Scientometric Analysis of Cognitive Neuroscience Research Literature: 2006-2015

Sandhya Dwivedi

Department of Library & Information Sciences

Banaras Hindu University, Varanasi

sandhpandey79@gmail.com

ABSTRACT

The aim of this study is to analyze cognitive neuroscience research output from year 2006-2015 by using various statistical methods and scientometric tools such as growth rate, transformative activity index, relative citation impact, citation per paper. Data for this study retrieved from SCI-Expanded for the year 2006-2015. A total 6012 number of data were found related to the cognitive neuroscience over the study period that had been cited 129405 times. USA scores the highest number of publications (n= 2485) followed by UK (n= 692). Continuous increase is observed in cognitive neuroscience research output. Frontiers in Human Neurosciences traced as highly productive journal. In this era when scientometric indicators are increasingly used in performance evaluation, this study should definitely give interesting information to those working for betterment of cognitive neuroscience research.

Keywords: **Scientometrics, Activity Profile, Citation Rate, Cognitive Neuroscience**

INTRODUCTION

Michael Gazzaniga and George A. Miller have given the name "cognitive neuroscience" in 1976, over martinis at Rockfeller University Faculty Club. They coin the name to designate a new research program at the interface of systems neuroscience, computational neuroscience, and cognitive psychology (Gazzaniga M.S. 1985). According to Gazzaniga (2009), Cognitive neuroscience is a branch of psychology and neuroscience both, overlapping with sub-disciplines such as physiological psychology, cognitive psychology and neuropsychology. Cognitive Neuroscience is an educational field that studies the biological factors (substrates) that highlight and are the ground for cognition (thought and understanding). The study shows how the brain and nervous system associates with the mind , body, intellect and other important factors of life to create patterns of thought and behaviour.

The sub-discipline has materialized in the 1990s at the interface between the cognitive and computational sciences and the neural sciences. On one side, it comes out of the myth of cognitive psychology and neuropsychology, which use behavioural experiments to unearth the processes and mechanisms lying trailing human cognitive functions, and of computational method within cognitive psychology, which depends on computational models to develop definitive mechanistic accounts of these operations. On the other side, it comes out of the myth of functional, behavioural and systems neuroscience, which use neuroanatomical and neurophysiological methods to discover the mechanisms underlying complicated functions. It draws on principles and findings of molecular and cellular neuroscience. It unites these approaches with the use of advanced functional brain imaging methods, such as functional magnetic imaging (FMRI), positron emission tomography (PET), as well as other

methods including electro-encephalography(EEG) magneto-encephalography(MEG), and with a growing research tradition in computational neuroscience.

Several scientometric study have been carried out to map the particular fields like organic chemistry (Dwivedi S.2015), horticulture (Ranganathan C.2015), neuroscience (Garg K.C.2013) . There are no specific studies reported in the literature dealing with scientometric analysis of research papers in the area of cognitive neuroscience. The present study examines the status of research in the area of cognitive neuroscience in terms of publication output and its impact as judged by the number of citations received by these papers.

Objectives

The objective of this study is to analyse the research output of cognitive neuroscience research globally, as reflected in its publications output during the period 2006-2015. The main objectives are following:

- To examine the pattern of growth of publications in cognitive neuroscience research in world during 2006-2015.

- To examine the publication output of most prolific countries in cognitive neuroscience research during 2006-2015 and how it has changed during two five year blocks by using transformative activity index.

- To examine the impact of research output of most prolific countries using different bibliometric indicators.

- To study the contribution by sub-disciplines.

- To examine the pattern of citations of the research output.

Methodology

Thomson Reuters WoS (formerly Institute of Scientific Information) was used to download data for the present study. Cognitive neuroscience is an interdisciplinary area of study, thus data has been retrieved from SCI-Expanded, Social Science Citation Index and Art and Humanities Citation Index. All the scientific output in the area described by Topic = (Cognitive Neuroscience)   are retrieved. Downloaded data transferred to the excel files and arranged according to country-wise. Total 6085 data retrieved, out of these, 73 publications not having sufficient information. Of the remaining 6012 data, 69% (4148) article, 21% (1277) review, 5% (332) editorial material, 3% (161) article proceedings and 2% others. Bibliographic details for each record included document type, title of the paper, author(s) and their affiliation, name of the journal with its place of publication and the number of citations received by each paper.

Different approaches are available in scientometrics for count of authors and the most widely used is the first author approach (straight count), though it sometimes leads to bias as is under represents co-authors. However, authors of the present paper have used the same.

Analysis

Growth pattern of global cognitive neuroscience research

Fig. 1 shows the pattern of cognitive neuroscience research output during 2006-2015. The graph shows increasing trend with slight decrease in 2003. Cognitive neuroscience research increases from 343 publications in year 2006 to 792 in 2015. Maximum publication (816) observed in the year 2014 and minimum publication observed in 2006 (343).
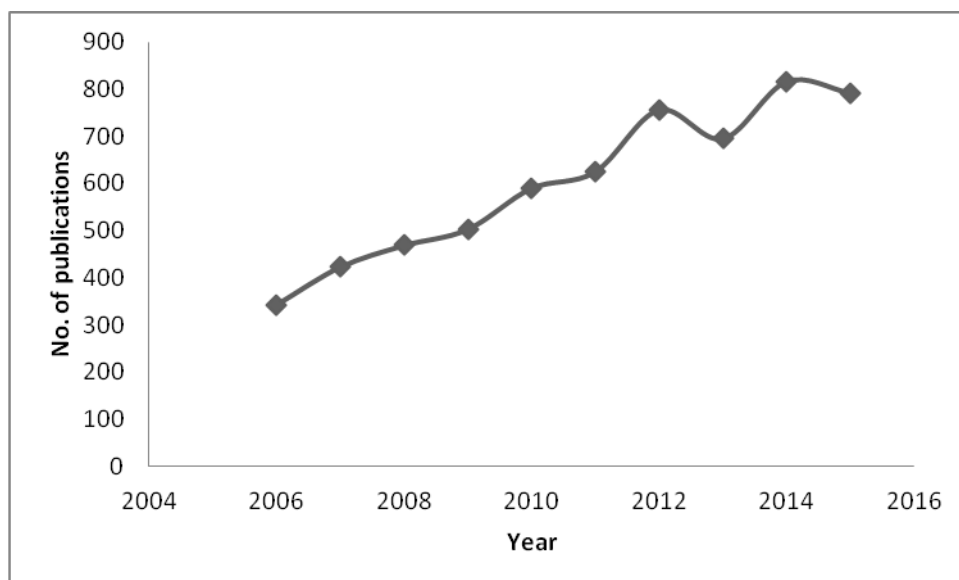
Fig. 1 Growth pattern of World publications output

Focus of research in major sub-disciplines

On the basis of discipline classification followed by Web of Science the research efforts comes under cognitive neuroscience scattered under 112 sub-disciplines. Table 1 shows top ten sub-discipline involved in the research on cognitive neuroscience. More than 50% of the total output comes under the two sub-discipline Neuroscience & Neurology (30.3%) and Psychology (24.5%) followed by Psychiatry, Behavioural sciences, Science and Technology, Radiology Nuclear Medicine & Medical imaging, Computer Science, Education & Educational Research, Linguistics, Social Science and other 102 sub-discipline.

Table 1. Scatter of publication output in major sub-disciplines

Subject	Paper (%)
Neuroscience & Neurology	2887(30.3)
Psychology	2337(24.5)|
Psychiatry	582(6.1)
Behavioral Sciences	577(6)
Science & Technology- Other Topics	299(3.1)
Radiology, Nuclear Medicine & Medical imaging	235(2.4)
Computer Science	181(1.9)
Education & Educational Research	134(1.4)
Linguistics	116(1.2)
Social Sciences-Other Topics	115(1.2)
Other 102 sub-discipline	2056(22)

*The total output is more than the actual output as several journals are classified in more than one sub-discipline.

Most prolific journals

Table 2 list the journals having minimum (1%) publication of the total research output in the field of cognitive neuroscience research. Majority of journal in the list from USA (4) followed by UK (2) and Switzerland(2) and one from Ireland. *Frontiers*

in human neurosciences topped the list with 190 publications and *Trends in cognitive sciences* traced as highest impact factor journal.

Table 2. Top ten journals in the field of cognitive neuroscience

	Title of Journal and country of publication	Number of Paper	JIF 2013
1	FRONTIERS IN HUMAN NEUROSCIENCES(Switzerland)	190	2.906
2	NEUROIMAGE(USA)	158	6.252
3	FRONTIERS IN PSYCHOLOGY(Switzerland)	121	-
4	NEUROSCIENCE RESEARCH(Ireland)	118	2.204
5	NEUROPSYCHOLOGIA(UK)	116	3.477
6	JOURNAL OF COGNITIVE NEUROSCIENCE(USA)	115	4.493
7	PLOS ONE(USA)	108	3.73
7	NEUROSCIENCE AND BIOBEHAVIORAL REVIEWS(UK)	83	9.44
9	TRENDS IN COGNITIVE SCIENCES(UK)	80	16.008
10	JOURNAL OF NEUROSCIENCE(USA)	65	6.908
	Other 1388 journals	4858	

Citation pattern of Cognitive Neuroscience Research output

Table 3 shows the citation pattern of publications on cognitive neuroscience. Citations were examined from 2006- Jan 2016 on which the data was downloaded. Total 6012 publications received 129405 citations. Average rate of citation per paper is 22.

Table 3. Distribution of Citation

Number of Citation	Number of Papers	Total Citation
0	1080	0
1	559	559
2	421	842
3	315	945
4	259	1036
5	218	1090
6-10	845	6536
11-20	849	12621
21-30	426	10722
31-40	264	9281
41-50	165	7404
51-75	229	14000
76-100	102	8871

>100	280	55498
Total papers	**6012**	
Total citation	**129405**	
Citation/ paper	**22**	

Prolific countries in cognitive neuroscience research

The total research output originated from 74 countries. Table 4 list 14 prolific countries that produced minimum (1%) publications or more of the output. These prolific countries contributed the 90% of the total output. Rest 10% was scattered in other 60 countries. Among the most prolific countries USA contributed the most 41.3% followed by UK 11.5%, Germany 6.9%, Canada 5.2 %, France 4% and Italy 3.8%. Remaining 28 % contributed by Netherlands, Australia, Japan, China, Spain, Switzerland, Belgium, Israel and others.

As output observed in two five year blocks from 2006-2010 and 2011- 2015 indicates output increases in second block in case of all the prolific countries. India scores 24 publications in cognitive neuroscience.

Table4. Output in Cognitive Neuroscience research in two different blocks

Country	2006-2010 No. of Papers	2011-2015 No. of Papers	Change in TAI	2006-2015 No. of Papers
USA	1043(108)	1442(95)	-13	2485
UK	261(97)	431(102)	+5	692
Germany	155(96)	260(102)	+6	415
Canada	127(105)	184(97)	-8	311
France	104(113)	134(92)	-21	238
Italy	87(97)	144(102)	+5	231
Netherlands	74(89)	141(107)	+18	215
Australia	49(77)	116(115)	+38	165
Japan	58(102)	89(99)	-3	147
China	40(79)	91(113)	+34	131
Spain	44(92)	80(105)	+13	124
Switzerland	31(74)	77(116)	+42	108
Belgium	39(117)	47(89)	-28	86
Israel	17(70)	46(119)	+49	63
Other Countries	199(86)	402(109)	+23	601
	2328	3684		6012

Transformative activity index (TAI) suggested by Guan and Ma [19] used to calculate the change in the output in two blocks among prolific countries. Author followed the same methodology to calculate TAI that has been used by Garg et al. [2013] in their studies on Japanese Encephalitis. The formula used for calculating TAI is as follows:

$$TAI= \{(C_i/C_o)/(W_i/W_o)\}\times100 \text{ where}$$

C_i = Number of publications of the specific country in the ith block;

C_o = Total number of publications of the specific country during the period of study;

W_i = Number of publications of all countries in the ith block;

W_o = Total number of publication of all countries during the period of study.

Fig. 2 shows the change in the values of TAI for the prolific countries. From the figure it is clear that the activity has increased significantly for Israel, Switzerland, Australia, China and Netherland, in second block and it went down significantly for Belgium, France, USA, and Canada. The rise is substantial in case of Israel.
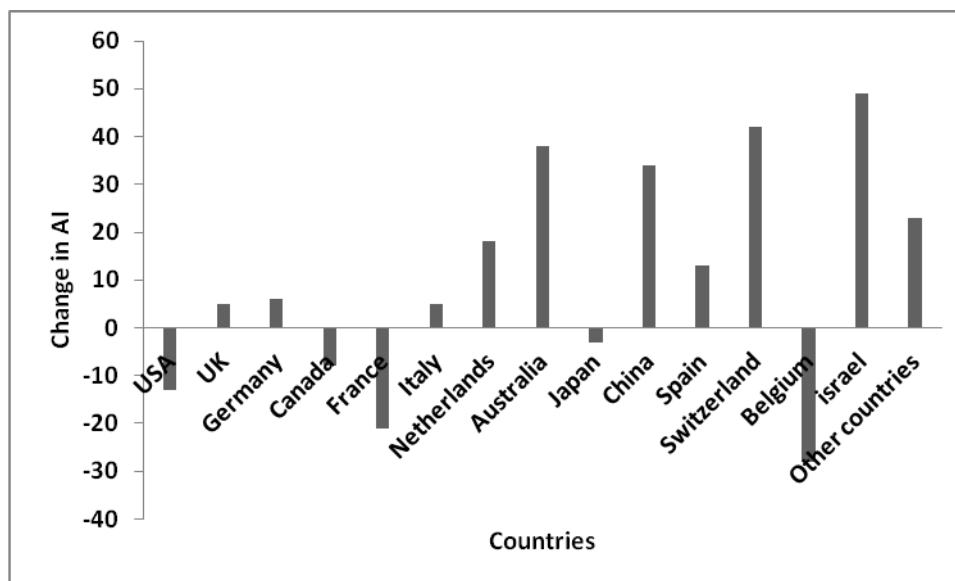

Fig.2: Change in transformative activity index

Prolific Countries and their Citation Impact

The scientific impact of prolific countries was examined by using two relative indicators, namely Citation per paper (CPP), and Relative Citation Impact (RCI). Citation per Paper (CPP) is a relative indicator computed as the average number of citation per paper. It has been widely used in bibliometric studies as it normalizes a large disparity in volumes of published output among prolific countries and small nations for a meaningful comparison of research performance.

Citation per paper= (Total number of   or a country or an institution / total number of papers for that country or institution)

Relative Citation Impact (RCI) was developed by the Institute of Scientific Information (now Thomson Reuters, USA) and has been used by Joshi [20101] et al. to examine the impact of different countries and institutions in the field of forest fungal research. RCI measures both the influence and visibility of nation's research in global context.

Relative Citation Impact (RCI) = (A Country's share of world citations /country's share of world publications). RCI= 1 indicates that country's citation rate is equal to world's citation rate; RCI> 1 indicates that country's citation rate is higher than world' s citation rate and RCI < 1 indicates that country' s citation rate is less than world's citation rate.

Table 5 list 14 prolific countries with their total number of publication (TNP), total number of citations (TNC), share of world publications and citations as well as the values of CPP and RCI. The average value of CPP is 22 and is highest (28) for USA followed by UK (24), Netherlands (24). CPP is considerably less than average for rest of the other countries France, Italy, Australia etc. It is lowest for China (8). The standing of different countries as judged by the values of RCI indicates that it is more than world average for USA, UK and Netherlands. It is highest for USA closely followed by UK and Netherlands. The value of RCI is less than world average for remaining countries listed in Table 5. The ranking of countries on these two parameters follow almost the similar trend.

Table 5. Prolific countries and their citation impact

Country	TNP	World's Share (%)	TNC	World's Share (%)	CPP*	RCI
USA	2485	41.3	68766	53.1	28	1.3
UK	692	11.5	16858	13	24	1.1
Germany	415	7	8370	6.4	20	0.9
Canada	311	5.2	6167	4.8	20	0.9
France	238	4	3407	2.6	14	0.7
Italy	231	3.8	3823	3	17	0.8
Netherlands	215	3.6	5086	4	24	1.1
Australia	165	2.7	1616	1.2	10	0.4
Japan	147	2.4	2556	2	17	0.8
China	131	2.2	1020	0.8	8	0.3
Spain	124	2.1	1136	0.9	9	0.4
Switzerland	108	1.8	1382	1.1	13	0.6
Belgium	86	1.4	1656	1.3	19	0.9
Israel	63	1	711	0.5	11	0.5
Other Countries	601	10	6851	5.3	11	0.5
	6012		**129405**			

Conclusions

- The output in cognitive neuroscience research has increased many folds since 2006 with slight decrease in 2013. Most of the papers have been published in journals originated from the advanced countries of the West. Highest number of article published in Frontier in Human Neuroscience (Switzerland).

- More than 50% of the total output comes under the two sub-disciplines, Neuroscience & Neurology (30.3%) and Psychology (24.5%).

- The total research output originated from 74 countries and 14 prolific countries that produced (01%) publications or more of the output produced about 90% of the total output.

- The publication activity increased significantly for Israel, Switzerland, Australia, China and Netherlands and gone down for Belgium, France, USA and Canada in the second block.

- As seen by the values of CPP and RCI, USA followed by UK and Netherland has made the highest impact and China has the lowest impact. The average rate of citation per paper is 22.

Acknowledgements

.

REFERENCES

[1] M. S. Gazzaniga, "Hand book of Cognitive Neuroscience," Newyork: Plenum Pres, 1984.

[2] M. S. Gazenniga, "The Cognitive Neurosciences," England: MIT PRESS, 2009.

[3] S. Dwivedi, S. Kumar, and K. C. Garg, "Scientometric profile of organic chemistry research in India during 2004-2013," *Current Science*,109(5), p.869-877, 2015.

[4] C. Ranganathan, "Scientometric analysis of authorship trends and collaborative research in   horticulture," *IJNGLT International Journal of Next Generation Library and Technologies,* 1(3), p. 1-11, 2015.

[5] K. C. Garg, S. Kumar, and Kashmiri Lal, "Mapping of Indian neuroscience research: a scientometric analysis of research output during 1999-2008," *Neurology India,* 58(1), p. 35-4, 2013.

[6] J. Guan, and Nan, Ma, "A comparative study of research performance in computer science," *Scientometrics*, 61(3): 339-359, 2004.

[7] K. C. Garg, S. Dwivedi, and S. Kumar, "Scientometric profile of vectorborn diseases: a case study of global Japaneses Encephelitis Research" *SRELS Journal of Information Management,* 50, p. 543-554, 2013.

[8] K. Joshi, A. Kshitij, and K. C. Garg, "Scientometric profile of global forest fungal research," *Annales of Library and Information Science,* 57, 130-139, 2010.