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Scientometric portraits of recognized scientists: a structured literature review

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Abstract

The purpose of scientometric portraits is to recognize prominent scholars, inspire others, and guide those who dedicate their lives to scientific advancement. This study presents the results of a structured literature review of 110 publications that developed scientometric portraits of 91 recognized scientists. Findings indicate that scientometric portraits are a growing topic in library & information science, scientometrics, and discipline-specific venues. Since 2010, the number of publications devoted to creating scientometric portraits has been growing steadily, reaching approximately seven works per year by 2019. 139 authors of scientometric portrait papers roughly fall into two categories of researchers: the majority, who have only contributed once, and a smaller group who have written many portraits and frequently cooperated with others. 65% of all scholars described in the portraits are Indian nationals. This reveals a great interest among Indian scholars in promoting domestic research. We recommend that authors of future scientometric portraits publish their work in discipline-specific outlets as such venues may better reach their target audience, focus on underrepresented disciplines, and recognize women scientists. They should also conduct a more comprehensive literature review to integrate previous findings and inform the study's research methods to discover relevant variables, measures, metrics, and analysis techniques. Producing a scientometric portrait paper should not be considered a bibliometric exercise: the authors should put themselves in place of their readers—for instance, graduate students, academics, and policymakers—and find ways to inform and inspire them. This study also presents an archetype of scholars memorialized in scientometric portraits.

Keywords Scientometric portrait · Bibliometric portrait · Bio-bibliometrics · Structured literature review · Scholarship

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Introduction and purpose of the study

The human brain has evolved to intrinsically reward people for novelty-seeking, experimentation, discovery, and exploring the unknown (Báez-Mendoza & Schultz, 2013; Schultz, 2015). Consequently, throughout the entire history of our civilization, people have persistently engaged in various forms of scientific endeavors to improve the quality of their lives and to meet their natural curiosity. The oldest surviving records documenting formal scientific practices date back several millennia. For example, the development of recorded scholarly divination commenced in Babylonia in the 1600s BC (Rochberg, 2018). Mathematical texts originated in Egypt between 2055 and 1650 BC (Imhausen, 2018), and an ancient Egyptian medical text that describes various surgical procedures, commonly referred to as the Edwin Smith Papyrus, was written in 1550 BC (Nunn, 2018). Since those times, millions of men and women have dedicated their lives to ensuring the sustained success of scientific progress.

Presently, at least 7.8 million individuals worldwide may be formally classified as scientists (Soete et al., 2016). Yet despite this hive of activity, the scientometric measures of productivity and citation impact appear highly skewed to a small number of queen bees (Albarrán & Ruiz-Castillo, 2011; Ruiz-Castillo & Costas, 2014, 2018; Seglen, 1992). That is, scientific progress seems to emanate from a small group of scholars referred to as "the scientific elite" (Parker et al., 2010, 2013; Zuckerman, 1977) or "the skewed few" (Macdonald, 2011). As Kelchtermans and Veugelers (2011) state, there is a "great divide in scientific productivity" and "the average scientist does not exist" (p. 295). Overall, many scientometric studies conclude that a small cluster of researchers produces a disproportionate number of works and attracts a large share of citations. Thus, it is critical to understand the personal characteristics of highly productive and influential scholars to recognize them formally, inspire their contemporaries, and guide future generations of researchers.

Over a century ago, Cattell (1910) argued in favor of the "application of scientific methods to the advancement of science" (p. 634) to understand the nature, motivation, and work preferences of the "scientific men." As a result, two general research streams have appeared. The goal of the first research direction is to understand the personal characteristics of an "outlier" scholar by analyzing a large sample of highly successful and influential scientists. Attributes explored in such studies include everything from demographic factors and academic training to motivation, work history, career mobility, work habits, collaboration patterns, and methodological preferences. For example, these studies report that many highly productive and influential academics are most prolific between 31 and 35 years of age (Falagas et al., 2008). They are somewhat opportunistic, possess a high degree of intellectual curiosity, tend to challenge the status quo, frequently question assumptions, and recognize the value of serendipity (Serenko & Dumay, 2017). The key characteristic of the line of research above is that such studies attempt to reach generalizable conclusions by analyzing the experiences and characteristics of multiple "research stars"—the goal being to help a new generation of scholars navigate the elaborate maze of the "prestige economy" so as to achieve "academic excellence."

The purpose of the second line of inquiry is slightly different. Instead of developing explicit recommendations on building a successful academic career by analyzing a sample of research stars, this second group of studies creates a scientometric portrait of one highly productive and influential researcher. This research describes this individual's significant achievements along with his or her career paths, collaboration preferences, methodological approaches, scholarly influences, contribution to the education of future scholars, etc.

Scientometric portraits are different from posthumous tributes and festschrifts because tributes and festschrifts represent a narrative summary of one's personal and professional life journey without any analysis (e.g., see Matsson et al., 2021; Palvia et al., 2020; Pouchard, 2020). By contrast, scientometric portrait projects are studies that employ generally accepted scientometric or bibliometric methods. These projects develop a comprehensive profile of someone's scholarly output, influence, and legacy to recognize their contribution and inspire and direct others. Scientometric portraits extend their analysis beyond a basic narrative description and a pictorial history and can be undertaken both antemortem and postmortem.

The term scientometric portrait was coined by Kalyane and Kalyane (1993) who showed that the "list of publications of a successful scientist can be analyzed scientometrically and it can throw light on the history of science, scientific development, interactions in the research group, organization of a research system and quality of scientific leadership" (p. 32). Kalyane and Devarai (1994) and Kalyane and Samanta (1995) proposed the term informetrics to emphasize the quantitative aspect of analyzing one's academic achievements, and Sen and Gan (1990) recommended the term bio-bibliometrics to describe "the application of bibliometric concepts and methods to analyzing biobibliographic data" (p.14). However, the terms informetrics and bio-bibliometrics did not gain momentum in this particular context.

The value of works presenting scientometric portraits of eminent scholars is three-fold. First, they acknowledge the intellectual contribution of successful academics and pay homage to those who have made a remarkable contribution to the progress of science. Scientometric portraits represent an independent, prestigious endorsement of one's academic lifetime achievements. Second, scientometric portraits inspire other scholars, especially those at the earlier stages of their careers. Of the various intrinsic and extrinsic factors motivating researchers (e.g., see Lechuga & Lechuga, 2012), the most salient pertains to a desire to be recognized by the scientific community (Gustin, 1973). Scientometric portraits are extrinsic encouragement that shows how one's research contribution can be formally memorialized and preserved for future scholars. Third, scientometric portraits present an image of a role model and a path traveled, allowing others to finetune their careers in a desirable direction.

Thus, due to the three primary functions discussed above—endorsing, inspiring, and mentoring—scientometric portraits have become an integral part of the scientific literature. On the one hand, the corpus of literature on scientometric portraits has been steadily growing. On the other hand, many studies are conducted in relative isolation. They rarely follow a cumulative research tradition when subsequent works rely on the body of knowledge created earlier. For instance, a brief analysis of several latest scientometric portrait papers revealed a lack of common vocabulary, definitions, methodology, and narrative approaches. A visual inspection of these papers' bibliographies showed that citations to previous scientometric portraits are an exception, confirming the observation above. Therefore, the scientific community may benefit from having a guide at their disposal with which to develop scientometric portraits. Equipped with such knowledge, the future authors of scientometric portraits may enhance their research practices, boost their creativity, improve the previous methodologies, and extend the key strengths of the previous lines of research. In addition, readers may benefit from knowing what constitutes a successful scholar. However, developing such an archetype cannot be achieved through a scientometric portrait of a single scholar. Many successful scholars must be analyzed, whether this be in one study or analyzing numerous scientometric portraits published in multiple journals.

The knowledge gaps above may be filled by conducting a structured literature review of previous scientometric portraits. A structured literature review is a "method for studying a corpus of scholarly literature, to develop insights, critical reflections, future research paths and research questions" (Massaro et al., 2016a, p. 767), which has become a popular methodological approach in various research areas (Dumay et al., 2016; Grimaldi & Cricelli, 2020; Linnenluecke et al., 2020; Paoloni et al., 2020). Using this method, researchers follow a pre-specified yet flexible series of steps to identify and analyze many works within a particular research domain. Structured literature reviews have many advantages over traditional literature reviews, meta-analyses, and research syntheses (Massaro et al., 2015, 2016a, 2016b). Most importantly, they rely on a formalized and well-documented approach that reduces subjectivity on the part of the researcher. For example, findings can be presented using quantitative measures to reduce the subjectivity inherent in a traditional literary analysis. Structured literature reviews also allow for deeper and broader reviews of the literature, and using this method does not require comprehensive a priori knowledge of the phenomenon of interest. Additionally, the technique is transparent and replicable. Last, researchers can ensure coding reliability by including multiple coders. The following section describes this study's structured literature review protocol in detail.

Methods

The structured literature review protocol follows the recommendations of Massaro et al., (2016a, 2016b). All types of scholarly publications that developed scientometric portraits of prominent scholars were included in the sample. Posthumous tributes and festschrifts were excluded. Articles were collected by following the five-step procedure outlined below.

Step 1 Keyword search. A search of Google Scholar, Web of Science, ScienceDirect, ProQuest, and JSTOR databases using multiple keywords (scientometric portrait, bibliometric portrait, scientometric profile, bibliometric profile, bio-bibliometric profile, scientist portrait, scientist profile, academic profile, academic portrait, scholarly profile, scholarly portrait, productive scientist, productive academic, productive researcher, influential scholar, elite researcher, etc.). In Google Scholar, a search was done on full text, while in the other databases, a search was done on the title, abstract, and keywords. No timespan was specified.

Step 2 Analysis of bibliographies. In all papers found, bibliographies were reviewed to discover additional relevant papers.

Step 3 Analysis of citing works. Google Scholar citations to all works identified earlier were reviewed to find additional relevant papers.

Step 4 Keywords update. Additional keywords that were identified in the newly discovered papers were added to the list of keywords.

Step 5 Repeat. Step 1 was repeated using the new keywords, followed by Steps 2-4 until no new papers or keywords were found.

Two authors of this paper performed the search, which was finalized on January 1st, 2020 and resulted in 110 relevant papers. Each author independently examined the full text of each paper to confirm its relevance, and the verdicts were compared. Each identified work was then read and analyzed by two coders. A codebook was developed during the coding process and updated as the analysis progressed. Each code pertained to two general

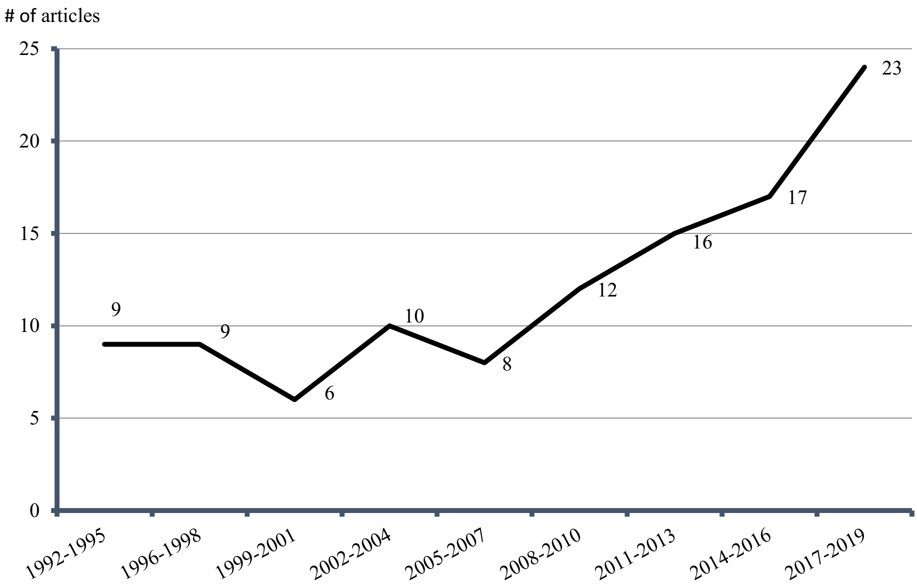

Fig. 1 The number of scientometric portraits published

categories: (1) the attributes of works' content to compile a list of items that are mentioned in these works; and (2) the characteristics of individuals described in these works. All discrepancies in the codes were discussed and resolved by the coders to ensure reliability. The authors also relied on secondary information sources by means of archival research to determine scientists' attributes that were omitted in the coded papers (e.g., gender, nationality).

Findings

The findings are presented in two sub-sections. The first focuses on the content of the portraits or, in other words, the attributes of the studies. The second identifies the personal and professional characteristics of the researchers described in the portraits, i.e., the attributes of the recognized scholars.

Attributes of the publications

Overview

Within the sample, 139 researchers produced 110 papers devoted to scientometric portraits of 91 prominent scientists. Figure 1 reveals that, since 2010, the number of scientometric portraits has been growing, reaching approximately seven works per year by 2019.

A vast majority of papers present a scientometric portrait of a single scholar and only a few describe portraits of multiple individuals in a single publication. Eleven people have had multiple scientometric portraits written about them. For instance, Chandrasekhara Venkata Raman, the winner of the 1930 Nobel Prize in Physics, and Rabindranath Tagore,

Table 1 The number of scientometric portrait works per author

Number of authors	Number of each author's contributions
1	34
1	20
1	14
1	10
1	6
3	5
2	4
6	3
8	2
115	1

a poet, writer, composer, philosopher, and painter, each boast four portraits. Surprisingly, only two papers have been written about Eugene Garfield. Many portraits describe all types of publications, while some only consider journal articles (Mukherjee, 2013) or books (Koley & Sen, 2015). Further, 56% of the portraits were published during the lifetime of the scientist described in the paper, confirming that scientometric portraits differ from tributes, which are usually done only posthumously.

Authors of scientometric portraits

In terms of the number of authors: 18% of all papers were written by one author; 50%, by two; 22%, by three; and 10%, by four or more authors. 82% of papers were multi-authored. Two categories of authors also emerged: the vast majority (83%) who wrote one portrait versus a small minority who have turned the crafting of scientometric portraits into a long-term academic career (see Table 1). It is possible that researchers in the former group wrote their portrait to acknowledge the contribution of a particular individual, for instance, a mentor, a collaborator, or someone who spearheaded their chosen discipline, while those from the latter category became very interested in the development of scientometric portraits. In addition, almost all authors from the latter group cooperated with one another on multiple projects. For instance, V.L. Kalyane, B.S. Kademani, B.K. Sen, and V. Kumar contributed to 34, 20, 14, and 10 publications, respectively, by frequently collaborating with one another on multiple studies. Thus, a sizable proportion of all works was produced by a small cluster of interconnected authors. In several cases, the same group of researchers published two scientometric portrait works devoted to the same person by focusing on the different aspects of his or her scientific contribution or using different data sources (e.g., see Manjunath & Ramesha, 2015a, 2015b). Two of the highly productive authors (V.L. Kalyane and B.K. Sen) had scientometric portrait publications devoted to them to honour their outstanding scientific accomplishments (see Dutta, 2019; Koley & Sen, 2016).

Venues publishing scientometric portraits

Table 2 demonstrates the breadth of the distribution of scientometric portrait publications: 110 works appeared in 61 unique outlets. Of these, only 13 have published

Table 2 Outlets publishing scientometric portrait works

Title	Number of works
Annals of Library and Information Studies	16
Malaysian Journal of Library & Information Science	9
Scientometrics	7
Library Philosophy and Practice (e-journal)	6
SRELS Journal of Information Management	5
International Journal of Library and Information Studies	4
DESIDOC Journal of Library & Information Technology	3
Indian Journal of Information, Library and Society	2
International Journal of Scientometrics and Informetrics	2
Journal of Information Sciences	2
Journal of Library, Information and Communication Technology	2
Kelpro Bulletin	2
Scientific Information Resource Division, Knowledge Management Group, Bhabha Atomic Research Centre	2
Other (48)	1

multiple portraits. A vast majority of journals pertain to the domains of library & information science and scientometrics. There are also a number of specialized journals from information systems (e.g., *European Journal of Information Systems*), various branches of sciences (e.g., *Journal of Solid State Chemistry*, *International Journal of Current Research in Life Sciences*), education (e.g., *Biology Education*, *Journal of Curriculum Studies*), etc. It is worth noting that *Scientometrics* published its last scientometric portrait in 2009 (see Prakasan et al., 2009), and no such papers have ever appeared in the *Journal of the Association for Information Science and Technology*.

The quality of literature reviews, methods, and implications

Conducting a literature review was an exception as 86% of the papers did not have one. In the remaining 14%, most literature reviews merely introduced and defined the concept of scientometrics or bibliometrics, listed a few previous studies, justified the need for their study, or briefly explained the key metrics used in portrait development (e.g., the *h*-index). Only a tiny number situated their works in prior literature by discussing and extending previous scientometric portrait publications. 84% described the methodology employed in the development of a scientometric portrait but, in most cases, the methods section was limited to a brief note that described the data sources that were used to identify the authors' publications and their corresponding citations, explained the calculation of metrics and indices, and outlined the major analysis steps. Overall, having comprehensive literature review and methodology sections was an exception (for exemplars, see Ahirwal and Pathak (2015) and El Aichouchi and Gorry (2018)). The importance of including such sections is further explained in the Discussion section.

Only 6% of the papers offered implications of the key findings and made recommendations for academic or practitioner stakeholders. The rest of the papers merely presented the results, often in long and difficult-to-read tables, stated several facts, and left it up to the reader to summarize the results and to derive actionable items.

A bibliographical sketch

Some studies documented the scientists' life journey as a brief bibliographical sketch by going back as far as the scholars' childhood, including their place of birth (55%), their date of birth (52%), their parents (9%), and their place of upbringing (6%). Surprisingly, only 50% provided details on their doctoral education, such as their PhD alma mater, and a mere 10% mentioned the name of their doctoral supervisors. 38%, 32%, and 11% discussed their master's, undergraduate, and secondary education. Slightly over half covered the scientists' academic work experience—memberships in academic bodies and associations (28%) and editorial and peer-review responsibilities (13%). 31% discussed their industry engagement. Leisure activities, such as travel (26%) and hobbies (3%), were occasionally used to portray the personal side of the scholar's life, but such statements were generally very brief.

Research output, impact, and awards

As expected, all publications covered the scientists' research output. Almost all works (94%) mentioned the number of publications. Many categories of publications were mentioned; namely, journal articles (71%), books (44%), and other publications (56%), which included conference papers, book chapters, letters, book reviews, research notes, monographs, mathematical reports, editorials, meeting abstracts, newsletter articles, technical notes, technical reports, biographies, symposium articles, festschrifts, philosophy reports, speeches, encyclopedia entries, abstracts, information bulletins, and translations. The sheer number of these categories shows the breadth of the publication history of these scientists. A few studies focused on paintings and drawings (Ray & Sen, 2019), songs (Ray & Sen, 2012), and screenplays (Ray, 2018) rather than on conventional scientific publications. 58% of the studies analyzed researchers' productivity over their age. 69% of the studies analyzed knowledge dissemination channels. 74% reported the results of a longitudinal analysis of scientists' contributions. 63% discussed in detail the domains of expertise and preferred topics of investigation. Many undertook a formal analysis of the keywords used in their publications.

Another aspect often included in the scientometric portraits were author impact metrics. 48% of all studies investigated researchers' impact, predominately measured as an overall citation count. 30% performed longitudinal citation impact analysis, and some focused on domain-wise impact and the use of self-citations. 23% reported the scholars' *h*-index, 7%—the *g*-index, and 7%—another index from the *h*-index family (e.g., the *hc*-index, the i10-Index). A small number of papers discussed the practical impact of one's scientific contributions on non-academic stakeholders, such as individuals, businesses, and society. Even though it was evident that most scientists received awards, medals, and formal recognitions during their academic careers, only 59% of the papers explicitly mentioned this fact. A few studies mentioned honorary doctoral degrees. No papers made use of altmetric indicators.

Collaboration practices and authorship distribution

74% of all papers discussed researchers' collaboration practices based on their research output. The most frequently used quantitative measures were the collaborative index and the degree of collaboration. 71% listed the names of research collaborators; 59% reported collaboration patterns, rates, and coefficients; and 6% covered the geographic distribution of collaborators. 79% analyzed authorship distribution patterns (e.g., single vs. multi-authored works and author order).

Contribution to teaching and the training of future researchers

Scientists' contribution to teaching and the training of future researchers received minimal attention. Only 17% mentioned doctoral student supervision, and only 10% mentioned courses taught. Of those that mentioned doctoral student supervision, only one discussed the students' subsequent careers (Truex et al., 2011). Another listed the students' names and their dissertation titles (Swain, 2009). Works that covered teaching mentioned course titles without offering much detail.

Analysis of recognized scientists described in scientometric portraits

Gender, nationality, and country of residence

Of the 91 scientists described in scientometric portraits, only three were women. 65% were Indian nationals, followed by citizens of the USA (14%) and the UK (6%). Seven people held dual citizenship with the USA and Germany/Egypt/Israel/India/the UK. There were also citizens of European countries (France, Spain, Romania, Italy, and Denmark), and a few were from Asia (Pakistan and Malaysia) and Africa (Zambia, Tanzania, and Kenya). In terms of their present or last country of residence, 40 researchers resided in India; 19, in the USA; 4, in the UK; 3, in Pakistan; 2, in Canada, France, and Malaysia; and the rest in various, mostly European, countries.

Education and affiliation

Table 3 lists the top undergraduate and doctoral degree alma maters of the scientists. According to the 2021 QS World University Rankings,[1] on average, undergraduate institutions were ranked 422, and graduate institutions were ranked 242. Table 4 further outlines the countries in which researchers obtained their undergraduate and doctoral degrees. India was identified as a leading country, followed by the UK and the USA. Interestingly, around one-third of them completed their doctorate in a country different from where they obtained their undergraduate degree, which shows a high degree of mobility.

With respect to their last or present institution, 5 were affiliated with the Indian Institute of Science (India) and 2 with California Institute of Technology (USA), University of Cambridge (UK), University of Chicago (USA), University of Karachi (Pakistan), University of Malaya (Malaysia), University of Wisconsin-Madison (USA), and Visva-Bharati

[1] See https://www.topuniversities.com/university-rankings/world-university-rankings/2021. Only institutions that received QS ranking scores were included in the analysis.

Table 3 Top alma maters

Institution	Number of alumni
Undergraduate Degree Alma Maters	
University of Madras (India)	5
University of Cambridge (UK)	4
Mysore University (India)	3
University of Calcutta (India)	3
Banaras Hindu University (India)	2
Madurai Kamaraj University (India)	2
Presidency University (India)	2
University of Kerala (India)	2
University of the Punjab (Pakistan)	2
Doctoral Degree Alma Maters	
University of Cambridge (UK)	8
University of Madras (India)	4
Indian Agricultural Research Institute (India)	2
Karnatak University (India)	2
Ludwig Maximilian University of Munich (Germany)	2
Madurai Kamaraj University (India)	2
Mumbai University (India)	2
University of Pennsylvania (USA)	2
University of the Punjab (Pakistan)	2

Table 4 The top countries of undergraduate and doctoral degrees

Undergraduate degree		Doctoral degree	
Country	Number of alumni	Country	Number of alumni
India	35	India	25
UK	11	UK	15
USA	8	USA	15
Pakistan	3	France	3
Israel	2	Germany	3
		Canada	2
		Israel	2

University (India). On average, these institutions were ranked 307 in the 2021 QS World University Rankings. Twelve people were affiliated with non-degree-granting (i.e., non-educational) scientific institutions.

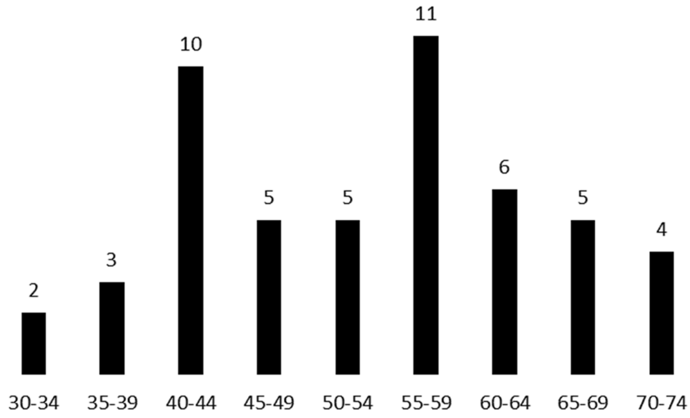

Fig. 2 Productivity peaks: The age at which scholars were most productive. The bar labels represent the number of scholars most productive at this age. Note that the total does not add to 91 because not all studies analyzed researchers' productivity over their age

Table 5 Scientists' work and collaboration patterns—description

Factor	Rare collaborators	Moderate collaborators	High collaborators	Extreme collaborators
% of single-authored works	100.0–85.0	84.9–50.0	49.9–15.0	14.9–0.0
% of all scientists	6.8	19.3	40.9	33.0
Avg. # of collaborators	25	42	91	270
Avg. % of first authorship in collaborative works	41.0	71.3	39.1	24.1
Avg. # of total publications	473 (130 after removing 1 outlier)	266	275	385

Areas of expertise

More than half of these scholars worked in the field of natural sciences (biology, physics, chemistry), followed by formal sciences (computer science, mathematics), applied sciences (medicine/health, engineering/technology), social sciences (economics, geography, sociology), and humanities (history, arts, philosophy, language/literature). Other fields (e.g., education, management, and space sciences) were underrepresented.

Table 6 Scientists' work and collaboration patterns—Spearman's rank-order correlations

	# of collaborators	% of single-authored works	% of first authorship in collaborative works
% of single-authored works	− 0.60 ($p < 0.0005$)		
% of first authorship in collaborative works	− 0.32 ($p < 0.1$)	0.50 ($p < 0.005$)	
# of total publications	0.26 ($p < 0.05$)	− 0.06 (n.s.)	0.14 (n.s.)

Research productivity, student supervision, and awards

On average, these scientists produced 285 publications in total. Four scholars produced more than 1,000 publications, with the highest number exceeding 2,000 individual works. The most popular publications were journal articles (mean = 199) followed by books (mean = 24). In some cases, scientists' works appeared posthumously.

Figure 2 shows the age distribution of the productivity peaks of researchers over their age (of those who had only one productivity peak). It shows that scientists were especially productive when they were 40–44 and 55–59 years of age. 13 individuals had two productivity peaks.

On average, researchers who engaged in doctoral student supervision supervised 31 doctoral students, ranging from 3 to 95. Sixteen were Nobel Prize winners.

Collaboration patterns

Table 5 presents scientists' collaboration patterns. Four groups of collaboration patterns emerged: rare, moderate, high, and extreme collaborators, which leads to several conclusions. First, most scientists predominately engage in joint research projects and have a high number of research collaborators. Rare collaborators represent a small percentage of all scholars, and they tend to have few research partners, 25 on average. In contrast, extreme collaborators have more than ten times more collaborators. Second, moderate collaborators receive the first authorship twice as often as the other types of collaborators. Extreme collaborators are listed as first authors rarely, in only 24% of their works. Third, collaboration leads to higher research output in terms of the number of publications. However, a visual inspection of the data shows that there are occasional outliers that defy this rule. For example, Eugene Garfield published 1,501 works but had only 4% of collaborative contributions (Sangam & Savanur, 2010).

By contrast, S.S. Kubakaddi collaborated in 95% of all research projects but produced only 85 publications (Keshava et al., 2010). Table 6, which shows Spearman's Rank-Order Correlations between scientists' work and collaboration patterns, supports the above observations. Thus, collaborative authors tend to publish more works but receive first authorship less often.

Discussion

Recommendations for the authors of scientometric portrait papers

First, scientometric portraits have become a recognized line of research appearing in various academic journals. Since 2010, the volume of such publications has steadily grown. Thus, the development of scientometric portraits represents a fruitful future research opportunity. Similarly, Serenko (2013, 2021) conducted a structured literature review of scientometric research of the knowledge management discipline and concluded that the volume of scientometric publications in that domain is continuously growing.

Second, while library & information science and scientometrics venues have attracted the most publications, other discipline-specific journals also occasionally welcome these works. Library & information science and scientometrics outlets are highly appropriate journals for such works. However, they may not reach the target audience within the area of expertise of a scholar described in the publication. For instance, a scientometric portrait of a management information systems scholar that gets published in an information systems outlet (e.g., *Communications of the Association for Information Systems*) would likely reach more information systems stakeholders than the one that appears in a non-domain specific outlet. Such papers, however, are unorthodox and should be handled differently by the editorial team, and the authors are advised to describe this in a cover letter accompanying their manuscripts. To overcome possible scepticism on the part of journal editors, the authors should clearly emphasize the value of their perspective publication for the broad discipline's community. Editorial teams should also realize the value and contribution of scientometric portrait publications and assist authors during the review process.

Third, a majority of scientometric portraits are devoted to individuals working in the fields of biology, physics, chemistry, computer science, mathematics, medicine, and technology. Some domains, however, are dramatically underrepresented, and this offers excellent future research opportunities. Thus, future scholars are recommended to find their own "blue ocean" with untapped research potential.

Fourth, only three out of 91 individuals described in scientometric portraits were women. While investigating the reason for this disparity is beyond the scope of this study, it clearly shows the existence of a gender gap in recognition of scholarly research accomplishments. Future scientometric portrait authors are strongly recommended to keep this issue in mind. In a similar vein, Silver et al. (2018) also report that women physicians have been almost ignored in recognition awards given by the Association of Academic Physiatrists.

Fifth, recall that 65% of all scholars were Indian nationals. Also, India was a leading country where many recognized researchers obtained their undergraduate and graduate degrees. The focus on India does not suggest that India is a top country regarding the number of recognized scholars. However, it reveals a great interest among Indian scholars in promoting research on the national level. This observation is consistent with India's commitment to supporting national research and improving its international scientific rankings (Smith et al., 2014). At the same time, future researchers are recommended to develop the scientometric portraits of scholars from underrepresented countries.

Sixth, the development of scientometric portraits is a data analysis-intensive process that requires multiple coders to double-check and verify all numbers and calculations. It is for this reason, 82% of all works analyzed in this study were multi-authored. An ideal research team should include members with the knowledge of scientometrics and those with expertise in the domain of the person described in the scientific portrait.

Seventh, most authors of scientometric portrait papers either skip the literature review entirely or limit their review to a shallow discussion of a small number of previous scientometric portraits. On the one hand, scientometric portraits clearly represent a distinct category of publications where including a comprehensive literature review is not warranted. On the other hand, literature reviews may be fruitfully employed in scientometric portraits to integrate and generalize previous findings, for instance, to compare recognized scientists with one another. They can also be used to uncover the strengths and limitations of previous studies and justify the significance of this line of publications. For instance, the purpose of a literature review may be to understand other successful scholars' personal and professional characteristics to compare them with those reported in the study. A good literature review may also inform the study's research methods to discover relevant variables, measures, metrics, and analysis techniques. In this regard, Cooper's (1988) taxonomy of literature reviews represents an excellent starting point (for a detailed guide, consult Randolph, 2009). As is often the case in scientometric papers, instead of creating a dedicated Literature Review section, a literature review may be incorporated as a part of the Introduction section.

Eighth, measuring research impact predominantly relies on various citation-based measures. Since the advent of the first academic journals, citations have become an integral part of scientific communication (Cronin, 1984). They are "a structurally embedded component of the primary communication process" (Cronin, 1998, p. 49). In contemporary scientific communication, citations serve many critical functions, including giving credit to previous scholars for their scientific contribution (Garfield, 1965). Thus, it seems logical that scientometric portrait developers should follow this practice and rely on several citation-based measures to acknowledge one's scientific impact. At the bare minimum, they are recommended to report a scientist's *h*-index and/or another index from the *h*-index family. Regrettably, only a small fraction of all examined papers followed this practice. At the same time, future researchers should keep in mind that citation-based measures are imperfect. Even popular indexes such as the *h*-index have limitations (Ding et al., 2020; Zhu et al., 2015).

Ninth, research output, impact, and collaboration practices generally receive at least some coverage because these represent the key attributes of a scientometric portrait. At the same time, other important items are often omitted, such as contributions to teaching and industry engagement. In addition, only half of all papers offered detail on scientists' doctoral education, and only 10% mentioned their doctoral supervisors. This is regrettable since it is equally important to honor those who contributed to the education of highly successful scholars. While such information may not be included in one's resume or Google Scholar profile, authors are recommended to contact their respective scholars or their family members and colleagues directly and use all publicly available information sources.

Tenth, producing a scientometric portrait paper should not be considered a bibliometric exercise. Recall that only a small fraction of the analyzed papers developed practical and actionable implications for academic and/or practitioner stakeholders while most only documented their findings and left them open to interpretation which places a high cognitive load on the readers and leaves them disappointed. Making conclusions and recommendations based on the findings is a key attribute in scholarly communication, and scientometric portrait papers should be no exception. Therefore, the authors should put themselves in place of the readers—for instance, graduate

Table 7 A guide for the development of scientometric portraits

- A bibliographical sketch
  - Early life
    - Date of birth, place of birth, place of upbringing
    - Family
    - Secondary education
  - Education
    - Undergraduate degree(s)
    - Graduate (master's and doctoral) degree(s)
      - Alma mater(s)
      - Concentrations and research topics
      - Supervisors, advisors, role models, and influencers
  - Work experience
    - Academic
      - Places of work
      - Memberships in academic bodies and associations
      - Editorial and peer-review responsibilities
    - Industry engagement
  - Leisure activities
    - Travel, hobbies
- Research output
  - Types of works published
    - Journal articles, conference papers, book chapters, letters, book reviews, research notes, monographs, mathematical reports, editorials, meeting abstracts, newsletter articles, technical notes, technical reports, biographies, symposium articles, festschrifts, philosophy reports, speeches, encyclopedia entries, abstracts, information bulletins, translations, etc
    - Other creative works
      - Paintings, drawings, screenplays, songs, etc.
  - Number of publications
    - Longitudinal analysis of productivity
    - Productivity over age
  - Knowledge dissemination channels
    - Journals, publishers, conferences, etc.
  - Expertise domains
    - Spheres of influence
    - Preferred topics
    - Keywords
- Research impact
  - Impact on scholarship
    - Citation impact
      - The *h*-index, *g*-index, and their extensions (e.g., *hc*-index, i10-Index)
      - Longitudinal citation analysis
      - The use of self-citations
    - Domain-wise impact
  - Impact on practice
    - Individuals, organizations, and society (e.g., policymaking)

Table 7 (continued)

Altmetric indicators
Collaboration practices
Quantitative measures
The collaborative index, the degree of collaboration, etc.
Major research collaborators
Names, geographic locations, affiliations, nature of relationship
Authorship patterns
Single vs. multi-authored works
Order of authorship
Longitudinal analysis of collaboration practices
Contribution to teaching
Courses taught/developed
Graduate student supervision
Names, dissertation titles/topics, careers
Awards
Prizes, medals, honorary degrees, recognitions, etc.

students, young academics, and policymakers—and find ways to inform and inspire them. As Wagner et al. (2021) demonstrate, extending a study's contribution beyond a mere description of the findings may dramatically increase its future scientific value.

Eleventh, none of the scientometric portrait papers reported altmetric indicators. Altmetrics keep track of various online sources—e.g., social networks, electronic media, public policy documents, Wikipedia, etc.—that mention a scholarly publication and use an algorithm to calculate its score (Priem et al., 2010). Despite the shortcomings of altmetrics (e.g., see Gumpenberger et al., 2016), they may become an indispensable addition to future scientometric portraits by depicting the visibility and reach of a contemporary scientist and providing a new perspective on one's contribution to society at large.

Last, Table 7 presents a list of items to guide scientometric portrait developers. While this list is not exhaustive and researchers are encouraged to use their creativity to add more items, it may serve as a good starting point.

An archetype of scholars memorialized in scientometric portraits

Many of these scholars received their undergraduate degrees from reputable universities (having an average QS ranking of 422). Later, they pursued their doctoral studies in even more prestigious universities (having an average QS ranking of 242). However, completing an undergraduate and/or a doctoral degree at the world's most prestigious universities is not a must to achieve an outstanding scholarly reputation because some individuals attended 1000+ranked universities and even non-ranked ones. They are frequently highly mobile and often move to a new country to complete a doctoral degree. At the peak or dawn of their careers, most worked in high-quality educational institutions (ranked 307, on average). At the same time, they also occasionally chose research-only, non-teaching careers.

These scholars are true academic outliers who exhibit extraordinary research productivity producing 285 lifetime publications, on average, by primarily focusing on journal articles and books, with their productivity often peaking from 40 to 44 and from 55 to 59 years of age. They engage in the training of future researchers and receive various awards, including the prestigious Nobel Prize. These researchers may be rare, moderate, high, and extreme collaborators. Generally, collaboration is positively related to their scholarly productivity, yet there are vivid exceptions to this rule: some scholars are rare collaborators yet are highly productive, while some are extreme collaborators yet have fewer publications. Collaborative scholars tend to engage in multiple projects in advising, guiding roles and, therefore, receive first authorship on a paper less often.

Conclusion

The purpose of scientometric portraits is to recognize prominent scholars, inspire their followers, and guide those who decide to dedicate their lives to advancing the state of scholarship. This study shows that scientometric portraits have become a growing, recognized topic that frequently appears in various academic venues. Such portraits are published in library & information science, scientometrics, and discipline-specific venues. Analysis of the content of 110 scientometric portraits facilitated the development of a list of general guidelines that can be employed in future studies. We suggest that the proposed guidelines be considered a starting point rather than a rigid set of items that must be included in every scientometric portrait. While the archetype of a renowned scholar constructed in this study is far from complete, we believe that it accurately reflects the effort of outlier academics who have made a tremendous impact on scientific progress.

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Declarations

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