Mapping of neuroscience research: a quantitative analysis of publications output of China, 1999-2008

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KEY WORDS

Citation
Publications
China
Neuroscience

ABSTRACT

Background: Neuroscience is one of the most active research fields in many countries including China since 1970. The Chinese neuroscientists are playing an ever growing and important role in IBRO activities for the development of worldwide cooperation in Brain research. Purpose: The main objective of this study is to analyze the research performance of China in neurosciences in national and global context, as reflected in its publication output during 1999-2008. Methods: This study is based on the Chinese publication data in neurosciences retrieved from the Scopus Citation database for the 10 years (1999-2008). Several parameters including total research output, its growth, rank and global publication share, citation impact, share of international collaborative papers and major collaborative partner countries and patterns of research communication in most productive journals were studied. Results: China's world ranking improved to 8th position in 2008. The cumulative publication output of China accounts for 39.69 % share of international collaborative papers during 1999-2008. Chinese authors in neuroscience field together contributed 794 papers, with an average of 49.63 papers per author. Conclusion: The top 49 highly cited papers in neurosciences from China had scored higher impact with 126.73 citations per paper. These 49 high-cited papers have appeared in 25 journals and are affiliated to 32 Chinese institutions.

doi : 10.5214/ans.0972-7531.1017204

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Introduction

Neuroscience is one of the most active research fields in many countries including China, which is an economically and scientifically emerging country with rapid developments occurring since 1970. Among the biological sciences at large, neuroscience is one of the most advanced fields in China.

Neurosciences as a distinct discipline or research program have been a rather recent event in most Chinese universities, research institutes and other organizations. However, the last few years have witnessed increased funding and an improved research environment for neurosciences in China, both of which facilitated an influx of Chinese neuroscientists trained abroad.

A recent team members from International Brain Research Organization's (IBRO) visited to neuroscience centres in China and later termed the country as 'The Chinese Neuroscience Dragon'. The neuroscience community is growing fast in China. In several Institutes in Beijing, Xi'an, Hangzhou and Shanghai, neuroscientists are playing an active and leading roles in the development of neuroscience in the country and a number of centers of excellence have been recently established. The Chinese neuroscientists are playing an ever growing and important role in IBRO activities for the development of worldwide cooperation in brain research. For the growth of neuroscience in China, a unique China-Australian collaboration in neurosciences has been formed between Queensland Brain Institute (QBI) and the Institute of Biophysics, Chinese Academy of Sciences.

Much of the progress in neurosciences has been driven by small group of foreign trained scientists who have paired up with Institutes in China. Neurosciences growth story in Beijing and Shanghai is largely as a result of dedication and hard work of a few prominent individuals, but Institutes in Chinese provinces

have still a long way to go to establish neurosciences programs and centers.

A few quantitative studies analyzing neuroscience literature in some countries have been carried out in the past. Braun et al.¹ analyzed the characteristics of publication activity and co-authorship in world neurosciences literature. Evaluation of country research output in neurosciences have been carried out on Europe²⁻³ (Mela & Mancardi, 2002) (Robert, 2006), Spain⁴⁻⁵ (Lopez-Munoz, 1996) (Gomez, 1990), Italy⁶ (Berardelli, 2005), Sweden⁷ (Glanzel, 2003), China⁸⁻⁹ (Xu, 2003) (Han, 2008), and Cuba¹⁰ (Dorta-Contreras, 2008) by different scholars from time to time. The main objective of this study is to analyze the research performance of China in neurosciences in national and global context, as reflected in its publication output during 1999-2008. In particular, the study focuses on the following objectives: (i) To study the Chinese research output, its growth, rank and global publication share and impact, (ii) To study the patterns of international collaboration, (iii) To study the publication productivity and impact of leading institutions of China (iv) To study the characteristics of prolific authors and high cited-papers, and (v) To study the patterns of research communication in most productive journals.

Methods

This study is based on the Chinese publication data in neurosciences retrieved from the Scopus Citation database for last 10 years (1999-2008). Three-year citations window has been used for counting the citations and for accessing the impact of Chinese research output, which included leading Chinese institutions and authors.

Results

Global Publication Share and Rank

The global publication shares of the top 26 countries varies from

0.84% to 36.13% during 1999-2008. The United States tops the list with global publication share of 36.13% and holds first rank during 1999-08, followed by United Kingdom (10.92%, 2nd rank), Germany (8.77%, 3rd rank), Japan (8.09%, 4th rank), Canada (5.71%, 5th rank), France (5.46%, 6th rank) and Italy (5.24%, 7th rank). Netherlands, Australia, Spain, Sweden and China ranks between 8th-12th position (with their global publication share ranging from 2% to 3%). The countries that rank between 13th and 20th positions include Switzerland, Columbia, Brazil, Israel, Belgium, South Korea, Finland and Turkey with their global publication share ranging from 1% to 2%. The next six countries (India, Austria, Denmark, Poland, Russia and Taiwan) rank from 21st to 26th positions with their global share less than 1% (Table 1).

Among developed countries, that has shown decline in publication share from the year 1999 to the year 2008 are United States, United Kingdom, Germany, Japan, France, Sweden, Finland and Russia. In contrast, developed countries that have shown rise in their publication share during the same period are Canada, Netherlands, Australia, Spain, Switzerland, Belgium, Finland, Turkey, Austria, Denmark and Poland. In contrast, most developing countries (except Columbia) has shown rise in their publication share from 1999 to 2008: China by 3.93%, South

Korea by 1.42%, Brazil by 1.29%, India by 0.63%, Taiwan by 0.60% and Israel by 0.28% (Table 1).

China ranks at 12th position among the top 26 countries in Neurology, with its global publication share of 2.03% during 1999-08. Brazil, South Korea and India ranks at 15th, 18th and 26th position, with global publication share of 1.74%, 1.24% and 0.99% during 1999-08. China's global share has increased from 0.86% to 4.79% and also its world ranking from 21st to 8th from 1999 to 2008. In comparison, Brazil, South Korea and India's global publication share increased from 1.09% to 2.38%, 0.57% to 1.99% and from 0.72% to 1.35% from 1999 to 2008 and their global ranking increased from 15th to 12th, 18th to 15th and from 23rd to 19th (Table 1).

China's publication output in Neurosciences

China's total cumulative publication output during 1999-0 consists of 9184 papers, with average number of papers per year as 918. Compared to China, the publication output of Brazil, South Korea and India during the same period consists of 7850 papers, 5625 papers and 4503 papers, with average number of papers per year as 785, 562 and 450 respectively. The cumulative number of publications of China increased from 2182 papers in

Table 1 : Global publication output, publication share and rank of top 26 most productive countries in Neurosciences

S.No.	Country	No. of Papers			% Share of Papers			Rank		
		1999-08	1999	2008	1999-08	1999	2008	1999-08	1999	2008
1	USA	163055	14360	18539	36.13	36.61	35.09	1	1	1
2	U.K.	49283	4284	5665	10.92	10.92	10.72	2	2	2
3	Germany	39594	3517	4664	8.77	8.97	8.83	3	4	3
4	Japan	36532	3643	3544	8.09	9.29	6.71	4	3	4
5	Canada	25786	2154	3237	5.71	5.49	6.13	5	6	5
6	France	24642	2395	2697	5.46	6.11	5.10	6	5	7
7	Italy	23634	2091	2845	5.24	5.33	5.38	7	7	6
8	Netherlands	13716	940	1830	3.04	2.40	3.46	8	10	9
9	Australia	13098	1020	1786	2.90	2.60	3.38	9	8	10
10	Spain	12044	918	1579	2.67	2.34	2.99	10	11	11
11	Sweden	9282	942	987	2.06	2.40	1.87	11	9	16
12	China	9184	337	2534	2.03	0.86	4.79	12	21	8
13	Switzerland	8699	692	1156	1.93	1.76	2.19	13	12	13
14	Columbia	7852	527	1063	1.74	1.34	2.01	14	14	14
15	Brazil	7850	429	1257	1.74	1.09	2.38	15	17	12
16	Israel	7484	559	900	1.66	1.42	1.70	16	13	17
17	Belgium	5636	435	739	1.25	1.11	1.40	17	16	18
18	South Korea	5580	224	1051	1.24	0.57	1.99	18	24	15
19	Finland	4580	451	452	1.01	1.15	0.85	19	15	24
20	Turkey	4540	181	694	1.00	0.46	1.31	20	26	20
21	India	4503	284	715	0.99	0.72	1.35	21	23	19
22	Austria	4387	349	485	0.97	0.89	0.92	22	19	23
23	Denmark	4302	346	535	0.95	0.88	1.01	23	20	22
24	Poland	4136	302	419	0.92	0.77	0.79	24	22	25
25	Russia	3825	424	405	0.85	1.08	0.77	25	18	26

Table 2 : Publication output and citations received by China, Brazil, South Korea and India Papers in Neurosciences, 1999-08

	China			Brazil			South Korea			India		
	TP	TC	ACPP	TP	TC	ACPP	TP	TC	ACPP	TP	TC	ACPP
1999	337	1849	5.49	429	2008	4.68	224	1934	8.63	284	700	2.46
2000	386	2343	6.07	527	3212	6.09	312	2329	7.46	319	1416	4.44
2001	361	2128	5.89	533	2949	5.53	336	2503	7.45	312	1308	4.19
2002	460	3165	6.88	653	3746	5.74	391	2928	7.49	359	1308	3.64
2003	638	4640	7.27	729	4799	6.58	525	4313	8.22	463	1694	3.66
2004	789	6267	7.94	733	4644	6.34	554	4999	9.02	411	1888	4.59
2005	942	7957	8.45	872	5589	6.41	646	5994	9.28	464	2349	5.06
2006	1284	9282	7.23	1020	6013	5.90	772	5802	7.52	546	2626	4.81
2007	1453			1097			814			630		
2008	2534			1257			1051			715		
99-03	2182			2871			1788			1737		
04-08	7002			4979			3837			2766		
99-08	9184			7850			5625			4503		
TP = Total Paper; TC = Total Citations; ACPP = Average Citation per Paper												

1999-03 to 7002 papers in 2004-08, witnessing a growth of 220.90% (Table 2). Compared to China, the cumulative publication output of Brazil, South Korea and India has increased from 2871 papers to 4979 papers, 1788 papers to 3837 papers and from 1737 papers to 2766 papers respectively from 1999-03 to 2004-08, witnessing a growth rate of 73.42%, 114.6% and 59.24% as against 20.59% growth of the world cumulative publication output during the same period (Table 2).

In terms of impact and quality, the average citations per paper registered by China's publication output during 1999-06 were 7.24. In comparison, South Korea publications have registered a comparative higher impact of 8.29 than China, followed by Brazil (5.99) and India (4.21) with comparative less impact for their publications during the same period. The average citations per paper for China's cumulative publications decreased from 7.70 in 1999-02 to 7.24 in 2003-06. In comparison, the average citations per paper for cumulative publications of Brazil, South Korea and India decreased from 6.27 to 5.99, 8.61 to 8.29 and from 4.54 to 4.21 from 1999-02 to 2003-06 (Table 2).

International collaborative share in China's publication output

Based on the publication data, the total cumulative International collaborative papers of China consist of 3645 papers, which accounts for 39.69% share in the cumulative output of China in Neurosciences during 1999-08. In comparison, South Korea's International collaborative papers share in their cumulative publication output during 1999-08 was 28.18% share (with 1585 collaborative papers), followed by Brazil with 24.09% (with 1891 collaborative papers) and India with 17.34% share (with 781 collaborative papers) (Table 3).

China witnessed a marginal decrease in the share of international collaborative papers from 40.74% in 1999-03 to 39.36% in 2004-08. In comparison, the international collaborative publications share of Brazil and India has increased from 22.78% to 24.84% and from 13.59% to 19.70%, as against decrease from 28.35% to 28.09% in case of South Korea from 1999-03 to 2004-08 (Table 3).

Considering the contribution of collaborative partners in China's publication output, 19 countries were found to publish more

Table 3 : Number and share of International papers of China, Brazil, South Korea and India.

Year	China			Year	Brazil		
	TP	TICP	%TICP		TP	TICP	%TICP
1999-03	2182	889	40.74	1999-03	2871	654	22.78
2004-08	7002	2756	39.36	2004-08	4979	1237	24.84
1999-08	9184	3645	39.69	1999-08	7850	1891	24.09

Year	South Korea			Year	India		
	TP	TICP	%TICP		TP	TICP	%TICP
1999-03	1788	507	28.36	1999-03	1737	236	13.59
2004-08	3837	1078	28.09	2004-08	2766	545	19.70
1999-08	5625	1585	28.19	1999-08	4503	781	17.34
TP = Total Paper; TICP = Total International Collaborative Papers							

Table 4 : Major collaborative country's share in total International collaborative papers (TICP) of China, 1999-2008

Country	Total International Collaborative Papers (TICP)			% Share of TICP		
	1999-03	2004-08	1999-08	1999-03	2004-08	1999-08
USA	371	1283	1654	41.73	46.55	45.38
Japan	141	336	477	15.86	12.19	13.09
Taiwan	69	163	232	7.76	5.91	6.36
Canada	32	171	203	3.60	6.20	5.57
Germany	38	161	199	4.27	5.84	5.46
Sweden	58	95	153	6.52	3.45	4.20
Australia	23	94	117	2.59	3.41	3.21
France	26	81	107	2.92	2.94	2.94
UK	26	73	99	2.92	2.65	2.72
Netherlands	17	62	79	1.91	2.25	2.17
Singapore	12	66	78	1.35	2.39	2.14
South Korea	7	56	63	0.79	2.03	1.73
Denmark	22	38	60	2.47	1.38	1.65
Italy	13	43	56	1.46	1.56	1.54
Columbia	9	47	56	1.01	1.71	1.54
Switzerland	9	33	42	1.01	1.20	1.15
Belgium	8	24	32	0.90	0.87	0.88
Israel	6	18	24	0.67	0.65	0.69
Spain	3	18	21	0.34	0.65	0.58
Total	976	3259	4235			

than 20 collaborative papers with China during 1999-2008 and they are considered as major collaborative partners. United States is the largest collaborating partner during 1999-08, by contributing 45.38% share in China's total international collaborative papers in Neurosciences during 1999-08, followed by Japan (13.09% share), Taiwan, Canada, Germany, Sweden, and Australia, (between 3.21% to 6.36% share), France, UK, Netherlands and Singapore, (between 2% to 3%), South Korea, Denmark, Italy, Columbia and Switzerland (between 1 to 2% share). On analyzing the shift in International collaborative publications share of these countries from 1999-03 to 2004-08, it was found that the share of United States have increased by 4.82%, followed by Canada (2.6%), Germany (1.57%) South Korea (1.24%), Singapore (1.04%) and Australia (0.82%), while the share of all other collaborating countries have decreased by 3.67% in Japan, followed by Sweden (3.07%), Taiwan (1.85%), Denmark (1.09%), and U.K (0.27%)(Table 4).

Research profile of most productive Chinese Institutions

The top 15 Chinese most productive Institutions in Neurosciences have published more than 170 papers during 1999-2008. The list of these Institutions along with their research output, percentage share, growth rate, number of collaborative papers, citations and h index value registered is presented in Table 5 & 6. These 15 institutions together contributed 57.61% share (with 5291 papers) in the cumulative publication output of China in Neurosciences, with an average of 352.73 papers per Institution. Only 4 institutions registered the higher publications output than the group average. These are Chinese University of Hong Kong (with 831 papers and 9.05%

share), Peking University (with 669 papers and 7.28% share), The University of Hong Kong (with 628 papers and 6.84% share), and Fudan University (with 466 papers and 5.07% share).

Considering the growth rate of these 15 Institutes' publications from 1999-2003 to 2004-2008, the overall growth rate was found to be 179.01%. Nine institutions have achieved the higher growth rate than the group average. These are Shanghai Jiaotong University, Shanghai with a growth rate 1442.11%, followed by Sun Yat Sen University, Guangzhou (with 1220% growth rate), China Medical University, Shenyang (with 870% growth rate), Capital Medical University, Beijing (with 760.61% growth rate), Zhejiang University, Hangzhou (with 659.10% growth rate), Sichuan University, Chengdu (with 600% growth rate), Huazhong Univ. of Science & Technology, Wuhan (with 490.91% growth rate), Peking University (with 284.78% growth rate) and Fudan Univ., Shanghai (with 194.92% growth rate).

The average citation per paper received by the total papers of these 15 most productive Institutions is 4.08. Among these 15 Institutions, Shanghai Inst. for Biological Sciences, Shanghai scored the highest impact with 5.40 citations per paper, followed by The University of Hong Kong, China (with 4.67 citations per paper), Sun Yat-Sen University, Guangzhou (with 4.61 citations per paper), Peking University and Fudan University (with 4.50 citations per paper each), Huazhong University of Science & Technology, Wuhan (with 4.38 citations per paper), Univ. of Science & Technology, Hefei (with 4.37 citations per paper) and Chinese University of Hong Kong (with 4.14 citations per paper).

Considering the number and share in the form of international

Table 5 : Percentage share and growth rate of top institutions of China in Neuroscience during 1999-2008

Institution name	TP			%share 1999-2008	Growth Rate 99-03 to 04-08
	99-03	04-08	99-08		
Chinese Univ. of Hong Kong, Hong Kong China	289	542	831	9.05	87.54
Peking Univ., Beijing	138	531	669	7.28	284.78
The University of Hong Kong, Hong Kong, China	242	386	628	6.84	59.50
Fudan Univ., Shanghai	118	348	466	5.07	194.92
Capital Medical Univ. China, Beijing	33	284	317	3.45	760.61
Shanghai Jiaotong Univ., Shanghai	19	293	312	3.40	1442.11
The Fourth Military Medical Univ., Xi'an	142	160	302	3.29	12.68
Zhongshan Ophthalmic Center, Guangzhou	172	122	294	3.20	-29.07
Shanghai Inst. for Biological Sc. Chinese Academy of Sc., Shanghai	68	179	247	2.69	163.24
Huazhong Univ. of Sc. & Tech., Wuhan	33	195	228	2.48	490.91
China Medical Univ. Shenyang, Shenyang	20	194	214	2.33	870.00
Sun Yat-Sen Univ., Guangzhou	15	198	213	2.32	1220.00
Univ. of Sc. & Technology, Hefei	63	142	205	2.23	125.40
Zhejiang Univ., Hangzhou	22	167	189	2.06	659.10
Sichuan Univ., Chengdu	22	154	176	1.92	600.00

collaborative papers, these Institutions together contributed 1979 International collaborative papers, with an average share of 37.40% in total papers by these Institutions. Only six Institutions have scored more than the average share of International collaboration of all 15 Institutions. They are Zhejiang University, Hangzhou with 53.44% share of International collaborative papers), followed by The University of Hong Kong, China (with 52.71% share), Sichuan University, Chengdu (with 48.86% share), Sun Yat Sen University, Guangzhou (with 46.95% share), China Medical University, Shenyang (with 46.26% share), and Peking University (with 40.66% share).

The average h-index value of these 15 most productive institutions was 23. The six institutions have registered higher h-

index value than group average. These are Chinese University of Hong Kong and The University of Hong Kong (each with h-index value of 38), followed by Peking University, Beijing (32), Fudan Univ., Shanghai (30), The Fourth Military Medical Univ., Xi'an (25) and Shanghai Inst. for Biological Sciences, Shanghai (24).

Most prolific authors in Neurosciences research in China

Considering the prominent authors in Neurosciences research in China, 16 Chinese authors are identified as productive ones, who have published 39 and above papers during 1999-2008. Of these 16 authors, 3 are affiliated to Peking University, Beijing, 2 each with Fourth Military Medical Univ., Xi'an and Fudan University, Shanghai, and 1 each to other institutions. (Table 7).

These 16 authors together contributed 794 papers, accounting

Table 6 : Research output, impact, International collaborative papers share and h- index of top institutions of China in Neurosciences during 1999-2008.

S.No.	Name of Institution TP	TC	ACPP	TICP	% Share of TICP		h-index
1.	Chinese Univ. of Hong Kong, Hong Kong, China	831	3442	4.14	309	37.18	38
2.	Peking University, Beijing	669	3012	4.50	272	40.66	32
3.	The University of Hong Kong, Hong Kong, China	628	2932	4.67	331	52.71	38
4.	Fudan Univ., Shanghai	466	2098	4.50	158	33.91	30
5.	Capital Medical Univ. of China, Beijing	317	1197	3.78	99	31.23	22
6.	Shanghai Jiaotong Univ., Shanghai	312	1267	4.06	88	28.21	21
7.	The Fourth Military Medical Univ., Xi'an	302	1088	3.60	106	35.10	25
8.	Zhongshan Ophthalmic Center, Guangzhou	294	199	0.68	29	9.86	9
9.	Shanghai Inst. for Biological Sciences, Shanghai	247	1333	5.40	61	24.70	24
10.	Huazhong Univ. of Sc. & Tech., Wuhan	228	1000	4.38	81	35.53	21
11.	China Medical Univ. Shenyang, Shenyang	214	797	3.52	99	46.26	16
12.	Sun Yat-Sen Univ., Guangzhou	213	982	4.61	100	46.95	15
13.	Univ. of Sc. & Technology, Hefei	205	895	4.37	59	28.78	22
14.	Zhejiang Univ., Hangzhou	189	734	3.88	101	53.44	16
15.	Sichuan Univ., Chengdu	176	637	3.62	86	48.86	16

TP = Total Papers; TC = Total Citations; ACPP = Average Citations Per Paper

Table 7 : Research output, impact and h-index of top productive authors of China in Neurosciences, 1999-2008

S.No.	Name	Affiliation	TP			TC			ACPP	h-index
			99-03	04-08	99-08	99-03	04-08	99-08		
1.	Lin YanHe	Shanghai Institute for Biological Sciences, Shanghai	10	64	74	50	412	462	6.24	16
2.	Y.Q Li	Fourth Military Medical University, Xi'an	40	24	64	151	65	216	3.38	13
3.	Tianle L. Xu	Institute of Neuroscience, Shanghai	16	42	58	58	299	357	6.15	15
4.	Long Chuan Yu	Peking University, Beijing	29	27	56	145	94	239	4.27	15
5.	Jisheng Sheng Hans	Peking University, Beijing	25	30	55	148	163	311	5.65	16
6.	Gong Ju	The Fourth Military Medical University, Xi'an, Shaanxi	29	24	53	101	46	147	2.77	11
7.	Gen Cheng Wu	Shanghai Medical College, Shanghai	32	20	52	119	65	184	3.54	13
8.	Jian Zhong Ge	Zhongshan Ophthalmic Center, Sun Yat-sen University, Guangzhou	26	22	48	2	44	46	0.96	6
9.	David T W Yew	Department of Anatomy, Chinese University of Hong Kong, Shatin	10	37	47	31	102	133	2.83	10
10.	Xiong Li Yang	Fudan University, Shanghai	24	21	45	85	75	160	3.56	11
11.	Rui Qiong Wang	Institute of Biochemistry & Molecular Biology, Lanzhou	6	37	43	40	196	236	5.49	13
12.	Tianzi Jiang	Institute of Automation, Beijing	5	36	41	25	473	498	12.15	16
13.	Jiang Ning Zhou	School of Life Sciences, Hefei	11	29	40	60	137	197	4.93	13
14.	Yu Feng Zhang	Fu-Dan University, Shanghai	21	19	40	70	92	162	4.05	13
15.	Shihui Hans	Peking University, Beijing	7	32	39	39	152	191	4.90	11
16.	Tao Yuan Li	Xi'an Jiaotong University, Xi'an	7	32	39	51	179	230	5.90	12

for 8.65% share in the cumulative publication output of China, with an average of 49.63 papers per author. However, the contribution of these authors witnessed decrease in their publication share from 13.66% in 1999-2003 to 7.08% in 2004-08. Seven Chinese authors have published higher number of papers than the group average (49.63 papers per author). These are L.Y. He with 74 papers during 1999-08), followed by Q.Y. Li (with 64 papers), T.L. Xu (with 58 papers), L.C. Yu (with 56 papers), J.S. Han (with 55 papers), G. Ju (with 53 papers) and G.C. Wu (with 52 papers) (Table 7).

These combined publications output of these 16 most productive Chinese authors have received an average citations per paper of 4.75 citations per paper during 1999-2008, which rose from 3.94 citations per paper in 1999-2003 to 5.23 in 2004-2008. Eight Chinese authors have scored higher citations average per paper than the average citation per paper of all 16 authors (4.75 citations per paper). Among these authors, T. Jiang had registered the highest average citations per paper of 12.15, followed by L.Y. He (with 6.24 citations per paper), T.L. Xu (with 6.15 citations per paper), T.Y. Li (with 5.90 citations per paper), J.S. Han (with 5.65 citations per paper), R.Q. Wang (with 5.49 citations per paper), J.N. Zhou (with 4.93 citations per paper) and S. Han (with 4.90 citations per paper) (Table 7).

The average h-index value of these authors is 12.75. Ten authors registered higher h-index value than group average. The highest h-index value (16) is achieved by Jisheng Sheng Han, Lin Yan He and Tianzi Jian, followed by Long Chuan Yu and Tiangle L. Xu (each with h-index value of 15), Y.Q. Li, Gen Cheng Wu, Gen Wu, Qiang Wang Rui, Jiang Ning Zhou and, Yu Feng Zhang (each with

h-index value of 13) (Table 7).

Research communication profile of high productive journals

The top productive 21 Chinese and foreign Journals together contributed 54.20% share in the cumulative publication output of China in Neurosciences during 1999-2008. Of these 21 journals, only 4 journals are of Chinese origin contributing 8.83% share and 17 are International journals contributing 45.37% share in the total publication productivity of China in Neurosciences. The cumulative share of these journals showed decrease in its share from 56.69% in 1999-2003 to 53.43% in 2004-2008. (Table 8).

Research patterns of high cited papers

The characteristics of selected highly cited papers of China in Neurosciences were also evaluated in this section and the list of such high-cited papers is presented in Table 9. Based on publication output of China in this area, 49 papers are identified as highly cited ones, who have received citations (since their publications till 30 October 2009) from 90 to 216 during 1999-2009. Of these 49 papers, 41 appeared as articles, 6 as reviews, and 2 as short surveys. Of the 49 high-cited papers, 73.47% involve international collaboration (26 bilateral and 10 multilateral) and 6.12% national collaboration.

These 49 papers together received 6210 citations with an average of 126.73 citations per paper. Of these 49 papers, 7 papers are in citation range of 161-250, 26 papers in citations range of 101-160 and 16 papers in citations range of 90-100. The authors of these high cited papers are affiliated to 32 Chinese institutions including 5 papers each from Dalian Medical

Table 8 : List of highly productive journals publishing papers of China in Neuroscience, 1999-2008.

S. No.	Journal Name	Total Papers		
		1999-2008	1999-03	2004-08
1.	Neuroscience Letters	751	206	545
2.	Brain Research	582	179	403
3.	Yan Ke Xue Bao Eye Science Yan Ke Xue Bao Bian Ji Bu	383	246	137
4.	Neurocomputing	377	28	349
5.	European Journal of Pharmacology	367	86	281
6.	Neural Regeneration Research	314	0	314
7.	Neuroreport	295	104	191
8.	Neuroscience	251	68	183
9.	Peptides	225	48	177
10.	Neuroscience Bulletin	208	0	208
11.	Journal of Neuroscience Research	148	31	117
12.	Journal of Neurochemistry	136	24	112
13.	Chinese Journal of Contemporary Neurology and Neurosurgery	124	0	124
14.	Journal of Neuroscience	117	23	94
15.	Neurochemical Research	114	20	166
16.	Brain Research Bulletin	107	36	71
17.	European Journal of Neuroscience	106	28	78
18.	Neurological Research	99	11	88
19.	Chinese Journal of Neuroscience	96	49	47
20.	Neuroscience Research	89	25	64
21.	Regulatory Peptides	89	25	64
Total	4978	1237	3741	

Table 9 : List of top 49 highly cited papers, 1999-2008

Author	Title	Source title	Cited by	Affiliation	Collaboration
Gao H.-M., Jiang J.etal	Microglial activation-mediated delayed and progressive degeneration of rat nigral dopaminergic neurons: Relevance to Parkinson's disease	Journal of Neurochemistry,2002,81(6)	216	Dalian Medical University, Department of Physiology, Dalian, China	BC
Chen Z., Sandercock P.,etal	Indications for early aspirin use in acute ischemic stroke: A combined analysis of 40 000 randomized patients from the Chinese Acute Stroke Trial and the International Stroke Trial	Stroke, 2000,31(6)	214	Chinese Academy of Medical Sciences, Beijing, China	BC
Liao X., Chen G., Sanchez E.N.	Delay-dependent exponential stability analysis of delayed neural networks: An LMI approach	Neural Networks, 2002,15(7)	210	Department of Computer Science and Engineering, Chongqing University, Chongqing	MC
Feng R., Rampon C.,etal	Deficient neurogenesis in forebrain-specific presenilin-1 knockout mice is associated with reduced clearance of hippocampal memory traces	Neuron, 2001,32(5)	189	Shanghai Institute of Brain Functional Genomics, East China Normal University, Shanghai, China	MC
George M.S., Nahas Z.,etal	A controlled trial of daily left prefrontal cortex TMS for treating depression	Biological Psychiatry, 2000,48(10)	181	Department of Psychiatry, Shangdong Medical University, Jinan, China;	BC
Arnsten A.F.T., Li B. - M.	Neurobiology of executive functions: Catecholamine influences on prefrontal cortical functions	Biological Psychiatry, 2005,57(11)	178	Institute of Neurobiology, Fudan University, Shanghai, China;	BC
Han J.-S.	Acupuncture: Neuropeptide release produced by electrical stimulation of different frequencies	Trends in Neurosciences, 2003,26(1)	162	Neuroscience Research Institute, Peking University, 38 Xue Yuan Road, Beijing 100083, China	ZC
Wemmie J.A., Chen J., etal	The acid-activated ion channel ASIC contributes to synaptic plasticity, learning, and memory	Neuron, 2002,34(3)	160	University of Science and Technology, Wuhan, China;	BC

Duan S., Anderson C.M., etal	P2X7 receptor-mediated release of excitatory amino acids from astrocytes	Journal of Neuroscience, 2003,23(4)	158	Institute of Neuroscience, Chinese Academy of Sciences, 320 Yue-yang Road, Shanghai 200031, China	BC
Zhang J.- M., Wang H.-K., etal	ATP Released by Astrocytes Mediates Glutamatergic Activity - Dependent Heterosynaptic Suppression	Neuron, 2003,40(5)	157	Institute of Neuroscience, Shanghai Institutes for Biol. Sci., Chinese Academy of Sciences, Shanghai,	BC
Zhang H., Craciun L.C.,etal	PIP2 activates KCNQ channels, and its hydrolysis underlies receptor-mediated inhibition of M currents	Neuron, 2003,37(6)	153	Basic Medical Research Institute, Hebei Medical University, Shijiazhuang, China	BC
Gao H.-M., Hong J.-S., etal	Distinct role for microglia in rotenone-induced degeneration of dopaminergic neurons	Journal of Neuroscience, 2002,22(3)	151	Department of Physiology, Dalian Medical University, Dalian 116027, China;	BC
Dong H.- W., Petrovich G.D., etal	Topography of projections from amygdala to bed nuclei of the stria terminalis	Brain Research Reviews, 2001,38(2)	150	Institute of Neuroscience, Fourth Military Medical University, Xi'an, Shannxi 710032, China;	BC
Huang Y.Z., Won S.,etal	Regulation of neuregulin signaling by PSD-95 interacting with ErbB4 at CNS synapses	Neuron, 2000,26(2)	150	Laboratory of Molecular Neurobiology, Institute of Neuroscience, Shanghai Research Center of Life Sciences, Shanghai 200031, China;	MC
Chen Z.-Y., Patel P.D., etal	Variant Brain-Derived Neurotrophic Factor (BDNF) (Met66) Alters the Intracellular Trafficking and Activity-Dependent Secretion of Wild-Type BDNF in Neurosecretory Cells and Cortical Neurons	Journal of Neuroscience, 2004,24(18)	149	Department of Basic Medical Sciences, Second Military Medical University, Shanghai 200433, China;	BC
Ho T.W., Willison H.J., etal	Anti-GD1a antibody is associated with axonal but not demyelinating forms of Guillain-Barre syndrome	Annals of Neurology,1999,45(2)	145	Department of Neurology, Second Teaching Hospital, Hebei Medical School, Shijiazhuang, China;	MC
Wang L., Zou X.	Exponential stability of Cohen-Grossberg neural networks	Neural Networks, 2002,15(3)	144	College of Mathematics and Econometrics, Hunan University, Changsha, Hunan 410082, China;	BC
Chen T.	Global exponential stability of delayed Hopfield neural networks	Neural Networks, 2001,14(8)	132	Lab. of Nonlinear Mathematics Science, Institute of Mathematics, Fudan University, Shanghai, 200433, China	ZC
Zhang J., Jin X.	Global stability analysis in delayed Hopfield neural network models	Neural Networks, 2000,13(7)	132	Traction Power National Laboratory, Southwest Jiaotong University, Chengdu 610031, China	ZC
Benazzouz A., Gao D.M., Ni Z.G., Piallat B., Bouali- Benazzouz R., Benabid A.L.	Effect of high-frequency stimulation of the subthalamic nucleus on the neuronal activities of the substantia nigra pars reticulata and ventrolateral nucleus of the thalamus in the rat	Neuroscience, 2000,99(2)	128	Department of Physiology, Jinzhou Med. Coll., 121002 Liaoning, Jinzhou, China	BC
Tang Y.L., Zhao Q., etal	Autologous mesenchymal stem cell transplantation induce VEGF and neovascularization in ischemic myocardium	Regulatory Peptides, 2004,117(1)	124	Shanghai Cardiovasc. Dis. Institute, Fudan University, Shanghai 200032, China;	BC
Xiang Y., Li Y., etal	Nerve growth cone guidance mediated by G protein-coupled receptors	Nature Neuroscience, 2002,5(9)	121	Institute of Neuroscience, Shanghai Inst. of Biol. Sciences, Chinese Academy of Sciences, 320 Yue-yang Road, Shanghai 200031, China	ZC
Li H., Li S.- H., etal	Huntingtin aggregate-associated axonal degeneration is an early pathological event in Huntington's disease mice	Journal of Neuroscience, 2001,21(21)	118	Huazhong University of Science and Technology, Wuhan 430030, China;	MC

Hommel J.D., Trinko R., et al	Leptin Receptor Signaling in Midbrain Dopamine Neurons Regulates Feeding	Neuron, 2006,51(6)	116	Department of Neurobiology, Yonyang Medical College, Shiyang, Hubei 442000, China;	BC
Cao J., Wang J.	Absolute exponential stability of recurrent neural networks with Lipschitz-continuous activation functions and time delays	Neural Networks, 2004,17(3)	116	Department of Mathematics, Southeast University, Nanjing 210096 Jiangsu, China;	BC
Hertz L., Zielke H.R.	Astrocytic control of glutamatergic activity: Astrocytes as stars of the show	Trends in Neurosciences, 2004,27(12)	114	College of Basic Medical Sciences, China Medical University, Shenyang, P.R. China;	BC
Zhu C., Qiu L., et al	Involvement of apoptosis-inducing factor in neuronal death after hypoxia-ischemia in the neonatal rat brain	Journal of Neurochemistry, 2003,86(2)	114	Perinatal Center, Department of Physiology, GÅlteborg University, GÅlteborg, Sweden; Department of Pediatrics, Third Affil. Hosp. Zhengzhou Univ., Zhengzhou, China;	MC
Chen Y., Lu J., et al	Association between genetic variation of CACNA1H and childhood absence epilepsy	Annals of Neurology, 2003,54(2)	107	Department of Pediatrics, First Hospital of Peking University, Beijing 100034, China;	NC
Fan J.-B., Zhang C.-S., et al	Catechol-O-methyltransferase gene Val/Met functional polymorphism and risk of schizophrenia: A large-scale association study plus meta-analysis	Biological Psychiatry, 2005,57(2)	105	Institute for Nutritional Sciences, SIBS, Chinese Academy of Sciences; Bio-X Life Science Research Center, Shanghai Jiao Tong University; Shanghai Institute of Mental Health, Shanghai, China;	NC
Li Y., Cichocki A., Amari S.-I.	Analysis of sparse representation and blind source separation	Neural Computation, 2004,16(6)	105	Southchina University of Technology, Guangzhou, China;	BC
Dong H.-W., Petrovich G.D., et al	Basic organization of projections from the oval and fusiform nuclei of the bed nuclei of the stria terminalis in adult rat brain	Journal of Comparative Neurology, 2001,436(4)	104	Institute of Neuroscience, Fourth Military Medical University, Xi'an, Shanxi 710032, China;	BC
Liu B., Wang K., et al	Molecular consequences of activated microglia in the brain: Overactivation induces apoptosis	Journal of Neurochemistry, 2001,77(1)	103	Dalian Medical University, Department of Physiology, Dalian, China	MC
Zhao M.-G., Toyoda H., et al	Roles of NMDA NR2B subtype receptor in prefrontal long-term potentiation and contextual fear memory	Neuron, 2005,47(6)	101	Laboratory of Higher Brain Functions, Institute of Neurobiology, Fudan University, 220 Han-Dan Road, Shanghai	MC
Han J.-S.	Acupuncture and endorphins	Neuroscience Letters, 2004,361(3)	99	Neuroscience Research Institute, Peking University, Ministry of Education, 38 Xue-Yuan Road, Beijing 100083, China	ZC
Gao H.-M., Hong J.-S., et al	Synergistic dopaminergic neurotoxicity of the pesticide rotenone and inflammogen lipopolysaccharide: Relevance to the etiology of Parkinson's disease	Journal of Neuroscience, 2003,23(4)	98	Department of Physiology, Dalian Medical University, Dalian 116027, China;	BC
Maness P.F., Schachner M.	Neural recognition molecules of the immunoglobulin superfamily: Signaling transducers of axon guidance and neuronal migration	Nature Neuroscience, 2007,10(1)	97	Sino-German Center for Neuroscience, Dalian Medical University, Dalian 116011, Liaoning Province, China	MC
Lu H.	On stability of nonlinear continuous-time neural networks with delays	Neural Networks, 2000,13(10)	97	Department of Computer Science and Engineering, Shanghai Jiao Tong University, 1954 Huashan Road, Shanghai 200030, China	ZC
Chen J., Luo C., et al	Primary hyperalgesia to mechanical and heat stimuli following subcutaneous been venom injection into the plantar surface of hindpaw in the conscious rat: A comparative study with the formalin test	Pain, 1999,83(1)	96	Dept. Anat. K.K. Leung Brain Res. C., Fourth Mil. Med. University, 710032, Xi'an, China	ZC

Mu J.-S., Li W.-P., et al	Deprivation of endogenous brain-derived neurotrophic factor results in impairment of spatial learning and memory in adult rats	Brain Research, 1999,835(2)	95	Department of Neurology, Nanfang Hosp., First Mil. Med. U., Guangzhou, China; Department of Anatomy, Sun Yet -Sen Univ. of Med. Sciences, Guangzhou, China;	BC
Zhang Z.-J., Yao Z.-J., et al	Effects of antipsychotics on fat deposition and changes in leptin and insulin levels: Magnetic resonance imaging study of previously untreated people with schizophrenia	British Journal of Psychiatry, 2004,184(1)	94	Department of Radiological Science, Nanjing Brain Hospital, Nanjing Medical University, Nanjing, China;	BC
Jiang J.-Y., Yu M.-K., Zhu C.	Effect of long-term mild hypothermia therapy in patients with severe traumatic brain injury: 1-Year follow-up review of 87 cases	Journal of Neurosurgery, 2000,93(4)	94	Department of Neurosurgery, Chang Zheng Hospital, 415 Feng Yang Road, Shanghai 200003, China	ZC
Luo Z.G., Wang Q., et al	Regulation of AChR clustering by Dishevelled interacting with MuSK and PAK1	Neuron, 2002,35(3)	93	Institute of Neuroscience, Shanghai Institutes of Biological Sciences, Chinese Academy of Sciences, Shanghai 200031, China;	BC
Halberg F., Cornelissen G., et al	Cross-spectrally coherent ~ 10.5- and 21-year biological and physical cycles, magnetic storms and myocardial infarctions	Neuroendocrinology Letters, 2000,21(3)	93	Institute of Materia Medica, Shandong Academy of Medical Sciences, Jinan, China;	MC
Booth J.R., Burman D.D., et al	Neural development of selective attention and response inhibition	NeuroImage, 2003,20(2)	92	MRI Research Center, 306 Hospital, Beijing, China;	BC
Song P., Zhao Z.-Q.	The involvement of glial cells in the development of morphine tolerance	Neuroscience Research, 2001,39(3)	92	Shanghai Institute of Physiology, Chinese Academy of Sciences, 320 Yue-Yang Road, Shanghai 200031, China;	NC
Lam D.S.C., Houang E., et al	Incidence and risk factors for microbial keratitis in Hong Kong: Comparison with Europe and North America	Eye, 2002,16(5)	91	Dept. Ophthalmology/Visual Sciences, Prince of Wales/Hong Kong Eye Hosp., The Chinese University of Hong Kong, Hong Kong, China	ZC
Zhang J.-Y., Luo X.-G., et al	Endogenous BDNF is required for myelination and regeneration of injured sciatic nerve in rodents	European Journal of Neuroscience, 2000,12(12)	91	Department of Anatomy, Hunan Medical University, Changsha, Hunan, China;	BC
Risedal A., Zeng J., Johansson B.B.	Early training may exacerbate brain damage after focal brain ischemia in the rat	Journal of Cerebral Blood Flow and Metabolism, 1999,19(9)	91	Department of Neurology, First Affiliated Hospital, Sun Yat -Sen Univ. of Med. Sciences, Guangzhou, China;	BC
Zhao, H.	Global asymptotic stability of Hopfield neural network involving distributed delays	Neural Networks 17 (1),	90	Department of Mathematics, Nanjing University, Nanjing 210093, China	ZC

University, Dalian and Institute of Neuroscience, Shanghai, 4 papers each from Fudan University, Shanghai and Fourth Military Medical university, Xi'an, 2 each from Peking University, Beijing, Univ. of Science & Technology and Wuhan, Hunan University, Changsha and 1 paper each from 29 other Chinese institutions. These 49 high cited papers have appeared in 25 journals, including 8 in Neuron, 7 in Neural Networks, 5 in Journal of Neuroscience, 3 in Journal of Neurochemistry & Biological Psychiatry, 2 each in Trends in Neurosciences, Annals of

Neurology and Nature Neuroscience and 1 paper each in 17 other journals.

Conclusion

China published 9184 papers in Neurosciences during 1999-08, compared to 7850 papers by Brazil, 5725 papers by South Korea and 4503 papers by India during the same period. China ranks at 12th position among the top 26 countries in Neurology, with its global publication share of 2.03% during 1999-08. Compared to

China, Brazil, South Korea and India ranks at 15th, 18th and 21st position, with global publication share of 1.74%, 1.24% and 0.99% during 1999-08. China witnessed rise in global publication share from 0.86% in 1999 to 4.79% in 2008. Correspondingly, China's world ranking improved from 21st position in 1999 to 8th position in 2008.

In terms of impact and quality, the average citations per paper registered by China's publication output during 1999-06 were 7.24. Compared to China, only South Korea publications have registered higher impact of 8.29 instead of Brazil (5.99) and India (4.21) for their publications during the same period.

The cumulative publication output of China accounts for 39.69 % share of international collaborative papers during 1999-2008. China has shown the decrease in its share of internationally collaborative papers from 40.74% in 1999-2003 to 39.36% in 2004-2008. Among the collaborative countries, USA is the major collaborator with China during 1999-08, followed by Japan, Taiwan, Canada, Germany, Sweden, Australia, France, etc.

The cumulative publication output of 15 most productive institutions in China's total research output in Neuroscience during 1999-2008 was 5291 papers (57.61% of the China's total output in this field) with the growth rate of 179.01% for the papers published from 1999-2003 to 2004-2008. These 15 Institutions have registered an average impact of 4.08 citations per paper and an average h-index value of 23. They have contributed 37.40% share of international collaborative papers in their total publication output during 1999-08.

The 16 most productive Chinese authors in Neuroscience field together contributed 794 papers, with an average of 49.63 papers per author, received an average of 4.75 citations per paper and average h-index of 12.75 per author.

The total publication output of top 21 productive journals together contributed 54.20% share to the total publication output of China in Neurosciences during 1999-2008.

Of the 49 high-cited papers, 73.47% involve international collaboration (26 bilateral and 10 multilateral) and 6.12% national collaboration. The top 49 highly cited papers in Neurosciences from China had scored higher impact with 126.73 citations per paper. These 49 high-cited papers have appeared in 25 journals and are affiliated to 32 Chinese Institutions.

Competing interests – None, Source of Funding - None

Received Date : 24 Nov. 2009; Revised Date : 5 May 2010

Accepted Date : 8 June 2010

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