majority-share producers and consumers are the native-speaking nations. Thus barriers of varying permeability exist around all non-English languages to some extent. These barriers, however, do not prevent or diminish a balanced awareness of research from a given country. As was shown, there is good intranational citation of the world literature, and it is primarily through a nation's English-language publications that the rest of the world learns of its research.

It should be kept in mind that this analysis reflects only one portion of the spectrum of research communication—formal publication. It might be argued that research publications are the most linguistically transparent form of communication: they are high in numeric and graphic content, and their structured narrative uses a high proportion of technical terms having universal meaning. Thus unilingualism might not be a hard barrier against comprehending the gist of published research.

Unilingualism is a limitation in other, perhaps more professionally important, forms of communication, however. For example, leading-edge research is discussed in personal conversations, departmental meetings, professional conferences, and other verbal exchanges between colleagues well before it appears in print. Thus conversational fluency in more than one language remains a valuable professional asset for researchers. It is also personally enriching, enabling researchers to appreciate more deeply the expression of other nations and cultures—their art as well as their science.