BRAZILIAN NEUROSCIENCES RESEARCH AREAS: a bibliometric analysis from 2006 to 2013

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ABSTRACT Bibliometrics is used to examine the different branches of Brazilian Neurosciences research, the annual advancement of specialization, and the relationship between scientific categories and author productivity through 9655 articles published on Web of Science from 2006 to 2013. Seventy-one areas are identified that form part of the Transdisciplinarity of Brazilian Neurosciences scientific output as well as the division between clinical research and basic and experimental research. The three most important areas identified were Neurosciences (higher frequency and co-occurrence, especially with "experimental" subjects), Psychiatry (present in the first three years of the survey) and Clinical Neurology (associated with other medical subjects, as with Psychiatry), in addition to significant subjects aimed at behavioral studies. Ninety-two author clusters were identified, with notable differences between the publishing habits of the most and least productive authors. The researchers specialize in certain subjects, with more groups investigating the fields of Psychology, Psychiatry and Occupational Health.

Keywords: Neurosciences. Scientific output. Scientific areas. Bibliometrics. Scientometrics.

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1 INTRODUCTION

The evaluation of scientific activity is a key process in countries where Science is funded mostly by public investments. Since these funds are limited, their availability involves competition between different areas of society. The evaluation process combines science policies with science indicators. From this perspective, the concept of a scientific indicator covers different levels of empirical information, which describe measurable and appreciative aspects of the state of a scientific activity (VELHO, 1986). Bibliometric analysis is traditionally used as a method to survey these indicators, such as the mapping of research areas.

Brazil is the leading country in scientific growth in Latin America, registering an 8% rate of annual increase in the Science Citation Index (GLÄNZEL; LETA; THIJS, 2006) and ranking 13th among nations that publish in journals indexed by the Web of Science (PACKER, 2011). With respect to Neurosciences research, Brazil is considered an emerging nation, since it is one of the largest producers in the world whose productivity in this area has grown the most (HAUSTEIN; CÓTÊ; BEAUDET, 2013). According to data provided by Essential Science Indicators, Brazil's scientific output in *Neuroscience and Behavior* over the last decade has placed it 13th in the world and 17th in citations received (THOMSON SCIENTIFIC, c2015). This field has gained global importance as a combination of different research areas that study the brain and nervous system (that's why it's named *Neurosciences*, in the plural form). The increase in mental health and neurological diseases (due to modern living conditions and global aging) and greater dissemination of neurosciences knowledge have earned the 21st century its title of "The Century of the Brain".

Brazilian Neurosciences is linked *a priori* to Physiology researchers and laboratories, but is also present in institutes and laboratories of many related areas (TIMO-IARIA, [20--]). According to neuroscientists Ventura (2004), Baschechi and Guerreiro (2004), Brazilian neuroscientific research is divided into basic/ experimental research and clinical research and it is represented by several scientific societies (VENTURA, 2010): the Brazilian Academy of Neurology, which refers to Brazilian neurologists as *clinical neuroscientists* (NITRINI, 2006), the societies of Psychiatry and Neuropsychology, which cover clinical research, and the Brazilian Society of Neuroscience and Behavior (SBNeC), which includes basic research. Ventura (2010) also mentions the scientific associations of Psychology, Pharmacology, Physiology, Biochemistry and the Brazilian Research Association on Vision and Ophthalmology as producers of neuroscientific research in the country. The division between basic and clinical research and an understanding of different areas as Neurosciences does not always feature in Neurosciences definitions from other countries, which often exclude branches related to behavior or focus only on experimental subjects – see, for example, Shahabuddin (2013), Ashrafi et al. (2012), and Xu, Chen & Shen (2003).

In view of these considerations, this study aims to analyze aspects of research areas and the productivity of Brazilian Neurosciences research articles published between 2006 and 2013 in order to identify the dynamics of this field. Relationships between subjects, the annual advancement of specialization and the relationship between scientific categories and author productivity are studied using bibliometric techniques and statistics. The ultimate goal is to analyze this field, not as a single homogeneous set of documents, but by highlighting the special features of the subjects that comprise it.

2 SOURCE AND METHODOLOGY

Study data were provided by Web of Science (WoS) database. Despite criticisms of this information source – especially concerning its thematic, language and regional bias (GÓMEZ CARIDAD; BORDONS GANGA, 1996), the WoS is an established source for bibliometric research due to the range of publications it covers (which meet several standards of excellence and are considered mainstream science publishers) and the detailed information provided on each indexed article, such as the name and affiliation of all authors (FALAGAS et al., 2008). In addition, it provides information in more than 240 subject categories, useful for the study of different branches.

The search strategy defined for data collection involved a detailed study that took into account: a) the constitution of Neurosciences research areas in Brazil and; b) analysis of the search strategy used in bibliometric studies in the same field conducted in other countries – China (XU; CHEN; SHEN, 2003), Sweden (GLÄNZEL; DANNEL; PERSSON, 2003), Cuba (DORTA-CONTRERAS et al., 2008), Iran (ASHRAFI et al., 2012), India (SHAHABUDDIN, 2013), and Canada (HAUSTEIN; CÓTÊ; BEAUDET, 2013). The search strategy was also validated by two experts (see HOPPEN, 2014).

Data were downloaded in July 2014. Articles collected were those published between 2006 and 2013, having at least one author affiliated with a Brazilian institution

(CU=Brazil), and indexed in the following Web of Science Categories (WC): Clinical Neurology, Neuroimaging, Neurosciences, Psychiatry and Psychology, Biological. These papers were categorized as Brazilian Neurosciences scientific output. Journals are classified into Web of Science Categories according to their research publication areas. Since many journals publish articles in a number of areas, or their domain can be considered interdisciplinary, they can therefore be classified into more than one Web of Science Subject Category (WC) (LEYDESDORFF; BORNMANN, 2016). Thus, all the articles in a specific journal are classified under the WC of its source, that is, the WCs of the journal.

After the identification of Brazilian Neurosciences publications, the study was organized around three axes:

a) identify the main areas of expertise - present the main characteristics of scientific production in Brazil according to the number of documents per area and social network analysis. Data were organized using Bibexcel (version 2014-06-25), Microsoft Excel (Excel 14.0, Office 2010) and VOSviewer (version 1.5.4) software;

b) annual output evolution by subject category - in order to verify the relationship between Brazilian Neurosciences specializations in specific subject areas over the years, a correspondence analysis was conducted between years and WoS categories (using XLSTAT software). This multivariate statistical method extracts the relationships between categories, defining their similarities and allowing clustering in the event that matches are detected. It also provides a means of displaying the coordinates of rows and columns and reflects the degree of similarity between the categories depending on the closeness or distance of points. The variables (thematic categories and years) were shown in bubble charts. First, a matrix formed by the 71 WoS categories was generated, where the output associated with Neurosciences was found (rows) and distributed according to year of publication (columns). To build the map, WoS categories containing at least 100 documents from the study period were selected. A chi-square test was performed to determine the correlation between the variables analyzed;

c) relationship between authors and subjects – in order to analyze the pattern of activity of different Neurosciences authors, signatures were normalized to avoid duplicates. For example, author Ivan Antonio Izquierdo signed one article "Izquierdo, I." and another "Izquierdo, I.A.", which would be considered two different people. Normalization identifies these errors and corrects them. From an initial 61,462 signatures, 24,751 standard names were obtained. Collaboration was used as a variable to classify the authors into one of the different clusters. First, authors with over 10 joint articles were selected (605 authors). Next, a cluster was formed using the clustering coefficient and Latapy's formula (LATAPY, 2008) with Gephi software. Ninety-two author clusters were detected. In order to better understand the behavior of clusters based on their productivity, correspondence analyses were performed between specialization and clusters according to their productivity.

After 2006, Brazil reached among one thousand publications a year in Neurosciences, with stable output distribution in the following years. Until 2006, the production was smaller and very variable per year. For this reason, the chosen data set ranges from the year 2006 up to 2013. Other analysis made up of the same data corpus was published by Hoppen and Vanz (2016).

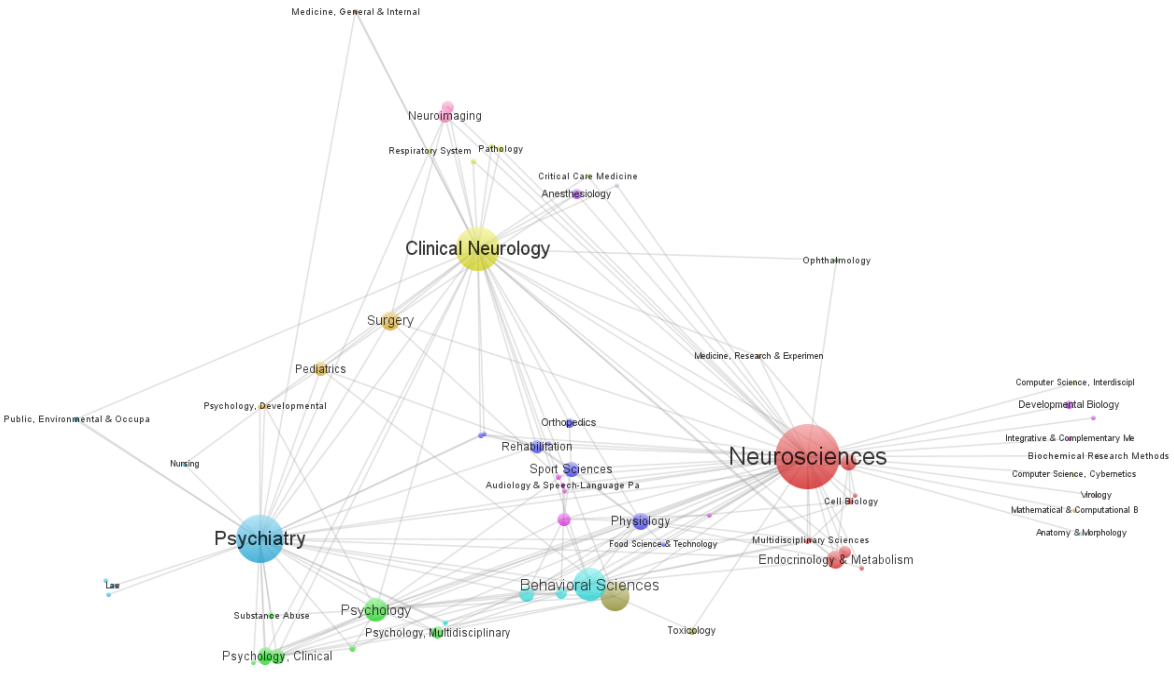
3 RESULTS

This section presents and discuss the results founded, organized in three sub-sections: dynamics of the field and relationship between areas, concerning objectives one and two; annual evolution of disciplinary production, regarding objective three; and the last one, author clustering in Neurosciences, about the fourth research objective.

3.1 Dynamics of the field and relationship between areas

The results show that 9,655 Brazilian Neurosciences publications were indexed in the Web of Science between 2006 and 2013. According to Web of Science categories, the Brazilian Neurosciences areas with highest output from 2006 to 2013 were *Neurosciences* (6243 papers, 33.62%), *Psychiatry* (3558 papers, 19.16%) and *Clinical Neurology* (2647 papers, 14.25%). These three areas divide Brazilian Neurosciences production into three large clusters that are also related to other areas, as shown in Figure 1, a cluster map in which the colors of the areas represent the clusters they belong to and the font size and circle indicate the importance of the area (VAN ECK; WALTMAN, 2013). The map demonstrates the importance of transdisciplinarity in research labeled "Neurosciences" since this field is connected to all other areas and clusters, but is mainly linked to experimental research specialties, such as Medicine, Research and Experimental; Cell Biology; Developmental Biology; and Biochemical Research Methods, among others. Two other significant clusters, Psychiatry and Clinical Neurology, contain subjects related to clinical research, such as branches of Psychology, Substance Abuse; General & Internal Medicine; Critical Care Medicine; Pathology; Surgery; and so on. This result confirms the division of Brazilian research into "more experimental" or "more clinical", as recommended by Ventura (2004) and Baschechi and Guerreiro (2004): Brazilian clinical neuroscientists show significant output in topics such as "[...] headache, dementia, movement disorders, demyelinating diseases, neuromuscular disorders, infectious diseases, cerebrovascular diseases, epilepsy and neuroimaging [...], unlike basic neuroscientists,

Figure 1 - Cluster map of Brazilian Neurosciences research areas indexed in WoS, 2006-2013



Source: research data prepared and presented with VOSviewer software

who work in laboratories or do experimental research." (BACHESCHI; GUERREIRO, 2004, p. 25, our translation).

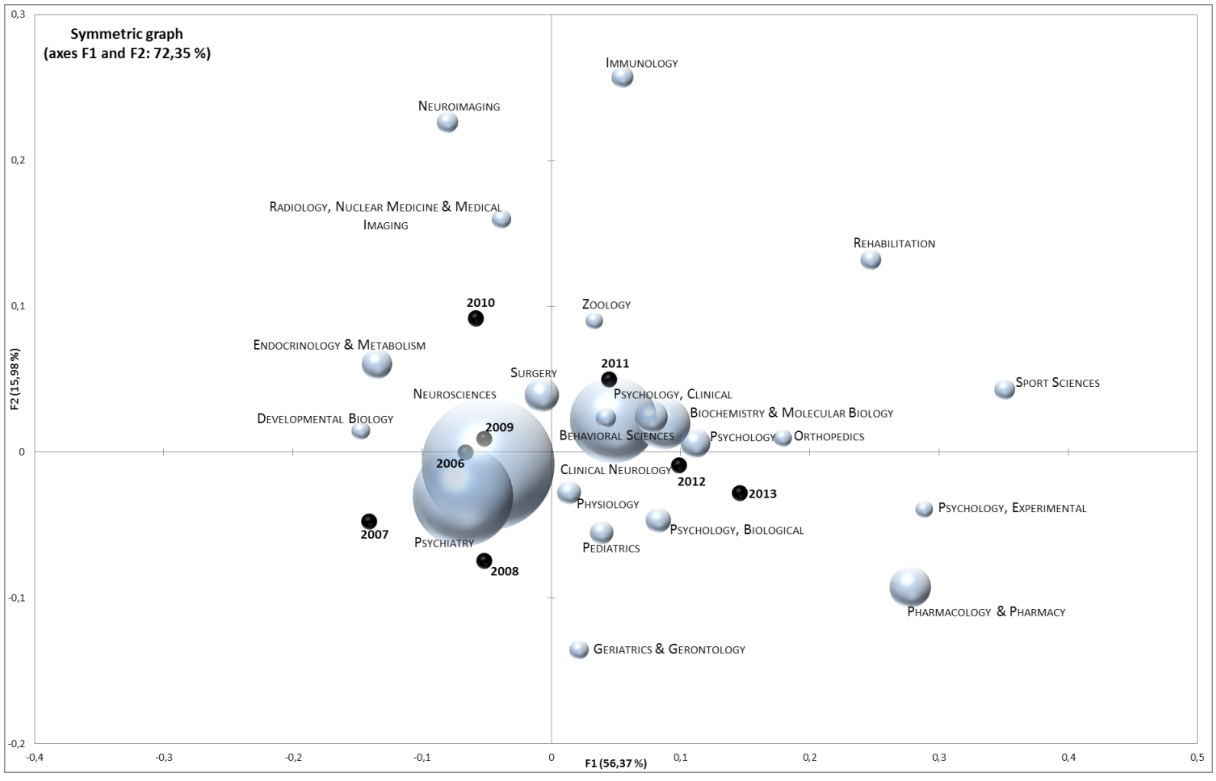
The map also shows that a substantial number of Behavioral Science papers (971 or 10.06% of total production) are situated at the intersection between the large Neurosciences and Psychiatry clusters.

Following these first four highlighted areas, the most productive fields are Pharmacology & Pharmacy (607 articles, 6.29% of total publications), Surgery (410 articles or 4.25% of production), Biochemistry & Molecular Biology (373 articles, 3.86%), Endocrinology and Metabolism (313 articles, 3.24%), Psychology (305 and 3.16%) and Psychology, Biological (220 and 2.28%). The ten most productive areas along with another 61 lower productivity branches total 71 different specialties within the transdisciplinarity of Brazilian Neurosciences.

3.2 Annual evolution of disciplinary production

After obtaining an overview of scientific output in Neurosciences, a correspondence analysis was performed to determine the production evolution per subject. The chi-square test identified a relationship between the variables "WoS category" and "years" ($p<0.005$), with 72.35% variance explained. Figure 2 shows the variables subject areas (gray circles) and years (filled black circles). The size of the gray circles is proportional to the relative contribution of each subject area (volume of documents published in the period).

Figure 2 - Correspondence analysis between areas and years from WoS, 2006-2013



Source: research data prepared with XLSTAT software presented in Microsoft Excel

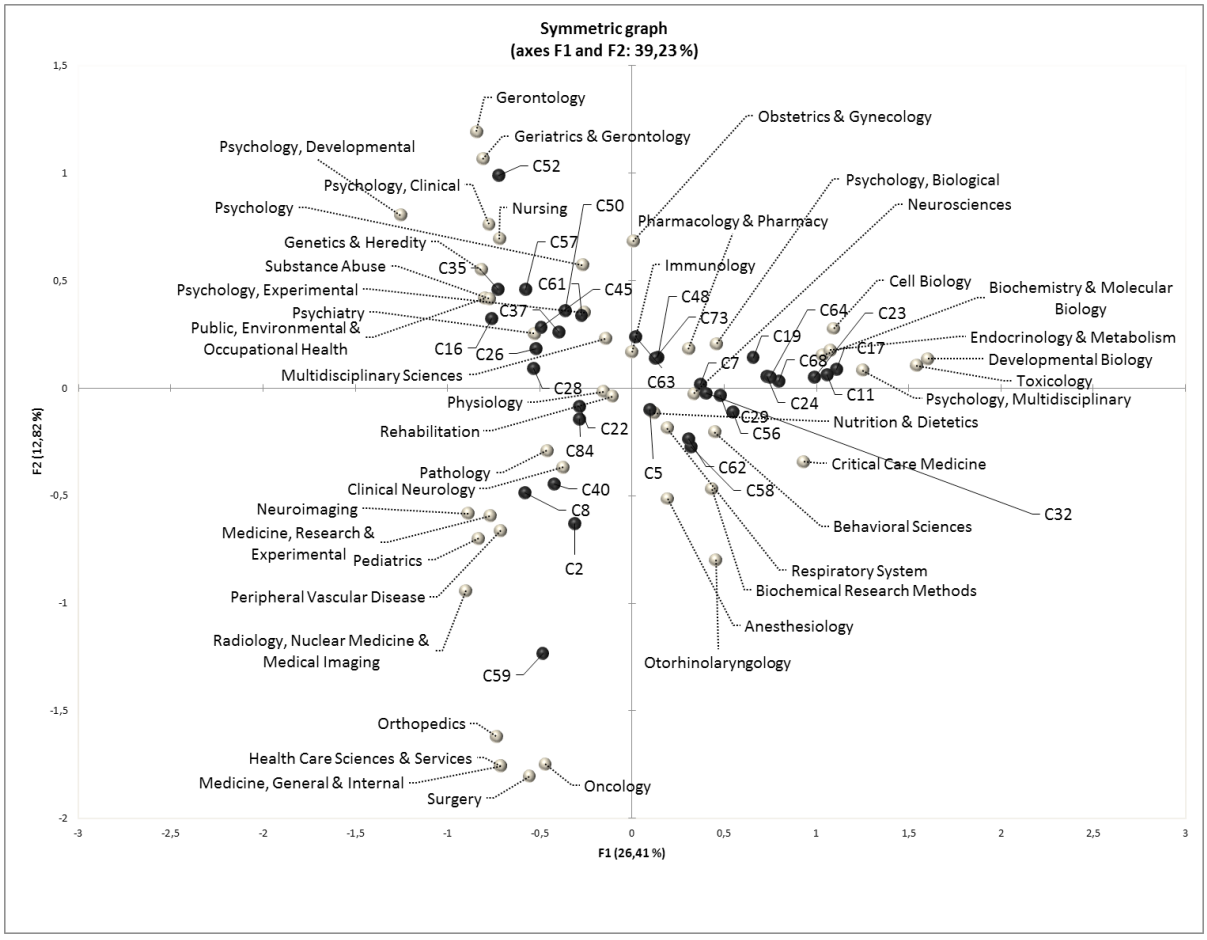
Graph distribution means that the distance between the points represents the degree of similarity degree. Points are distributed among the four quadrants, with closeness to the center of the map indicating greater similarity. Neurosciences displays a constant presence and the lower left quadrant indicates Psychiatry as a related specialty from the beginning of the study period (2006, 2007 and 2008). The upper left quadrant contains themes published between 2009 and 2010. In this quadrant the area closest to the axis intersection is Surgery, which is strongly associated with the study of the nervous system. Similar behavior is observed for themes in the upper right quadrant approaching the center of the map, with Clinical Neurology and Biochemistry & Molecular Biology highlighted as the most productive and relevant fields in 2011. Pharmacology & Pharmacy (lower right quadrant) shows considerable scientific activity, but no direct relationship with the other research areas. Experimental Psychology and Geriatrics and Gerontology are depicted as emerging areas in the field of Neurosciences in the last two years.

3.3 Author clustering in Neurosciences

Clusters representing author collaboration show 92 different clusters in Brazilian Neurosciences scientific output, with a minimum of 2 and maximum of 48 authors. Correspondence analysis reveals substantial differences between clusters for the most and least productive authors. Figure 3 shows the most productive authors (more than 100 articles). The upper left quadrant in Figure 3 indicates that about ten different author clusters are linked to studies on Psychology, Psychiatry, Gerontology, and Geriatrics & Gerontology (these are the most similar, with only one more specialized cluster), Nursing, Genetics & Heredity; Substance Abuse; among others. The upper right quadrant shows more experimental subjects (Cell Biology, Biochemistry & Molecular Biology, Developmental Biology, Endocrinology & Metabolism, Toxicology and Pharmacology & Pharmacy) as well as the only two branches of Psychology not present in the previously discussed quadrant (as the most different from other psychology areas under these parameters): Psychology, Multidisciplinary, and Psychology, Biological.

The lower right quadrant contains the area with the highest productivity and frequency in Neurosciences research, as well as four clusters of more specialized authors. This quadrant does not presuppose an umbrella theme and contains areas that are the most different from each other. This may be explained by the analysis of previous clusters (Figure 1), indicating that studies published under Neurosciences connect to a larger number of additional areas than other branches. Finally, the lower left quadrant comprises the same number of authors as the last two clusters (six groups of authors), with greater dispersion between fields. Orthopedics, Health Care Science & Services, General & Internal Medicine, Surgery and Oncology are similar areas, but exhibit have more distinct patterns from other branches. Additional areas linked to clinical research are also observed.

Figure 3 - Correspondence analysis between areas and most productive author clusters from WoS, 2006-2013



Source: research data prepared with Gephi software presented in Microsoft Excel

4 DISCUSSION AND FINAL CONSIDERATIONS

This study outlines Brazilian Neurosciences research and identifies its main activity patterns, such as Neurosciences, Psychiatry and Clinical Neurology, as the most productive areas. It is interesting to note the situation in other countries. In Iran, for example, the main areas of Neurosciences research focus on issues related to Neuropharmacology, Neurology, Neuroanatomy and Neurophysiology (ASHRAFI et al., 2012). This result was based on two WC labels used in the search and subsequent classification carried out by experts, demonstrating that areas within Neurosciences also stand out when compared to others in the country. Canadian Neurosciences studies, produced specifically by the province of Alberta (HAUSTEIN; CÓTÉ; BEAUDET, 2013), were identified in 50 research topics, with several areas of excellence (which are important because they produce better scientific results) and Neuroimaging as an area that is losing ground.

In Brazil, the frequency of Behavioral Science in Neurosciences research and output is also noteworthy considering the importance given to this approach in the minutes of the SBNeC (VENTURA, 2010), a Brazilian society dedicated to the field. The importance of this facet connected to behavioral areas does not seem to be unanimous in all countries, since it is not mentioned in the definition and analysis of

Neurosciences in other nations, including Cuba (DORTA-CONTRERAS et al., 2008) and India (SHAHABUDDIN, 2013).

The division between experimental Neurosciences research and clinical Neurosciences research, pointed out by Baschechi and Guerreiro (2004) and Ventura (2004, 2010), is evident in this study, both in terms of groups of authors specializing in publications and studies in certain fields and related areas, and in the co-occurrence between them. The majority of author clusters in Brazilian Neurosciences scientific output publish articles on subjects related to Psychology, Psychiatry and Occupational Health. However, many groups specialize in research labeled specifically as Neurosciences (also the area with the greatest frequency), which is also the most interdisciplinary research since it is connected to a larger number of additional areas than other fields and exhibits the highest productivity.

This study aimed to identify the areas that make up mainstream Brazilian Neurosciences research between 2006 and 2013, demonstrating that this important field is essentially interdisciplinary and therefore exhibits different publication and scientific activity patterns. It is evident that research on emerging topics is not unique to traditionally leading countries in science (GLÄNZEL, 2012), and in this respect Brazil is gaining ground and should continue focus its efforts accordingly. As such, further research is underway to study additional aspects of the field in the Brazilian context, since it is important to understand our existing science in order to plan the science of the future, with a view to ensuring that Brazil becomes not only one of the world's most productive Neurosciences research countries, but also one of the most competitive.

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ÁREAS DE PESQUISA EM NEUROCIÊNCIAS BRASILEIRAS: uma análise bibliométrica de 2006 a 2013

RESUMO *Utiliza-se bibliometria para analisar as áreas que compõem a pesquisa em Neurociências brasileira, a evolução anual da especialização e a relação entre categorias científicas e produtividade dos autores através de 9655 artigos publicados na Web of Science entre 2006 e 2013. Identifica 71 áreas componentes da transdisciplinaridade da produção científica brasileira em Neurociências e divisão entre pesquisa clínica e pesquisa básica/experimental, sendo as três áreas mais importantes a Neurosciences (Neurociências, maior frequência e coocorrência, principalmente com disciplinas "experimentais"), a Psychiatry (Psiquiatria, presente nos três primeiros anos da pesquisa) e Clinical Neurology (Neurologia Clínica, ligada, assim como Psychiatry, a outras disciplinas clínicas), além da importância das disciplinas voltadas aos estudos do comportamento. 92 clusteres de autores foram identificados, com notáveis diferenças entre os hábitos de publicação dos autores mais e menos produtivos. Os pesquisadores se especializam em determinadas temáticas e há maior número de grupos envolvido com pesquisa nas disciplinas de Psicologia, de Psiquiatria e Saúde Ocupacional.*

Palavras-chave*: Neurociências. Produção científica. Áreas científicas. Bibliometria. Cientometria.*

REFERENCES

ASHRAFI, Farzad et al. Iranian's contribution to world literature on Neuroscience. **Health Information and Libraries Journal**, Malden, v. 29, p. 323-332, 2012.

BACHESCHI, Luiz Alberto; GUERREIRO, Carlos A. M. Situação das Neurociências no Brasil: Neurociências clínicas. **Ciência e Cultura**, São Paulo, v. 56, n. 1, p. 25-26, jan. 2004.

DORTA-CONTRERAS, Alberto Juan et al. Productividad y visibilidad de lós neurocientíficos cubanos: estúdio bibliométrico del período 2001-2005. **Revista de Neurología**, Barcelona, v. 47, n. 7, p. 355-360, 2008.

FALAGAS, Matthew E. et al. Comparison of PubMed, Scopus, Web of Science, and Google Scholar: strengths and weaknesses. **The Federation of American Societies for Experimental Biology Journal**, Bethesda, v. 22 n. 2, p. 338-342, Feb. 2008.

GLÄNZEL, Wolfgang. Bibliometric methods for detecting and analyzing emerging research topics. **El Profesional de la Información**, Barcelona, v. 21, n. 2, p. 194-201, 2012.

GLÄNZEL, Wolfgang; DANNEL, Rickard; PERSSON, Olle. The decline of Swedish Neuroscience: decomposing a bibliometric national science indicator. **Scientometrics**, Dordrecht, v. 57, n. 2, p. 197-213, 2003.

GLÄNZEL, Wolfgang; LETA, Jacqueline; THIJS, Bart. Science in Brazil. Part 1: a macro-level comparative study. **Scientometrics**, Dordrecht, v. 67, n. 1, p. 67-86, 2006.

GÓMEZ CARIDAD, Isabel; BORDONS GANGA, María. Limitaciones en el uso de los indicadores bibliométricos para la evaluación científica. **Politica Cientifica,** Madrid, v. 46, p. 21-26, 1996.

HAUSTEIN, Stefanie; CÓTÊ, Grégoire; BEAUDET, Alexandre. **State of knowledge production in Neuroscience in Alberta**: a bibliometric assessment. Montréal: Science-Metrix, 2013.

HOPPEN, Natascha Helena Franz; VANZ, Samile Andréa de Souza. Neurosciences in Brazil: a bibliometric study of main characteristics, collaboration and citations. **Scientometrics**, Dordrecht, v. 109, n. 1, p. 121-141, 2016. doi:10.1007/s11192-016-1919-0

HOPPEN, Natascha Helena Franz. **A Neurociências no Brasil de 2006 a 2013, indexada na Web of Science**: produção científica, colaboração e impacto. 2014. 161 f. Dissertação (Mestrado em Comunicação e Informação) - Universidade Federal do Rio Grande do Sul. Porto Alegre, 2014.

LATAPY, Matthieu. Main-memory triangle computations for very large (sparse (power-law)) graphs. **Theoretical Computer Science**, [S.l.], v. 407, n. 1-3, p. 458-473, 2008.

LEYDESDORFF, Loet; BORNMANN, Lutz. The operationalization of "fields" as WoS Subject Categories (WCs) in evaluative bibliometrics: the cases of "Library and Information Science" and "Science & Technology Studies". **Journal of the Association for Information Science and Technology**, Hoboken, v. 67, n. 3, p. 707-714, 2016. doi: 10.1002/asi.23408

NITRINI, Ricardo. The scientific production of Brazilian neurologists: 1995-2004. **Arquivos de Neuro-Psiquiatria**, São Paulo, v. 64, n. 2B, p. 538-542, 2006.

PACKER, Abel L. Os periódicos brasileiros e a comunicação da pesquisa nacional. **Revista USP**, São Paulo, n. 89, p. 26-61, mar./maio 2011.

SHAHABUDDIN, Sheikh Mohammed. Mapping Neuroscience research in India: a bibliometric approach. **Current Science**, Bangalore,v. 104, n. 12, 25 jun. 2013.

THOMSON SCIENTIFIC. **Essential Science Indicators**. New York: Thomson Reuters, c2015. Updated July 9, 2015.

TIMO-IARIA, Cesar. **História da Neurofisiologia no Brasil**. São Paulo: Sociedade Brasileira de Neurociências e Comportamento, [20--]. Disponível em: <http://www.sbnec.org.br/site/index.php?page=historia>. Acesso em: 1 ago. 2015.

VAN ECK, Ness Jan; WALTMAN, Ludo. **VOSviewer manual**: manual for VOSviewer version 1.5.4. [S.l.]: Universiteit Leiden; Erasmus Uiversiteit Rotterdam, 2013.

VELHO, Léa Maria Leme Strini. A avaliação do desempenho científico. **Cadernos USP**, São Paulo, n. 1, p. 22-40, out. 1986.

VENTURA, Dora Fix. Situação das Neurociências no Brasil: disciplinas básicas. **Ciência e Cultura**, São Paulo, v. 56, n. 1, p. 25-26, jan. 2004.

VENTURA, Dora Fix. Um retrato da área de Neurociência e Comportamento no Brasil. **Psicologia: teoria e pesquisa**, Brasília, v. 26, n. especial, p. 123-129, 2010.

XU, Wei; CHEN, Yi-Zhang; SHEN, Zhi-Chao. Neuroscience output of China: a MEDLINE-based bibliometric study. **Scientometrics**, Dordrecht, v. 57, n. 3, p. 399-409, 2003.