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Scientific progress regarding neural regeneration in the Web of Science

*A 10-year bibliometric analysis**

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Abstract

BACKGROUND: Neural regeneration following nerve injury is an emerging field that attracts extending interests all over the world.

OBJECTIVE: To use bibliometric indexes to track studies focusing on neural regeneration, and to investigate the relationships among geographic origin, countries and institutes, keywords in the published articles, and especially focus on the region distribution, institution distribution, as well as collaborations in Chinese papers indexed in the Web of Science.

METHODS: A list of neural regeneration studies was generated by searching the database of the Web of Science-Expanded using the term “Neural Regenera*”. Inclusive criteria: (1) articles in the field of neural regeneration; (2) fundamental research on animals, clinical trials and case reports; (3) article types: article, review, proceedings paper, note, letter, editorial material, discussion, book chapter; (4) year of publication: 2003–2012; and (5) citation database: Science Citation Index-Expanded. Exclusive criteria: (1) articles requiring manual searching or with access only by telephone; (2) unpublished articles; and (3) corrections.

RESULTS: A total of 4 893 papers were retrieved from the Web of Science published between 2003 and 2012. The papers covered 65 countries or regions, of which the United States ranked first with 1 691 papers. The most relevant papers were in the neurosciences and cell biology, and the keyword “stem cell” was the most frequent. In recent years, China showed a great increase in the number of papers. Over the entire 10 years, there were 922 Chinese papers, with Jilin University ranking first with 58 articles. Chinese papers were published in connection with many countries, including the United States, Japan, and the United Kingdom. Among the connections, the papers published by the Chinese and the American are 107, with the highest rate. With regard to funding, 689 articles were funded from various projects, occupying 74.72% of the total amount. In these projects, National Foundation and Science and Technology programs were the majority.

CONCLUSION: Our bibliometric analysis provides a historical perspective on the progress of neural regeneration research. At present, the number of articles addressing neural regeneration is increasing rapidly; however, through analysis of citations it is clear that there is a long way to go to improve the academic quality.

Key Words

neural regeneration; bibliometrics; neurogenesis; neuroplasticity; neuroprotective; neuromodulatory; neurorestoration; stem cells; neurodegenerative disease; grants-supported paper; neuroregeneration

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INTRODUCTION

Nowadays, research on neural regeneration or neural restoration is a major focus of life sciences globally. Adult neural regeneration is a complex network of events, including neurogenesis, endogenous neuroprotection, neuroplasticity and neurorestoration. It is well known that neural regeneration differs between the peripheral nervous system and the central nervous system by the functional mechanisms and in particular the extent and speed. In the central nervous system, regeneration implies that new neurons, generated through proliferation of endogenous stem/progenitor cells or by administration of exogenous stem/precursor cells with potential to substitute for lost tissue, will differentiate, survive, and integrate into existing neural networks[1].

Neuroplasticity was first proposed by Ramón-y-Cajal in 1894, referring to it as, “associations already established among certain groups of cells would be notably reinforced by means of the multiplication of the small terminal branches of the dendritic appendages and axonal collaterals; but, in addition, completely new intercellular connections could be established thanks to the new formation of [axonal] collaterals and dendrites”[2]. In the 1960s, Joseph Altman proposed the concept of adult neurogenesis in his publications[3-4]. The newly emerged concept remained controversial until the early 1990s, when several reports[5-7] proved the existence of adult neural stem cells. Nowadays, adult neural stem cells have been extensively cultured and investigated in transplantation for treating neurodegenerative diseases[8-10]. The research interests of neural regeneration in world-class regeneration institutes now focus on the following four aspects: (1) Neural development and its relationship to repair mechanisms; (2) Neuronal cell death and survival; (3) Axonal and synaptic degeneration; and (4) Pain, as a response to neural injury and degeneration. Because neurodegenerative diseases greatly affect a patient’s quality of life, many studies focus on exploring neuroprotective, neuromodulatory and neural transplantation approaches for the treatment of neurodegenerative diseases.

The Web of Science[11] has a characteristic citation index that makes assessment of citations easy and reliable, with a restriction rule for choosing the journal indexed in the database. Therefore, scholars throughout the world can evaluate the academic level by country, region and institution with the data in the Science Citation Index, which is considered as the authoritative database.

Our study is designed to track articles focused on neural regeneration in the Web of Science from 2003 to 2012.

DATA SOURCES AND METHODOLOGY

Data retrieval

In this study, we used bibliometric methods to quantitatively investigate research trends in studies of neural regeneration. The Web of Science, a research database of publications and citations created by the Institute for Scientific Information in Philadelphia, PA, USA, was selected and evaluated, using the keywords ‘Neural Regenera*’. We limited the period of publication from 2003 to 2012, and downloaded the data on July 02, 2013.

Inclusion criteria

(a) Peer-reviewed articles on neural regeneration research published and indexed in the Web of Science; (b) type of article: original research articles and reviews; (c) year of publication: 2003–2012.

Exclusion criteria

(a) Articles that required manual searching or telephone access; (b) a number of corrected papers or book chapters from the total number of articles.

The search results were analyzed by the following: (1) Annual publication output; (2) distribution according to country and institution; (3) distribution based on subject area and keywords; (4) analysis of Chinese papers.

DISCUSSION

Annual publication output on neural regeneration research in the Web of Science between 2003 and 2012

From 2003 to 2012, 4 893 papers were published on neural regeneration research in the Web of Science, comprising 3 912 articles, 873 reviews, 141 proceeding papers, 69 meeting abstract, and 36 book chapters. The number of studies increased globally throughout the period 2003–2012. However, the number of publications in China maintained stable at a low level between 2003 and 2008, and began increasing from 2010 (Figure 1).

Publication distribution of countries and institutes investigating neural regeneration from 2003 to 2012

The publications covered 65 countries or regions. United States ranked first with 1 691 papers, followed by China. Moreover, Japan and Korea were also in the top 10

countries, which are shown in Figure 2.

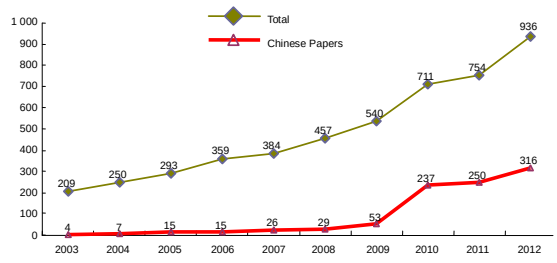

Figure 1 Annual number of publications on neural regeneration research in the Web of Science from 2003 to 2012.

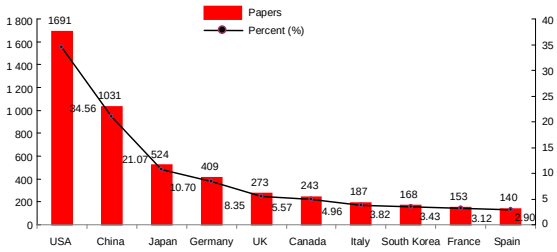

Figure 2 Top 10 countries on neural regeneration research in the Web of Science from 2003 to 2012.

Throughout the world, 933 institutions have published papers in the field of neural regeneration. Jilin University ranked 7th in the top 10 institutions (Table 1).

Table 1 Top 10 institutes publishing in neural regeneration research in the Web of Science from 2003 to 2012

Rank	Institution	Papers	Countries
1	Harvard University	122	USA
2	University Toronto	88	Canada
3	Kyoto University	78	Japan
4	University of California Los Angeles	68	USA
5	University Michigan	65	USA
6	Keio University	61	Japan
7	Jilin University	60	China
8	University Cambridge	55	UK
9	Stanford University	54	USA
10	University of California San Diego	54	USA

Affiliations of all authors count towards the final score, not just the first author.

Harvard University ranked a clear first. The Center for Neuroregeneration Research/Neuroregeneration Laboratories at McLean Hospital, with Prof. Ole Isacson as Director must also be mentioned. Prof. Isacson's laboratory produced great achievements in neuroregeneration research. They were the first group to transplant gamma-aminobutyric acid expressing neurons, differentiated in cell culture from embryonic stem cells, into animal models[12], and was also the first to demonstrate that normal midbrain dopaminergic neurons could develop from uninduced embryonic stem cells[13]. Their work led to the first demonstration that embryonic stem cells could provide functional dopamine neurons in animal models of Parkinson's disease in 2002[14]. Current studies in Prof. Isacson's laboratory concentrate on interactions between brain tissue repair, degeneration and immune responses to provide neurobiological insights and new agents for future therapies, the results of which have been published in many papers[15-18]. Important scientific discoveries for neurological and psychiatric diseases made in the Center for Neuroregeneration Research show how brain cell circuitry and synapses previously degenerated can be restored or replaced[19-23]. These scientific accomplishments provide novel technology and biological insights beyond currently available drug therapies for neurological and neurodegenerative diseases.

Distribution of subject areas and keywords in neural regeneration included in the Web of Science during 2002–2011

The field of neural regeneration briefly includes five subject areas, neuroscience, cell biology, cell tissue engineering, biochemistry molecular biology and clinical neurology. Of these areas, the most papers published were in neuroscience with 1 371 papers, followed by cell biology with 1 282 papers. With statistical analysis, we found that the term ‘stem cell’ is the most frequent keyword used[24]. Using co-keyword analysis with Software CiteSpace II software[25-26], the keyword ‘neural regeneration’ occurs frequently with ‘progenitor cell’ or ‘neural stem cell’ (Figure 3).

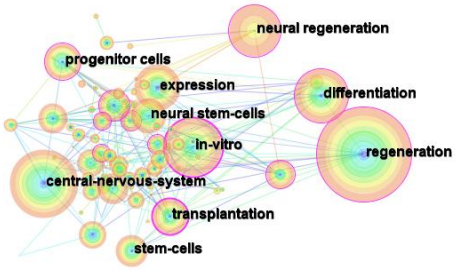

Figure 3 Co-keyword analysis for neural regeneration using CiteSpace II.

Analysis of articles on neural regeneration research in the Web of Science from 2003 to 2012

From 2003 to 2012, there were 4 893 neural regeneration papers, of which there were 922 articles with the author’s first affiliation in the Chinese mainland, covering 29 provinces and municipalities, except Qinghai Province and Tibet. The top five regions were Beijing, Guangdong, Shanghai, Liaoning and Jilin (Table 2).

Table 2 Regional distribution of articles in neural regeneration research from China

Rank	Region	Number	Rank	Region	Number	Rank	Region	Number
1	Beijing	126	11	Hubei	32	21	Henan	10
2	Guangdong	98	12	Chongqing	30	22	Yunnan	8
3	Shanghai	88	13	Sichuan	26	23	Xinjiang	7
4	Jiangsu	84	14	Zhejiang	23	24	Gansu	6
5	Liaoning	60	15	Tianjin	19	25	Jiangxi	5
6	Jilin	58	16	Anhui	16	26	Hainan	4
7	Shandong	48	17	Fujian	13	27	Guizhou	2
8	Hunan	45	18	Guangxi	13	28	Ningxia	2
9	Shaanxi	41	19	Heilongjiang	12	29	Inner Mongolia	1
10	Hebei	34	20	Shanxi	11			

Institute distribution of articles in neural regeneration research in China

In general, 134 universities, including their affiliated hospitals, contributed 87.09% of the total papers, while 47 independent medical institutions published 77 papers and 24 research institutes published 42 papers. The top 10 universities and medical hospitals are shown in the Table 3 and Table 4, respectively.

Table 3 Top 10 universities in the field of neural regeneration research in China

Rank	University	Number
1	Jilin University	58
2	Sun Yat-sen University	37
3	Central South University	36
4	Capital Medical University	34
5	Shanghai JiaoTong University	26
6	Nantong University	24
7	Chinese Medical University	24
8	Soochow University	21
9	Huazhong University of Science and Technology	20
10	Fudan University	18

The papers belonging to Jilin University are selected based on the affiliation of the first author.

Table 4 Top 10 medical institutions in the field of neural regeneration research in China

Rank	Medical Institution	Number
1	The Affiliated Hospital of Jilin University	22
2	China-Japan Union Hospital of Jilin University	18
3	Chinese PLA General Hospital	18
4	Huaxi Hospital of Sichuan University	13
5	3rd Xiangya Hospital of Central South University	12
6	Xuanwu Hospital in Capital University of Medical Sciences	10
7	General Hospital of Tianjin Medical University	10
8	Tongji Hospital, Tongji Medical College, Huazhong University of Science and Technology	9
9	Union Hospital, Tongji Medical College, Huazhong University of Science and Technology	9
10	The First Hospital of China Medical University	9

Although science and technology in China has improved significantly in recent years, there is still a need for collaboration with others to promote research quality, especially international collaborations, which are also a requisite in the field of neural regeneration. From the statistical data, it is obvious that percentage of collaborative paper increased from 10.6% to 14.4% from 2010 to 2012, which further increased to 16.1% in 2012. Compared with the percentage international collaboration of all the Chinese papers indexed in the web of Science (24.6%), the collaboration rate in neural regeneration is still low and needs much more development (Table 5, Figure 4).

Table 5 The collaborative status of papers published by Chinese groups

Year	FC	CF	CC	Total
2004	1	0	0	1
2005	5	7	4	16
2006	0	2	7	9
2007	8	4	15	27
2008	7	4	15	26
2009	9	5	31	45
2010	10	15	157	182
2011	12	24	153	189
2012	23	28	207	258

FC means collaboration including China; CF means international collaboration dominated by China; CC means collaboration between different Chinese institutions.

In Figure 4, every node indicates a country, and the size of the node is proportion to the papers published by each country; so the larger the nodes are, the more the papers they publish. Simultaneously, the line between two nodes indicates collaboration between two countries. The thickness of the line represents the correlation of the two nodes. The number in the rectangle is the paper number of the country and its collaborating country.

In all, Chinese science and technology research has connections with many countries, including the United States, Japan, the United Kingdom, Germany, Singapore, South Korea, Canada, Australia, Sweden, Italy, and Switzerland.

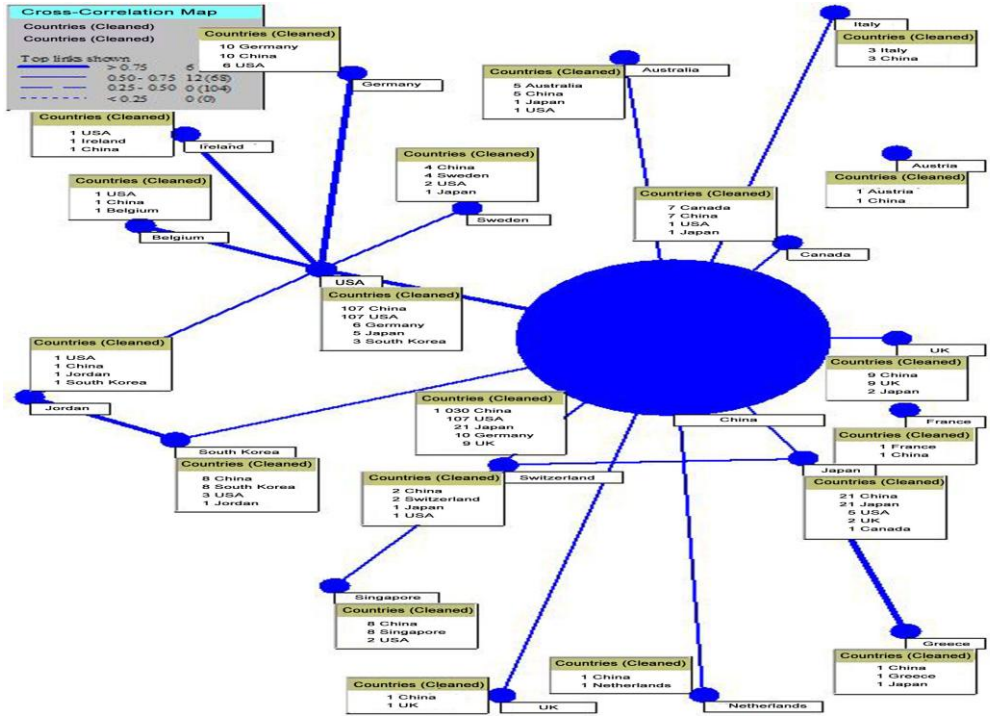

Figure 4 Collaboration between China and other countries in articles on neural regeneration research.

Among these connections, there were 107 papers published by collaborations between China and the United States, followed by collaborations with Japan as the second highest.

Funding analysis of papers in neural regeneration research in China

In general, papers supported by types of funds are considered to be innovative and creative. In the entire 10 years, 689 of all 922 papers were funded by projects, occupying 74.72% of total amount. In these projects, National Foundation and Science and Technology programs were the majority, in particular the National Natural Science Foundation of China, which supported 305 papers. In addition, 184 (77.6%) papers received funding in 2010, compared with 199 (79.6%) papers in 2011 and 258 (81.6%) papers in 2012. Thus, the percentage of papers receiving funding is rising each year. This percentage is far above the average funding percentage published in China, showing that research on neural regeneration has promoted the attention of science and technology administration in the government.

CONCLUSION

Based on the analysis above, we concluded as following:

First, life science in the 21st century is a hotspot of research studies. It is the common mission and vision for science and technology researchers throughout the world to emphasize the life and health of humans. Ingeneral, the number of papers published on neural regeneration by Chinese groups has increased along with the rest of the world, and will continue to increase for some time.

Second, collaboration is necessary for the development of science. In the field of neural regeneration, developed countries have had a great influence on high-level science and the development of technology. Thus, Chinese scientists need to improve collaboration with international experts in developed countries to advance Chinese science and technology.

Third, although the number of papers published increased significantly each year, the number of citations of Chinese papers needs to increase. Based on the period from 2003 to 2012[27], the citation per paper published by international authors is 25.3, while for Chinese papers it is 3.1. Simultaneously, there are 178 international papers that have been cited more than 100 times, while no Chinese articles have been cited to that extent. Furthermore, there are 500 international papers that have been cited more than 50 times. However, there are only 36 papers from China with more than 20 citations; the highest number of citations was 75[28-29]. Citation of Chinese papers remains low and there is a long way to go to improve the academic quality of this work before increasing article numbers.

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