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A Meta Review of HCI Literature: Citation Impact and Research Productivity Rankings

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ABSTRACT

The objective of this study is to conduct a meta-review analysis of the human-computer interaction (HCI) literature by investigating research productivity and conducting a citation analysis of individuals, institutions, and countries. The meta-analysis focuses on the three leading peer-reviewed, refereed journals in this area: International Journal of Human-Computer Interaction, Human-Computer Interaction, and Behavior and Information Technology. Results indicate that research productivity is exploding and that there are several leading authors and foundation publications that are referenced regularly.

KEYWORDS

Human-Computer Interaction, HCI, Scholarship, Meta Review, Citation Impact, Research Productivity.

INTRODUCTION

We embarked on this project to investigate the research productivity and impact of Human-Computer Interaction (HCI) scholars. As such, this study empirically investigates the two following issues: (1) research productivity and (2) research impact. The main questions are as follows:

RQ1. Research productivity
(a) What is the individual productivity ranking of HCI authors?
(b) What is the institutional productivity ranking?
(c) What is the country productivity ranking?

RQ2. Research impact
(a) What are the most frequently cited HCI publications?
(b) Who are the most frequently cited HCI authors?

methodology

In order to obtain empirical evidence to answer these research questions, we analyzed all articles published in the three leading peer-reviewed, refereed HCI journals: Behavior and Information Technology, Human Computer Interaction, and International Journal of Human Computer Interaction that was renamed to International Journal of Human Computer Studies in 1994. Although HCI articles are published in other journals, our efforts focused on these targeted publications for the following reasons. First, all these journals have at least 15 years of publication history, and they are widely recognized and read by the HCI community. Secondly, only HCI-related articles are published in these journals. Therefore, the results obtained by analyzing those publications will pertain to HCI exclusively. There are also several other journals, for example, Communications of the ACM, Information & Management, and the International Journal of Electronic Commerce, that at times present very good, interesting HCI papers. However, we found it impossible to include those journals in this study. When we attempted to analyze non-HCI exclusive journals like those mentioned earlier as well as others (e.g., Journal of the Association for Information Systems, Management Information Systems Quarterly), we found it impossible to classify articles as HCI-related or not because any discrimination by the coders introduced bias in the results.

It is for these reasons we chose to include IJHCI/IJHCS, HCI, and BIT only. Although we understand that the selection of only three journals limits the generalizability of results, it seems unlikely that a paper evaluating all, or at least most, HCI articles will emerge in the foreseeable future considering the amount of manual research effort involved (i.e., relatively newer journals are not covered by automatic citation indices such as Social Sciences Citation Index and Web of Science). Processing citation data is extremely time consuming and labor intensive

VARIABLES UTILIZED

Among the various challenges in a meta-review analysis, the most salient is the computation of per-author publication or citation credit in case of a multi-author paper (Lindsey, 1980). A review of previous research productivity studies reveals four basic approaches to assigning scores to a multi-author article: (1) straight count, (2) author position, (3) normalized page size, and (4) equal credit.

The first approach, referred to as straight count, advocates that each of the co-authors should receive a score of one regardless of the number of authors. However, the use of an absolute comparison mechanism is error-prone since it favors a publication of a person who often co-authors papers, and it understates the rating of an individual who mostly works alone (Bapna and Marsden 2002). For example, a researcher who was the third author in three independent publications would receive three credits, whereas someone who produced two sole-authored papers would only obtain two scores.

The second method argues that multi-author individual productivity ratings should be based on the original position of authorship. A formula developed by Howard et al. (1987) is used to distribute a credit in a multi-author paper. The formula favors dramatically the ratings of the first author and diminishes the rankings of the other ones. For example, the authors of a two-author article would receive the scores of 0.6 and 0.4 respectively. The authors of a four-author manuscript would receive the scores of 0.415, 0.277, 0.185, and 0.123 respectively. Despite the acceptance of this technique in psychology research (Howard and Day, 1995), we believe that it impacts negatively on multi-author publications for which names are arranged in alphabetical order. The application of this formula in the assessment of HCI research may substantially diminish cooperation in the community. Therefore, other techniques should be explored.

The third method addresses the contribution of each individual contributor more precisely by accounting for possible discrepancies in page numbers among different publications. Scott and Mitias (1996) normalize page size by allocating 1/ n pages to each of n co-authors. However, we believe that page allocation is unnecessary given the importance of quality over quantity in contemporary research and the fact that different journals have different word limits that would dictate length.

The fourth approach postulates that a per-author citation credit should be calculated by taking the inverse of the number of authors (Erkut, 2002). In this case, each co-author receives an equal credit. For example, the author of a solo publication would obtain a score of one, the authors of a two-author paper would receive the scores of 0.5 each, and the authors of a four-author manuscript would receive the scores of 0.25 per person. It is this approach that we have accepted for the purposes of this study.

Thus, the variables used in this study include author's name, institution or company affiliation, country of residence, article title, number of authors, year of publication, volume, and issue. The last two variables were collected for the sake of completeness and to avoid duplicate entries.

Another critical issue in conducting a meta-review research impact study is the calculation of an individual publication's citation impact index. Traditional meta-review studies report the total number of citations each publication has received. This number may be obtained by utilizing existing citation databases, for example, the Thomson Reuters' ISI Web of Science Social Sciences Citation Index. Although this score provides the total citation impact of each individual article, it does not account for the relative longevity of the paper. Consider, for instance, two different articles that have been published in 1995 and 2000. Both have been cited the same number of times, and, therefore, have obtained equal ranking. However, it seems logical to assume that the latter paper has been cited more frequently in any given year, and, therefore, its contribution is more significant since it has been available for less time. In order to account for the relative longevity of publications in the calculation of citation rankings, Holsapple et al. (1994) suggest the use of a normalized citation analysis in their ranking of business computing research journals. Their study argues that this approach does not penalize publications of more recent vintage, and it provides more accurate and reliable results.

CALCULATION OF INDICES

Given that the present investigation is the first attempt to assess the citation impacts of HCI scholars, we opt to report all indices that may help serve the purpose of this paper. The following indices were calculated as follows:

(1) INDIVIDUAL WORK CITATIONS

The cumulative number of citations obtained by each individual paper. To obtain this score, we manually created a database of all citations used in the target journals and counted how many times each paper was referenced. Only those papers that were explicitly cited in the body of a referencing article were counted. For that reason, we did not count 'suggested reading' sections. The maximum number of citation credits per referenced paper did not exceed one (i.e., even though a referencing paper A cited a work B three times, a score of one was still assigned to B).

(2) INDIVIDUAL AUTHOR CITATIONS

To calculate the cumulative number of citations obtained by each individual, we counted the number of papers that referenced a particular author. The total list of citations exceeded 86,787 entries.

(3) NORMALIZED CITATION IMPACT INDEX

The Normalized Citation Impact Index (NCII) considers the impact of a publication's longevity (Holsapple et al., 1994). The NCII was calculated as follows:

$$\text{NCII} = \text{(Total citations per referenced publication)} / \text{(Publication Longevity in years)}$$

Publication longevity refers to the number of years the referenced publication has been in print.

With respect to this study, the year 2010 is considered the end point of the period. For example, the NCII of an article which was published in 1998 and was cited a total of 28 times, would be calculated as follows:

NCII = 28/12= 2.333

DATA COLLECTION AND ANALYSIS

The data collection and analysis were independently performed by both authors of this study and then reconfirmed by a research associate. The following is a summary of the analytical steps that were completed in this study to determine research productivity.

RESEARCH PRODUCTIVITY

(1) LISTING

A list was created of all authors who published in at least one target journal from the first to the last available issue in 2010. The first year, last volume and last issue number for each journal were as follows: HCI (1985, 25, 1), IJHCI (1989, 26, 5) & IJHCS (1994, 68, 8), and BIT (1982, 29, 3). Editorials, book reviews, and interviews were excluded from the analysis. In total, 2,826 articles were identified and reviewed.

(2) PROOFREADING

The final list was validated by cross-checking references to identify double entries, misspelled authors' names, and inconsistent affiliations. Every possible attempt was made to identify inconsistent usage of authors' names. This inconsistent nomenclature made the automatic generation of scores unreliable. Thus, a manual revision of all names was done to solve this problem. If an author was affiliated with multiple educational institutions (e.g. Michigan State University and McMaster University), the first one listed was selected (i.e. Michigan State University). If an author was affiliated with an educational institution and with an organization in a unique publication (e.g., Michigan State University and IBM Global Services), the educational institution was selected (i.e., Michigan State University). This was done so that there was a clear attempt to make the university count as valid and reliable as possible. If an author was affiliated with two organizations in a unique paper neither of which was an educational institution (e.g., IBM Global Services and Xerox), the first-mentioned affiliation was selected. This was done to reduce double counting. Since there were only a handful of these cases, the overall findings of the paper should not have been adversely affected.

RESEARCH IMPACT

(1) LISTING

A list of all the articles and their associated citations was created from the first to the last available issue in 2010 for each of the target journals. Editorials, book reviews, and interviews were once again excluded from the analysis. A small portion of articles were unavailable in their full text, so although they appear in the article list, they could not be included in this portion of the analysis. In total, 86,787 citations were identified.

(2) PROOFREADING

The final list was validated to identify incorrect references. Incorrect or incomplete citations were discovered and corrected. For example, an author's name was misspelled, or a publication year or a title was incorrect, but these were corrected manually.

(3) COMPUTATION

The list was then run through a simple program to determine each author's points and the list of the top HCI contributors was compiled by counting the number of times each author was cited. The straight count method was used.

RESULTS

The following sections report the results of this study on both research productivity and research impact.

The results reveal that over 5,000 individual authors published over 2,800 distinct papers in the journals that we have reviewed from their inception to mid- 2010. Figure 1 shows that 25.35% of the papers were written by a single researcher, 34.83% by two co-authors, 23.20% by three individuals, and 16.62% by four or more individuals. Interestingly, these findings deviate from the results obtained by Bapna and Marsden (2002). In their study of Canadian business school research, they concluded that almost half of the journal articles published had two co-authors and only around 25% of the papers had three or more authors.

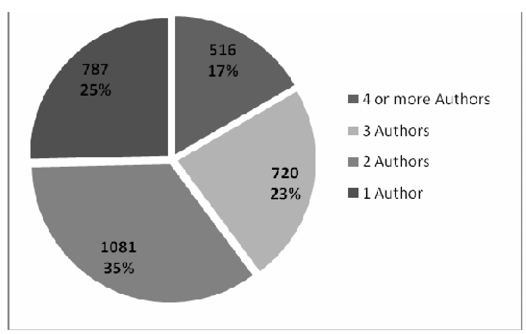

Figure 1. HCI Productivity (Articles by Number of Authors)

The list of the most productive HCI researchers is presented in Table 1. The productivity score of each contributor exceeds 6.5. The benefit of selecting this threshold is twofold. First, it produces a relatively short list of the top 10 academics and practitioners. Second, it allows new scholars to enter this list given a reasonable qualitative and quantitative input to the HCI community. It is suggested that future meta-review studies select a minimum score, which generates a list of least 100 of the most productive individuals so that incentive for new researchers continues.

Table 1. HCI Productivity by Scholar

Rank	Author	Articles	Pages	Points
1	Salvendy, Gavriel	69	1126	29.39
2	Carroll, John M.	27	440	14.33
3	Monk, Andrew F.	21	421	10.33
4	Sears, Andrew	22	365	10.15
5	Shneiderman, Ben	18	273	8.93
6	Payne, Stephen J.	16	356	8.00
7	Jacko, Julie A.	20	320	7.85
8	Murata, Atsuo	9	116	7.50
9	Stewart, Tom	7	20	7.00
10	Wiedenbeck, Susan	13	223	6.53

Table 2 provides a list of the most productive institutions. There are three measures listed: the total (normalized) score of each institution (accounting for multi-author papers), the total number of contributors, and the average individual researcher contribution score. The average individual researcher contribution score is the ratio of the total score and the number of individual contributors in a particular institution or an organization. All institutions with total score of 15 and higher are presented. The results yield three major findings. First, IBM is credited as being the leading HCI institution, and IBM's score is more than 4 times that of the next ranked non-academic institution, INRIA. Second, almost all highly productive institutions demonstrate the highest number of individual contributors, which highlights that research cooperation among colleagues is a key success factor. Last, about one-half (51%) of all articles were published by the top 25 institutions. This implies that the body of HCI research is highly diverse.

Table 2. HCI Productivity by Institution

Ranking	Institution	Country	Articles
1	IBM	International	152
2	Purdue University	USA	134
3	Carnegie Mellon University	USA	106
4	Stanford University	USA	119
5	Loughborough University of Technology	UK	58
6	University of Maryland - College Park	USA	84
7	University of York	UK	76
8	University of Wisconsin - Madison	USA	61
9	Georgia Institute of Technology	USA	90
10	University of Michigan	USA	65
11	University of Maryland - Baltimore County	USA	56
12	Virginia Tech	USA	58
13	The Open University	UK	65
14	University of Sheffield	UK	49
15	University of Toronto	Canada	44
16	National University of Singapore	Singapore	42
17	University of Amsterdam	Netherlands	52
18	University College London	UK	43
19	University of Washington	USA	61
20	Brunel University	UK	45
21	University of Nottingham	UK	47
22	Pennsylvania State University	USA	38
23	Massachusetts Institute of Technology	USA	33
24	Eindhoven University of Technology	Netherlands	44
25	INRIA	France	31

All countries whose residents published in the reviewed journals are accounted for. According to this ranking shown in Table 3, the USA and the UK are the most productive countries, having published over 50% of all the HCI articles. They are followed by Canada, Germany and the Netherlands. The top 10 countries produced almost 81% of all the research.

Table 3. HCI Productivity By Country

Rank	Country	Articles	Pages	Points
1	USA	2628	54434	1058.96
2	UK	1275	25621	539.94
3	Canada	313	6312	128.39
4	Germany	252	4425	110.12
5	Netherlands	272	5436	98.56
6	Japan	217	4094	77.43
7	France	165	3328	72.24
8	Australia	186	3732	71.73
9	Sweden	162	2426	63.94
10	Taiwan	109	1590	49.60

RESEARCH IMPACT

Recall that the purpose of the research impact investigation is to identify the most frequently cited HCI publications as well as the most frequently cited individual authors. On average, each HCI paper has 30 unique citations. Tables 4 lists the most frequently cited publications ranked by straight and normalized citations scores. Although there are several differences in these rankings, three publications stand out as the foundation pieces of the HCI field: Card, S.K., Moran, T.P., and Newell, A. (1983), Nielsen, J. (1993), and Suchman, L.A. (1987). These three citations have been very influential in the development of the HCI field.

Table 5 offers an overview of research impact of individual researchers by presenting a short list of the most frequently cited authors. The score is the number of times an author was cited. Journal articles and conference proceedings are included.

CONCLUSIONS

The meta-review of the HCI literature yielded several interesting results. First, in contrast to other research areas, almost 40% of all publications are authored by three or more scholars. It demonstrates that HCI is a relatively young field in which a single person may provide a substantial contribution, yet at the same time, as the body of knowledge and the complexity of the discipline grow, future authors may find it more difficult to embark on challenging projects alone

Table 4. Research Impact of Individual Articles

Author	Pub. Date	Title	Cit's	NCII
Card, S.K., Moran, T.P., Newell, A.	1983	The Psychology of Human–Computer Interaction: Applying Psychology to Design.	192	7.11
Nielsen, J.	1993	Usability Engineering.	124	7.29
Suchman, L.A.	1987	Plans and Situated Actions : The Problem of Human / Machine Communication.	105	4.57
Shneider man, B.	1987	Designing the User Interface: Strategies for Effective Human-Computer Interaction.	101	4.39
Davis, F.D.	1989	Perceived usefulness, perceived ease of use, and user acceptance of information technology.	93	4.43
Newell, A., Simon, H.A.	1972	Human Problem Solving.	68	1.79
Norman, D.A.	1988	The Design of Everyday Things.	68	3.09
Davis, F.D. Bagozzi, R.P. Warshaw, P.R.	1989	User acceptance of computer technology: A comparison of two theoretical models.	63	3.00
Reeves, B., Nass, C.	1996	The Media Equation: How People Treat Computers, Television, New Media like Real People and Places.	63	4.50
Norman, D.A.	1986	Cognitive engineering.	61	2.54

Table 5. Research Impact of Individual Authors

Rank	Author	Times Cited
1	Carroll, JM	677
2	Shneiderman, B	578
3	Nielsen, J	519
4	Norman, DA	492
5	Card, SK	487
6	Newell, A	487
7	Simon, HA	439
8	Moran, TP	391
9	Anderson, JR	357
10	Davis, FD	322

Secondly, in many universities and organizations, there is a single person who leads the HCI program, and he or she accounts for a substantial number of all publications produced by this institution. Usually, this person writes solo papers and co-authors articles with colleagues, research associates, and students. However, there are also many cases in which there are very few members of an institution who contribute to research in the HCI field. Hiroshima City University is the highest ranking institution with a single contributor, and it is ranked at 69th because of the research of Atsuo Murata. Murata is among many individuals standing behind various research initiatives in their respective universities. We hope that those individuals, if they have not already, seek opportunities for collaboration both in and outside of their institutions. This will dramatically increase the research outputs of their universities.

Given that this study is the first of its kind in the HCI field, it does have several limitations. First, since automated citation indices do not cover the target journals, data collection and analysis was done manually by using built-in spreadsheet functions and macros. Although we have made every possible attempt to avoid mistakes and omissions, a small probability of an error cannot be completely eliminated. Secondly, although every attempt was made to retrieve the bibliographic information from each article, some small portion of articles' work cited lists were unobtainable and could not be included in the analysis. This too introduced a small probability of error.

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