Neuromanagement in WOS and SCOPUS: a guide to the first twenty years of the 21st century, from 2001 to 2020

Antonio González-Morales (agmorales@us.es)
Universidad de Sevilla https://orcid.org/0000-0001-9829-2336
María Milagro Martín López (milagros@us.es)
Universidad de Sevilla https://orcid.org/0000-0001-7240-8652

Research Article

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Abstract

The objective of this work is to study the scientific papers on neuromanagement published in the WOS and Scopus databases during the last twenty years and to provide a document that helps readers to get a global idea of this area and select those that may be of their own interest. Initially, a search was carried out in both databases with the term neuromanagement. Then, a filter was made using inclusion and exclusion rules in the article. The inclusion criterion or rule was that the article dealt with neuroscience issues applied to the management of companies or organizations.

Highlights

The study of emotional arousal and valence are fundamental in modern management. Today there is a deeper understanding of the way in which emotions influence decision-making, memory and involvement; in short, in the way in which people are going to perceive and do something. For this reason, management cannot ignore neuromanagement, nor can scientific production; it can be seen that since 2001, when the first scientific publication on neuromanagement was made, these years have shown a greater scientific production in this area.

Key words: neuromanagement, business neuroscience, neuromarketing, emotion, affect, and bibliographic study.

JEL Classification: M10, M30

1. Introduction

The objective of this research is to carry out a bibliographic review, the main objective of which is to compile the existing scientific knowledge on neuromanagement that has been published in journals indexed in the WOS and Scopus databases, (considered two very important databases at the international level and easily accessible from the universities).

Scientific production in this area is very recent and has not been studied for many years, just enough to give the reader an idea of the beginning of these publications. Therefore, the time frame of the research ranged from 2001 (the year in which it is understood that the first scientific article was published in the journal called` Neuron`) to 2020; this research was carried out in 2021.

Currently neuroscience is evolving very quickly, which has led to it being applied to different areas of the company such as marketing, as proposed by (González-Morales, 2020), but the knowledge that neuroscience is providing about human behaviour is also very important in other areas of companies. This has allowed the study of aspects of human behaviour based on stimuli and reactions of the brain in the environment of the administration of organizations (Mendoza, 2018).

Business management is in need of new resources and tools to adapt to such a complex, competitive and changing environment that has generated the digital revolution and new economic trends. At present, a study of the purchasing processes and in general of the decision-making that needs to be taken in organizations is needed. Proposing neuromanagement is the new approach to helping business management (Parincu, Capatina, Varon, Bennet, & Recuerda, 2020)

Advances in neuromanagement have generated new knowledge that can be used by managers of organizations to better coordinate work teams and communicate more efficiently. The changes that take place at a global level require that organizations develop new strategies to be able to face the challenges that arise. The neuromanagement concept was first conceptualized by Qingguo Ma, administrator of the Neuromanagement laboratory at Zhejiang College (Ma & Wang, 2006).

Paul J. Zak used the term neuromanagement to describe how the findings of neuroscience can be used to create organizational cultures that motivate employees, cultivate trust and positive experiences and also generate a high level of organizational performance (Zeki & Zak, 2004).

Neuromanagement is a scientific approach to management, which explores management, economic and behavioural processes from the perspective of brain activity and the way it reacts. It is a discipline of neuroscience and aims to explore the activities of the human brain and mental processes when people are faced with managing situations, using cognitive neuroscience, in conjunction with other scientific disciplines and technology, to analyze economic issues and management.

The first formal article on neuromanagement was published in 2001 in the Journal Neuron. This represented the collaboration between Breiter, Shizgal and Kahneman, who combined the theory of psychological perspective in the decision-making procedure (Kahneman & Tversky, 1979) and brain scanning, an experiment that demonstrated certain assumptions about the activation of the brain involved in the decision-making procedure (Breiter, Aharon, Kahneman, Dale, & Shizgal, 2001).

Neuromanagement is conceived around the way in which the human brain and its functions are predominantly organized, for better self-management, to obtain superior performance, to generate relationships of involvement, motivation, collaboration and communication. Unlike traditional management methods that attempt to use reason and authority to control people's behaviour, neuromanagement works through emotions, respect, involvement, and motivation. (Parincu, Capatina, Varon, Bennet, & Recuerda, 2020).

Therefore it is important to bear in mind that there is a need for a proactive, motivating, leading business management that encourages the organization to make concrete progress, with a global and collective vision (Méndez & Ferrer, 2017).

Neuroscience has generated many connections with other sciences. This provokes a great debate not only in scientific research and technology, but also in social science, arts and humanities research. Interdisciplinarity is believed to become an increasingly important concept in science. Examples of the union between neuroscience and social sciences are neuromarketing, neuromanagement, neuro communication and neuroeducation, among others. Valanciene (2016) raises the question of whether the dialogue between neuroscience and social sciences is inevitable and essential.

1.1. Bibliometric

Bibliometry is part of scientometry and is based on the quantitative study of scientific development through literature, analyzing the nature and course of a scientific specialty. The

components used in bibliometric studies are the so-called bibliometric indicators (Escorcia, 2008), whose purpose is to measure aspects such as “the impact of scientific dissemination, productivity, the number of citations received, trend analysis, collaboration between publications or the connection between authors, among others” (Rodríguez, Sáenz, Arroyo, Herrera, De la Rosa Barranco, & Caballero-Uribe, 2009*)*).

Bibliographic research is very useful in understanding different aspects of scientific production such as finding authors, topics and types of documents in a research area; it also helps us to know the contribution of authors in a certain field of research and the pattern of citations. It also informs us of the journals that they publish on a certain topic and their impact factor” (Escorcia, 2008).

To develop a study of this type, computer databases are used, which are made up of a set of records that have bibliographic information. Most databases have descriptors, abstracts, keywords, and full publications, allowing long and in-depth searches.

1.2 From management to neuromanagement

For a long time, communication and marketing professionals have been trying to evaluate texts, images and other issues that can influence the effectiveness of communication using the techniques of market research. The above issues have been evaluated through questionnaires, interviews, focus groups and other traditional techniques (Keller & Kotler, 2012).

However, these have not yielded the desired results due to a number of issues, one of which is that when people participate, they sometimes do not really know how to answer what they are being asked because they are emotionally charged (Hernández, 2014), or they may lie (Huelva & Chaves, 2002). There may also be a lack of involvement and participants may not even bother to look for the right question.

Neuroscience and its technological improvement and knowledge of this field in the last 20 years have opened a different path to market studies using traditional techniques to understand and evaluate marketing decisions such as marketing communication, products and other marketing variables (McClure, Tomlin, Cypert, Montague, & Montagues, 2004), giving rise to what is known as neuromarketing.

In the same way, it could be said that neuroscience could help company directors in their decision-making by analyzing the emotion of people in work groups, in jobs, in terms of commitment to a project or position of work and many other issues.

The author Álvarez (2007, p.383) states, after learning about the contributions of neuroscience with respect to human behaviour, that "it seems that, in order to understand the complexities of our current society, the conventional and more classical formulations are not enough and that it seems necessary to rethink everything from the perspective of neuroscience".

Neurosciences and their techniques can help creators improve their understanding of the tastes of viewers, confirming this by stating that through neuroscience experimental research the consumer`s experience is analyzed through objective, systematic and replicable measurements. And in the same way that emotions are studied to make decisions in marketing matters, they must be studied to make management decisions through neuromanagement (Shimamura, 2013) With the use of technological equipment, neuromarketing / neuro communication allows the recording and measurement of brain activity and psychophysiological variables associated with different emotional states that occur when a subject is exposed to a stimulus. These are related to their attention and memorization (González-Morales, Mitrovic, & Garcia, 2020), analysing the two emotional dimensions: excitement and valence (González-Morales, 2018). In the same way, it can be applied to the management of jobs, personnel selection, motivational and trust actions. In this way, it is possible to understand the step from management based on interviews, questionnaires and other means of knowing the feelings and emotions of employees and collaborators, to neuromanagement, based on neuroscience teams that allows knowing the same, but in a more reliable and objective way .

The objective of this work is to analyse bibliographically the scientific production on neuromanagement published and collected in the WOS and Scopus databases, with the specific objectives of knowing:

- The evolution of the number of publications on neuromanagement in each year and type of documents.
- The questions being studied.
- The citations obtained by the different articles.
- The authors, foundations and countries that have generated knowledge.

2. Materials and methods

2.1 Material

The material used has been the scientific works collected in the Web of Science (WOS) and Scopus databases.

2.1.1 Web of Science (WOS)

It is the provider of information and technology for the global scientific research community.

Provides data, analysis and insights, as well as workflow tools and personalized professional services to researchers and the entire research community that supports the research: universities and research institutions, national and local governments, public research funding organizations and private publishers and intensive investigations. (WOS, 2021).

2.1.2 Scopus

It uniquely combines a comprehensive synthesis and citation database, curated by experts, with enriched data and associated academic literature in a wide variety of specialties.

Scopus quickly finds relevant and authoritative research, identifies experts, and provides access to trusted data, metrics, and analytical tools. (Burnham, 2006).

2.2 Methods

A review of the literature has been carried out through a cross-sectional exploratory research with a qualitative approach, through which the scientific contributions are collected under the term “neuromanagement” collected in the WOS and Scopus databases between the years 2000 and 2020, inclusive.

The works had to be published between the year 2000 (since 2001 is considered the year in which the first neuromanagement article is published) and 2020, inclusive. This time limitation was chosen to group all the works indexed in WOS and Scopus up to the present by complete years, excluding the year 2021 in which the study for this work was developed.

With all the results, those that met the inclusion rules were verified: that the title referred to the topic, that the keywords did so, and that the abstract provided knowledge on this topic.

A total of 9 study variables were determined:

- Number of publications per year.
- Main authors.
- Research domains.
- Types of documents.
- Conference / meeting titles.
- Editors.
- Joint corporate authorship.
- Publication language

- Research fields.
- Citations of the articles.

The search for scientific works in the databases was carried out using the following procedure:

- - The keyword under which the area of knowledge to be analyzed is published, neuromanagement, was chosen.
- A search for this term was carried out in the two databases.
- Once the different jobs were had (many were in the two databases), a table was made.

The information and data were obtained and analyzed with the data analysis tools of the WOS and Scopus databases. The database provides the number of publications per year, the sources, the authors, the publications according to the country, the type of document in question (articles, interviews, reviews ...), the area (scientific technology, social sciences, arts and humanities, neuroscience, psychology, etc.) and language.

Subsequently, a descriptive statistical study was carried out, using the graphics provided by the databases themselves and a content analysis.

3. **Results**

As a result of the search, 43 references were obtained in the WOS database and 42 in Scopus. Many of them were collected in both bases, a total of 40 works were collected in both, for which a sum of 45 different works was worked. Which are collected in table 1.

Article	Author
1. Ma, Q., Zhang, L., & Wang, M. (2019). Corrigendum: "You Win, You Buy"—How Continuous Win Effect Influence Consumers' Price Perception: An ERP Study. Frontiers in neuroscience, 13, 167.	Ma, Q., Zhang, L., & Wang, M.
2. Ma, Q., Shang, Q., Bian, J., & Fu, H. (2011). A research on the application of physiological status information to productivity enhancement. In Electrical Engineering and Control (pp. 801-808). Springer, Berlin, Heidelberg.	Ma, Q., Shang, Q., Bian, J., & Fu, H.
3. Crivelli, D., & Balconi, M. (2017). Agency and social skills: Theoretical remarks and implications for management. RICERCHE DI PSICOLOGIA, (3), 349-363.	Crivelli, D., & Balconi, M.
4. Opris, I., Ionescu, S. C., Lebedev, M. A., Boy, F., Lewinski, P., & Ballerini, L. (2020). Application of neural technology to neuro-management and neuro-marketing. Frontiers in neuroscience, 14, 53.	Opris, I., Ionescu, S. C., Lebedev, M. A., Boy, F., Lewinski, P., & Ballerini, L.
5. Ma, Q. G., Hu, L. F., Pei, G. X., Ren, P. Y., & Ge, P. (2014). Applying neuroscience to tourism management: a primary exploration of neurotourism. In Applied Mechanics and Materials (Vol. 670, pp. 1637-1640). Trans Tech Publications Ltd.	Ma, Q. G., Hu, L. F., Pei, G. X., Ren, P. Y., & Ge, P.

6. Duan, R. (2018). Cognitive Mechanism of Economic Management Risk Based on EEG Analysis. NeuroQuantology, 16(6). — Duan

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15. Shang, Q., Pei, G., Dai, S., & Wang, X. (2017). Logo effects on brand extension evaluations from the electrophysiological perspective. Frontiers in neuroscience, 11, 113. — Shang, Q., Pei, G., Dai, S., & Wang, X.

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37. Balconi, M., & Fronda, G. (2020). The dialogue between two or more brains: the “Hyperscanning” for organization. Frontiers in Psychology, 11.	Balconi, M., & Fronda, G.
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39. Ma, Q., Jin, J., & Xu, Q. (2014). The evidence of dual conflict in the evaluation of brand extension: an event-related potential study. Journal of Management Analytics, 1(1), 42-54.	Ma, Q., Jin, J., & Xu, Q.
40. Ma, Q., Bai, X., Pei, G., & Xu, Z. (2018). The hazard perception for the surrounding shape of warning signs: evidence from an event-related potentials study. Frontiers in neuroscience, 12, 824.	Ma, Q., Bai, X., Pei, G., & Xu, Z.
41. Ma, Q., & Hu, L. (2019). The Influence of the consumer ethnocentrism and cultural familiarity on brand preference: Evidence of Event-Related Potential (ERP). Frontiers in human neuroscience, 13, 220.	Ma, Q., & Hu, L.
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43. Yu, W., Sun, Z., Xu, T., & Ma, Q. (2018). Things become appealing when I win: Neural evidence of the influence of competition outcomes on brand preference. Frontiers in neuroscience, 12, 779.	Yu, W., Sun, Z., Xu, T., & Ma, Q.
44. Ma, Q., Qiu, W., Fu, H., & Sun, X. (2018). Uncertain is worse: modulation of anxiety on pain anticipation by intensity uncertainty: evidence from the ERP study. Neuroreport, 29(12), 1023-1029.	Ma, Q., Qiu, W., Fu, H., & Sun, X.
45. Venturella, I., Gatti, L., Vanutelli, M. E., & Balconi, M. (2017). When brains dialogue by synchronized or unsynchronized languages: hyperscanning applications to neuromanagement.	Venturella, I., Gatti, L., Vanutelli, M. E., & Balconi, M.

Table 1. Works on neuromanagement collected in the WOS and SCOPUS databases. Source: Regaña, 2021.

3.1 Number of published works

The first study that was carried out was the evolution of the number of papers published under the term neuromanagement over time, during the selected period. Obtaining that in the WOS database the first reference dates from the year 2010 and the last ones from the year 2020, so the period in which scientific works collected in this database have been published is 10 years,

being the years 2017, 2018 and 2019 the three years with the highest number of publications. The data is represented in figure 1.

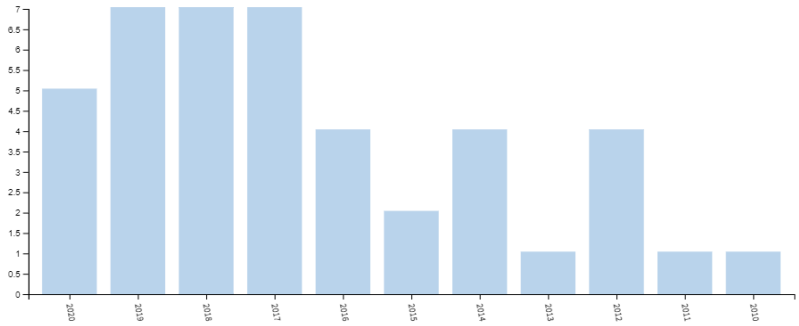

Figure 1. Number of annual publications on neuromanagement in WOS. Source: Source: Web of Science.

In the SCOPUS database, the first reference dates from 2011 and the last ones from 2020, so the period in which scientific works collected in this database have been published is 9 years, being the years 2018 and 2019 the two years with the highest number of publications, a total of 8 every year. The data is represented in figure 2.

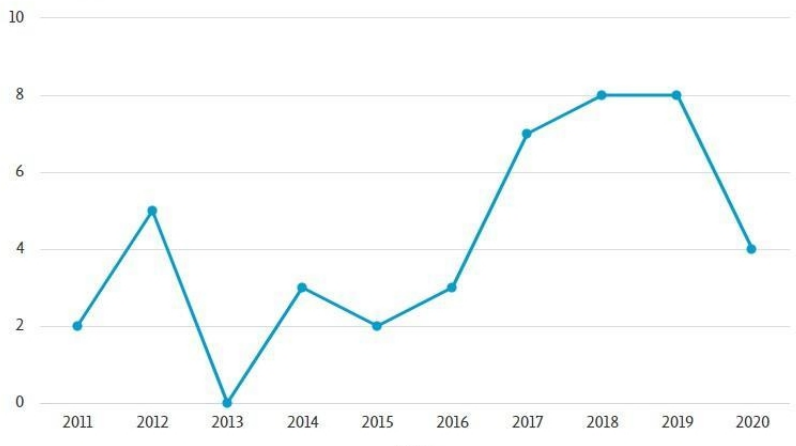

Figure 2. Number of annual publications on neuromanagement in SCOPUS. Source: SCOPUS.

3.2 Main authors

Regarding the authors who published articles related to neuromanagement, figure 3 shows the 10 authors with the highest number of publications in WOS, among which MA, QG stand out, with a total of 18 publications. The authors who signed a single publication were 33. The data is represented in figure 3.

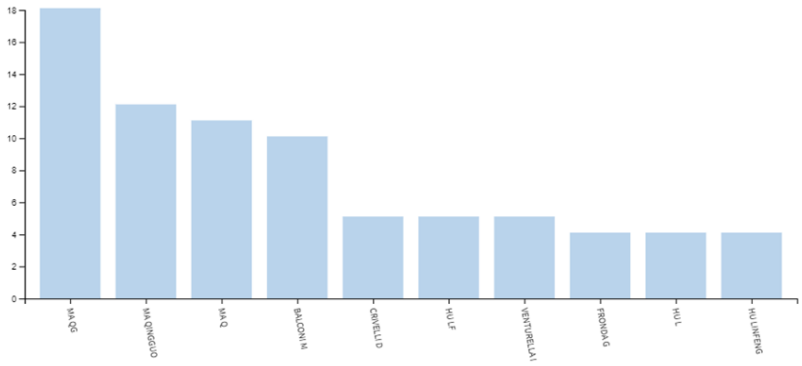

Figure 3. Authors with more scientific elaboration on neuromanagement in WOS. Source: Web of Science.

Regarding the authors who published articles related to neuromanagement, shows the 10 authors with the highest number of publications in SCOPUS, among which MA, QG stand out, with a total of 18 publications. The data is represented in figure 4.

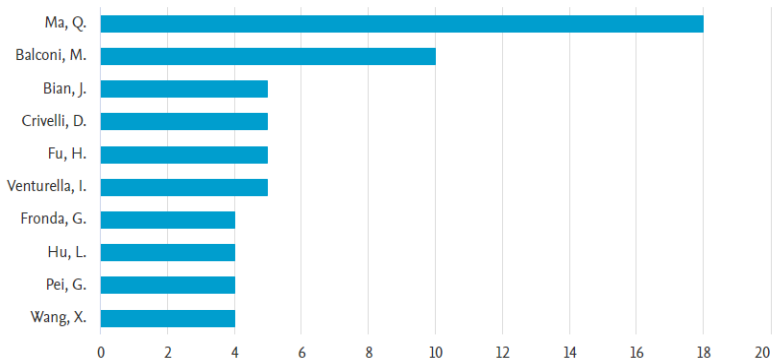

Figure 4. Authors with more scientific elaboration on neuromanagement in Scopus Fuente: Scopus.

3.3 Research knowledge areas

Paying attention to the areas of knowledge, figure 5 presents a bar graph that represents the 25 areas of research with the most scientific elaboration on neuromanagement in WOS. There are 26 areas of scientific research, highlighting the area of Neurosciences neurology with a greater number of publications, being 17, followed by Psychology with 15 publications, Behavioral Sciences with 12 and Economic Business with 6 publications.

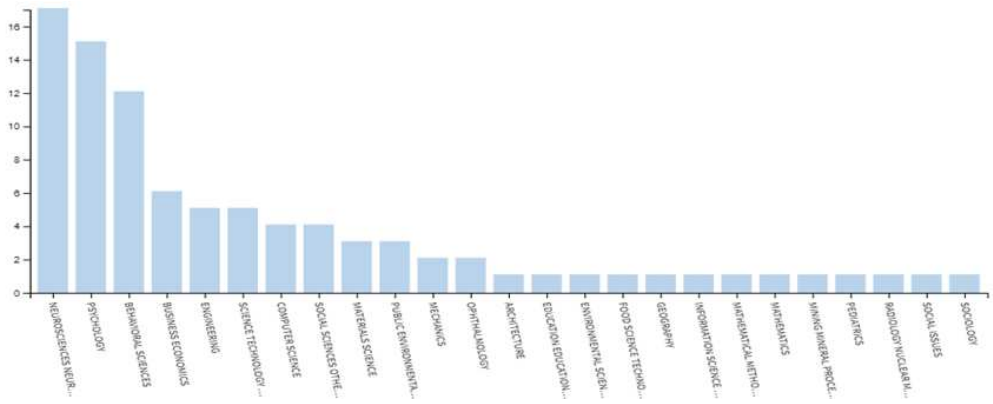

Figure 5. Areas of knowledge on neuromanagement in WOS. Source: Web of Science.

Figure 6 shows the percentage distribution of research areas in which neuromanagement works have been published in Scopus. The sum amounts to 99.9%, due to the fact that there is a publication in 2021 that is not within our time interval. There are 13 areas of scientific knowledge, highlighting the area of Neuroscience for being the one that presents the greatest amount of information with 22 publications, followed by Psychology with 11, Business, management and accounting with 6 publications and Engineering with 5 publications.

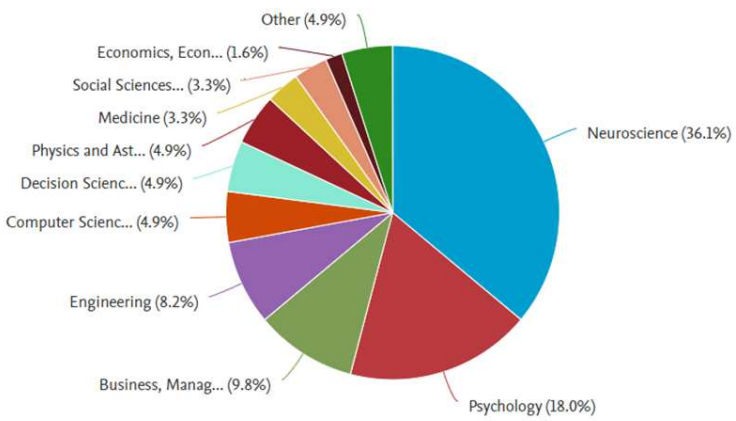

Figure 6. Areas of knowledge on neuromanagement in Scopus. Source: Scopus.

3.4 Mean Institutions

The researchers who published articles on neuromanagement were linked to 55 organisms. Figure 7 shows the 10 institutions that published the most in articles collected by WOS to which a greater number of references were assigned, among which Zhejiang University stands out with 18. In addition, 11 institutions have carried out a single study on neuromanagement.

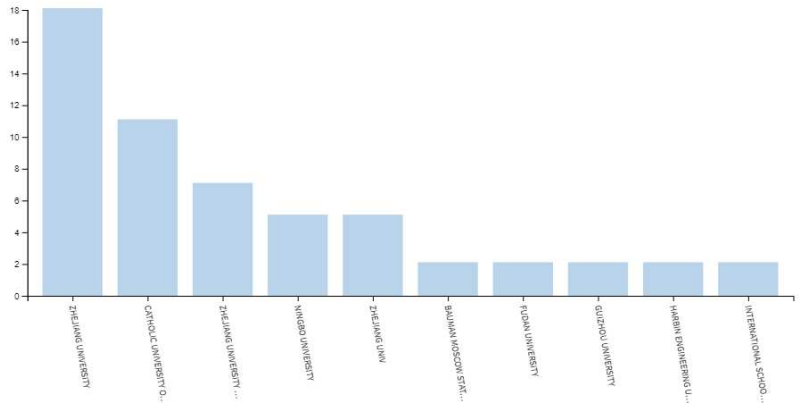

Figure 7. Institutions with the greatest scientific production on neuromanagement in WOS. Source: WOS.

The figure 8 shows the 10 institutions with the highest number of publications in Scopus, also highlighting Zhejiang University, with 20 publications.

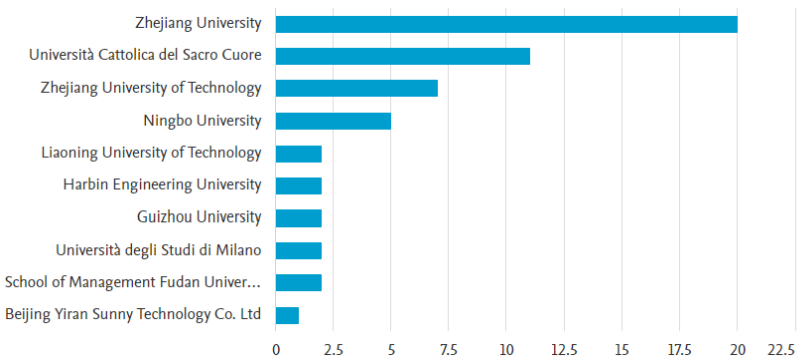

Figure 8. Institutions with the greatest scientific production on neuromanagement in Scopus. Source: Scopus.

3.5 Main countries

Regarding the number of publications per country in WOS, Peoples R China notably predominates with 21 publications (48,837% of the total), followed by Italy with 13 publications (30,233% of the total). The remaining countries are below 5 posts. In 2 of the publications (4,651% of the total) the country of origin is not determined. See figure 9.

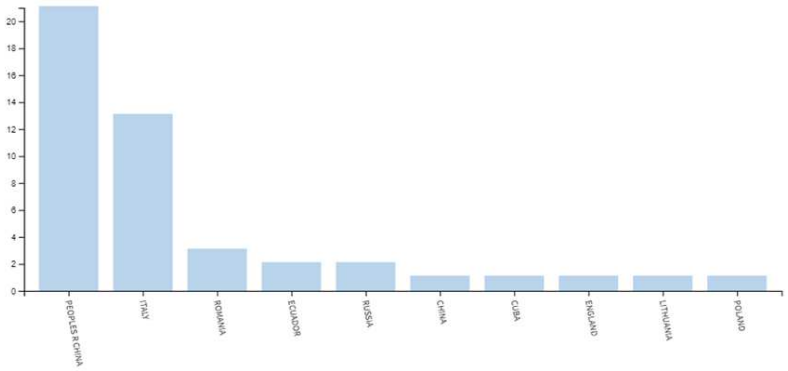

Figure 9. Number of publications by country in WOS. Source: WOS.

Figure 10 shows the publications by country in Scopus, with China standing out with 25 publications, followed by Italy with 12. The other countries are below 5 publications.

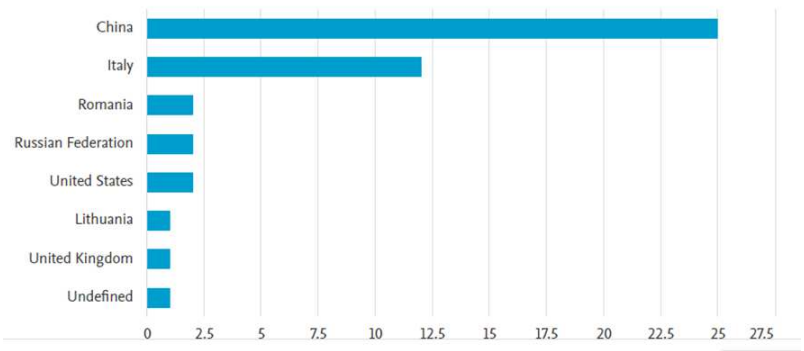

Figure 10. Number of publications by country in Scopus. Source: Scopus.

3.6 Main typologies

In relation to the typologies of the publications, Figures 11 and 12 show the typology in the WOS and Scopus databases respectively. They show that the type of document most used to publish scientific literature on neuromanagement is the scientific article, with 37 publications in WOS and 29 in Scopus, followed by meetings and others.

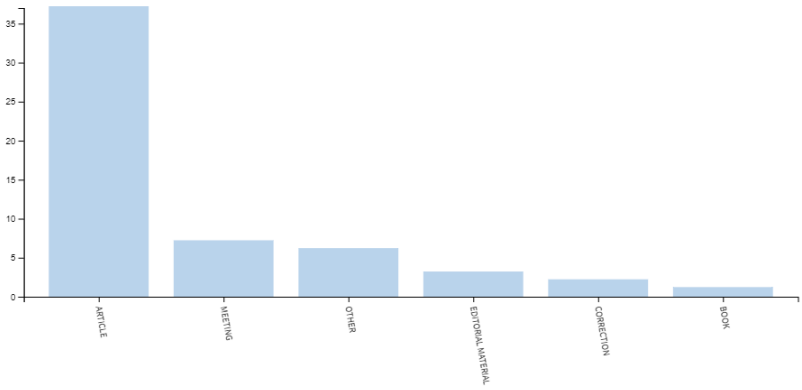

Figure 11. Types of documents published in WOS. Source: WOS.

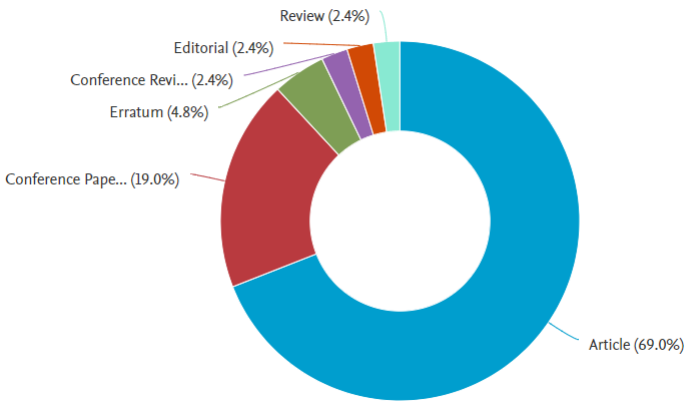

Figure 12. Types of documents published in Scopus. Source: Scopus.

The total number of journals that published works on neuromanagement were 29 in WOS and 18 in Scopus.

Figure 13 shows the 10 journals with the most publications in WOS, among which *Fronteras En Neurociencia* stands out with 8 publications. Figure 14 shows the same in Scopus, coinciding with *Frontiers In Neuroscience* with 8 publications.

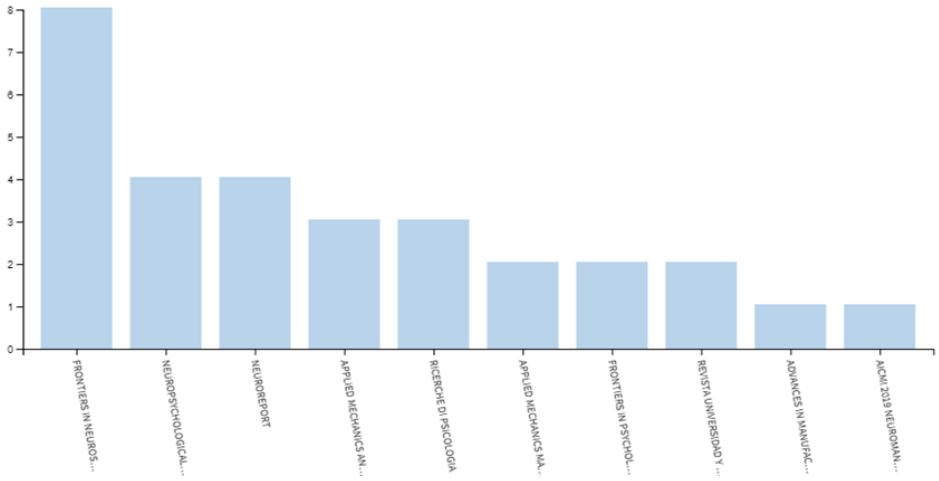

Figure 13. Number of publications in the journals collected in WOS. Source: WOS.

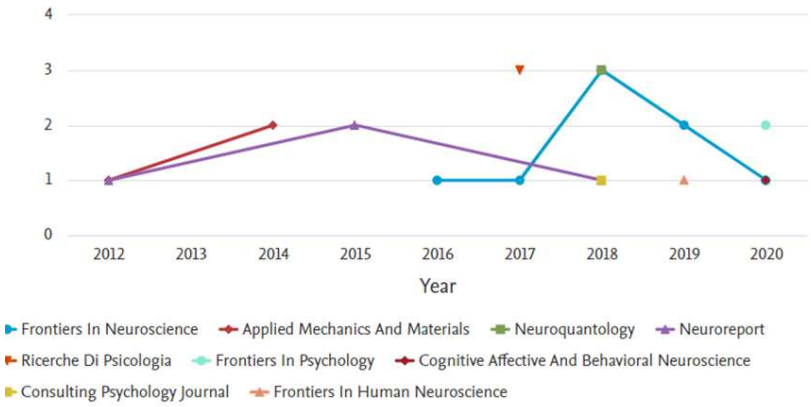

Figure 14. Number of publications in the journals collected in Scopus. Source: Scopus.

3.7 Main languages

Taking care of the language of diffusion, in WOS there are works in 4 languages in which the scientific production on neuromanagement was developed. Among those that visibly predominate, English, with 35 papers (81.40%), followed by Italian with 3 papers (7%), Spain with 3 papers (7%) and Russia with two papers (4.60%). In Scopus, 39 articles were found in English (93%) and 3 in Italian (7%).

3.8 Number of citations of scientific articles

Regarding the citations obtained by each work, the number of citations obtained by each of them is attached in table 2.

	Artícules	Citas
1.	Ma, Q., Zhang, L., & Wang, M. (2019)	6
2.	Ma, Q., Shang, Q., Bian, J., & Fu, H. (2011)	5

3.	Crivelli, D., & Balconi, M. (2017).	0
4.	Opris, I., Ionescu, S. C., Lebedev, M. A., Boy, F., Lewinski, P., & Ballerini, L. (2020)	2
5.	Ma, Q. G., Hu, L. F., Pei, G. X., Ren, P. Y., & Ge, P. (2014)	14
6.	Duan, R. (2018).	1
7.	Balconi, M., Cassioli, F., Fronda, G., & Vanutelli, M. E. (2019)	2
8.	Bielenia-Grajewska, M. (2013)	12
9.	Liu, H., & Xu, D. (2018)	0
10.	Ma, Q., Hu, L., & Wang, X. (2015)	11
11.	Herrera, C., & Salinas, E. (2018)	1
12.	Wang, X., Huang, Y., Ma, Q., & Li, N. (2012)	62
13.	Ma, Q., Pei, G., & Wang, K. (2015)	14
14.	Valanciene, D. (2016)	3
15.	Shang, Q., Pei, G., Dai, S., & Wang, X. (2017)	12
16.	Babanova, Y. V., Dolinskaia, A. Y., & Gorshenin, V. P. (2016)	2
17.	Ma, Q. G., Shang, Q., Fu, H. J., & Chen, F. Z. (2012)	17
18.	Balconi, M., & Fronda, G. (2020).	5
19.	Zhang, X. (2018)	2
20.	Wang, X., Ma, Q., & Wang, C. (2012)	40
21.	Ma, Q., Shi, L., Hu, L., Liu, Q., Yang, Z., & Wang, Q. (2016)	3
22.	Ma, Q. G. (2015)	4
23.	Balconi, M., Angioletti, L., & Crivelli, D. (2020)	2
24.	Buyankin, V.M. (2010)	0
25.	Ma, Q., Ji, W., Fu, H., & Bian, J. (2012)	7
26.	Da, W. (2019)	0
27.	Venturella, I., & Crivelli, D. (2017)	2
28.	Balconi, M., & Venturella, I. (2017)	1
29.	Balconi, M., & Venturella, I. (2017)	8
30.	TEACU, A. M., Capatina, A., Varon, D. J., Bennet, P. F., & Recuerda, A. M. (2020)	0
31.	Balconi, M., Natale, M. R., Benabdallah, N., & Crivelli, D. (2017)	5
32.	Álvarez-Calderón, J., & García-Rondón, I. (2016)	1
33.	Dumitraşcu-Bălduău, I., & Dumitraşcu, O. (2019)	3
34.	Ma, Q., Bian, J., Ji, W., Tang, Q., & Xu, Q. (2011)	8
35.	Crivelli, D., Fronda, G., Venturella, I., & Balconi, M. (2019)	7
36.	Buyankin, V.M. (2012)	0
37.	Balconi, M., & Fronda, G. (2020)	1
38.	Ma, Q. G., Zhou, X. L., Zhao, L., Bian, J., & Dai, W. H. (2014)	0
39.	Ma, Q., Jin, J., & Xu, Q. (2014)	2
40.	Ma, Q., Bai, X., Pei, G., & Xu, Z. (2018)	7
41.	Ma, Q., & Hu, L. (2019)	9
42.	Zak, P. J. (2018)	38
43.	Yu, W., Sun, Z., Xu, T., & Ma, Q. (2018)	6
44.	Ma, Q., Qiu, W., Fu, H., & Sun, X. (2018)	6
45.	Venturella, I., Gatti, L., Vanutelli, M. E., & Balconi, M. (2017)	15

Table 2. Number of citations of scientific articles. Source: own elaboration.

The number of citations that each work has received has been represented in a horizontal bar diagram in figure 15.

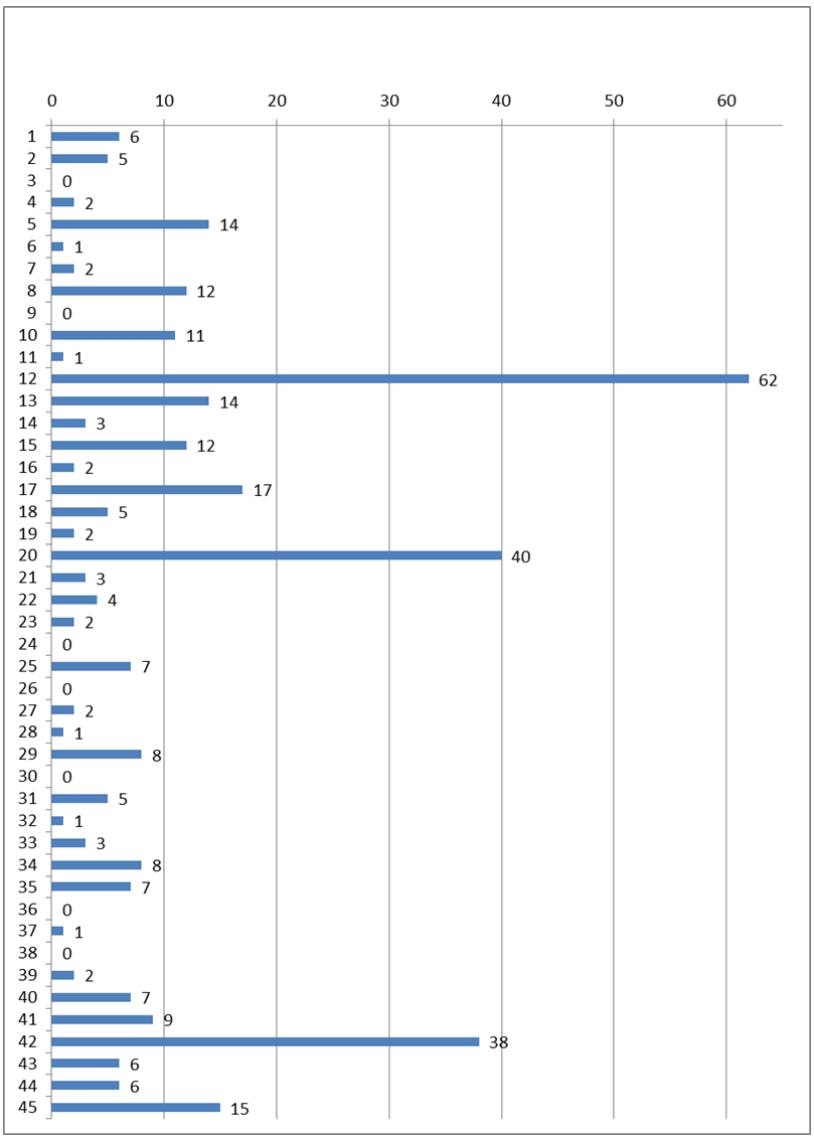

Figure 15. The number of citations that each works. Source: (Regaña, 2021)

4. **Discussion.**

After obtaining the papers collected in the two databases, an analysis of their content has been carried out in order to offer useful information to the reader. In this way it can serve as a guide to the papers collected in the two databases to any person or researcher in neuromanagement, helping them to select the most appropriate papers according to the information they are looking for.

Given that the conclusions that can be reached through experiments normally carried out with neuroscience techniques must be taken with caution due to the small sample size that is usually used, it is necessary to differentiate between two quite different questions: the physiological effects that originate in people facing an aversive stimulus is similar in all people, and this type

of experiment can be generalized with a limited sample size. However, another very different question is to carry out an experiment to find out the stimulus that people understand as aversive .In this case, it is necessary to take a considerable and representative sample of the population that the sample wishes to represent. Therefore, in this work, the information on the type of tool and technique used to carry out the experiments, which is what most researchers tend to look for, will be prioritized over the final conclusions of the experiments themselves, although the objective of the experiment will be shown so that the researcher or the interested party can easily access the work in question.

- Article 1 studies the perception of price in decision-making by EEG using the ERP P2 and P300, the results of both behaviour and ERP indicated that the perception of prices of the subjects was deeply impacted by emotions induced by previous experiences of winning or losing a game previously. In this article the reader can find out how to carry out a similar experiment.
- Article 2 deals with a study with different techniques such as EEG and peripheral meters (EMG, GSR) to study the states of stress and fatigue that generate accidents and errors at work. In this article the reader can find out how to carry out a similar experiment.
- Article 3 does not directly deal with neurosciences applied to companies, but rather a work on social skills in management from a point of view of business management psychology.
- Article 4 is a theory work in which different applications of neuroscience to marketing and management are exposed, explaining the main contributions of the different researchers.
- Article 5 is a pilot study that is carried out using the EEG through evoked potentials in the evaluation of issues related to tourism. Satisfaction, happiness and the intention to repeat the destination. In this article the reader can find out how to carry out a similar experiment.
- Article 6 studies the perception of risk in the economic environment through the use of EEG using the ERP P200 technique. In this article, the reader can discover how to perform a similar experiment.
- Article 7 studies the cerebral synchronization of two types of leadership with their subordinates through hyperscanning by electroencephalogram, demonstrating a greater synchronization in the participatory style than in the authoritarian one. In this article, the reader can discover how to perform a similar experiment.

- Article 8 is a work in which a theoretical treatment is carried out on the tools that could be useful in neuromanagement, although it includes some neurological techniques that are not recommended in the field of neuromanagement.
- Article 9 studies the brain reactions to EEG in terms of their perception of risk in entrepreneurs and their predilection for business collaboration. In this article, the reader can discover how to perform a similar experiment.
- Article 10 is a work in which EEG and ERP techniques are used to study the aesthetics of buildings in architecture. In this article, the reader can discover how to perform a similar experiment.
- Article 11 is a theoretical study in which it is revealed how neuroscience, together with other techniques, should be used to improve the performance of teams.
- Article 12 uses the EEG and the P2 ERP technique to compare the reactions to objects that are considered beautiful versus others that are not considered beautiful. In this article, the reader can discover how to perform a similar experiment.
- Article 13 is a basic experimental psychology work in which the perception of risk is studied in terms of saving lives in the face of negative emotions and relates it to decision-making, through EEG using the ERP technique P2, P3 and N2 . In this article, the reader can discover how to perform a similar experiment.
- Article 14 is a theoretical work that reflects on the application of neuroscience to the social sciences.
- Article 15 is a work that studies the acceptance of brand extensions by EEG following the ERP P300 and N2 technique. In this article, the reader can discover how to perform a similar experiment.
- Article 16 is a theoretical work in which the ability to manage the emotions of employees is related to the success of the leader.
- Article 17 is a work in which the mental workload of the employees is studied with EEG and peripheral meters (GSR). In this article, the reader can discover how to perform a similar experiment.
- Article 18 is a study using fNIRS in moral decision making, highlighting the different areas of the brain involved in fair and unfair offers. In this article, the reader can discover how to perform a similar experiment.

- Article 19 studies motivation in business management by EEG using the technique of evoked potentials feedback-related negativity (FRN) and P300. In this article, the reader can discover how to perform a similar experiment.
- Article 20 studies the acceptance of brand extension by EEG using the ERP N400. In this article, the reader can discover how to perform a similar experiment.
- Article 21 studies the different brain processing and effect of sentences depending on whether they are severe and dissuasive sentences or soft and kind sentences, using electroencephalography following the ERP P300 technique. In this article, the reader can discover how to perform a similar experiment.
- Article 22 is a theoretical article in which it is shown how the instruments used in neuromanagement, eyes-tracker and EEG can contribute to improved military management.
- Article 23 is a theoretical article in which the possibility of using neurosciences in business management is highlighted, but that there are different barriers to knowledge being applied in a general way in companies.
- Article 24 is an article outside the purview of neuromanagement.
- Article 25 is a theoretical article in which the importance and possible application of neurosciences to industrial engineering is stated.
- Article 26 is an article in which a new thematic field is proposed combining neuroscience and artificial intelligence proposing neuro artificial intelligence. It is not about neuromanagement, but it is a tool that could be included in this area.
- Article 27 is a theoretical article in which it is stated that neuromanagement is important because it is necessary to take into account the implicit and explicit factors of communication in business management.
- Article 28 is an article where a pilot study of leadership is carried out using EEG to study the reactions of the brain through hyperscanning to study leadership. In this article, the reader can discover how to perform a similar experiment.
- Article 29 theoretically exposes how neuroscience is important for the management of companies and communication within them.
- Article 30 is a theoretical article that highlights the transition from management to neuro-management, from leadership to neuro-leadership, the role and impact of these concepts in the holistic approach to management science.

- Article 31 theoretically shows how the EEG and the fNIRS can be tools for the company to get closer to the human being in the management of companies.
- Article 32 is a theoretical work in which the different disciplines that come together to give rise to neuromarketing are related although these are the same ones that can be applied to neuromanagement.
- Article 33 is not an article on applied neuroscience, but rather a statistical study in which it is revealed that the cultural factor is one of the variables that most influences the performance of work teams.
- Article 34 is an article in which, with EEG using the ERP P200 technique, the processing of security actions in the industrial context is studied. In this article, the reader can discover how to perform a similar experiment.
- Article 35 studies how through mindfulness combined with EEG it is possible to improve stress management and neurocognitive efficiency. In this article, the reader can discover how to perform a similar experiment.
- Article 36 is an article in which issues other than neuromanagement are studied, using algorithms for complex technical installations.
- Article 37 is a work in which it is shown how by recording the brain activity of two or more people who are communicating, it can be verified that there is a synchronization of brain activity by social activity. Hyperscanning is used. In this article, the reader can discover how to perform a similar experiment.
- Article 38 is an article in which the psychophysiological variables among workers on the surface or in depth are studied in order to avoid accidents that are generated in deep work. In this article, the reader can discover how to perform a similar experiment
- In article 39 a study of conflicts in the brand extension is carried out by EEG using different ERP N270 and N400. In this article, the reader can discover how to perform a similar experiment
- Article 40 is a work in which EEG following the ERP P200, P300, N300 technique verifies that the vertical triangular shape is the one that the brain processes with the greatest intensity, associated with warning signs of dangers. In this article, the reader can find out how to perform a similar experiment
- Article 41 studies ethnocentrism when choosing brands. EEG was used,utilising the ERP N200 technique. Differences were found between brands recommended by people of the same

ethnic origin and brands recommended by people of different ethnic origin. In this article, the reader can find out how to perform a similar experiment.

- Article 42 is a study in which psychological techniques are proposed to improve trust and reduce mistrust in companies.
- Article 43 studies through EEG using different potential ERPs related to emotion, the preference for known and unknown brands according to whether they had been winners or losers in a game that was proposed to them previously, reaching different conclusions. In this article, the reader can discover how to perform a similar experiment
- Article 44 is an article in which the anticipation of pain is studied by EEG and using the ERP technique. It is a study of basic experimental psychology. In this article, the reader can discover how to perform a similar experiment
- Article 45 studies different measures of the peripheral psychophysiological variables and the EEG that occur in the interaction between leader and employee, reaching different conclusions.

Once all the information collected from the articles published under the keyword "neuromanagement" has been analyzed, it is possible to see that there are 18 papers that deal with theoretical contributions that talk about the importance or convenience of applying neuroscience to the social sciences or directly to management; techniques to improve team performance or trust in organizations; contributions from psychology; the possibility of combining neuroscience with other disciplines and other similar issues these are the articles listed as 3, 4, 8, 11, 14, 16, 23, 24, 25, 26, 27, 29, 29, 30, 31, 32, 33, 36, and 42. Among these, there is one that should be highlighted, which is 8, as it provides some techniques that are non-invasive and harmless to humans, so they should not be used in neuromanagement. It can also be seen that articles 24 and 36 belong to other areas.

Therefore, there are 27 articles in which experimental work has been carried out with their own neuromanagement equipment, specifically the use of the electroencephalograph that is used in 24 of the 27 articles (articles 1, 2, 5, 6, 7, 9, 10, 12, 13, 15, 17, 19, 20, 21, 22, 28, 34, 35, 39, 40, 41, 43, 44, and 45), in one the fNIRS is used (article 18) and in two, the meters of the peripheral psychophysiological variables are used (articles 37 and 38).

In those who use the EEG, on three occasions it is combined with meters of peripheral psychophysiological variables (article 2, 17, and 45) and on one occasion with an eye tracker (article 22). When combined with peripheral psychophysiological variables, it studies stress, mental fatigue, the possibility of making errors, and the employee-leader relationship. When combined with an eye tracker, the handling of military equipment is studied (article 22).

On the other hand, studies where two EEGs are used, which is called hyper scanning to study the relationship of brain waves between two people, specifically between a worker and his leader (article 7 and 28) are verified.

In the studies carried out with EEG, those carried out using event-related potentials (ERP) stand out for their greater use. 17 experiments were carried out using this technique, and the potentials used are various, among which the P2, P3, P300, ERP, N2, N270, N400 and FRN, with the most varied studies indicated before in this section.

In the ERP technique in which the analyses are carried out in the frequency domain- a technique mostly used in clinical neuropsychology, which has some advantages and some drawbacks compared to the other method used, the "ecological electroencephalography paradigm", which is analyzed in the time domain (González-Morales, 2020). In the latter, it is possible to study the evolution of brain reactions over time, during a dynamic experiment that can last from seconds to hours. While the ERP technique can only study these reactions to static stimuli. Peripheral psychophysiological meters and eye trackers can also be used in dynamic experiments.

5. **Conclusions**

When examining the temporal evolution of scientific production on neuromanagement between 2001 and 2020, a slight increase in the number of publications can be observed over time, without any year standing out above the others while observing every topic each year, noting if any is gaining more importance. From the results obtained, it was possible to verify that neuromanagement is a growing discipline.

If we study the authors who have published on neuromanagement, we can distinguish that the majority gather a small number of publications, the majority signing a single work. Although quite a few authors have written on this topic, the low number of publications per author indicates the scarcity of writers with a certain level of specialization in neuromanagement.

Neuromanagement helps companies to better develop the emotional aspects of employees, cooperating so that more efficient company management is carried out. The type of motivation that must be used with workers must be both physical and mental to be carried out effectively.

The number of references on neuromanagement in the WOS and Scopus databases from the year 2001 to the year 2020 is 45. The initial references date from 2010 and are currently on the rise. The highest production has occurred in the years 2017 to 2019, possibly 2020, and it has been lower because it has been affected by Covid 19, which is a very recent issue. The author most cited is MA, Q.G. Most scientific publications on neuromanagement are published under the area of neuroscience and psychology. The vast majority of papers are written in English. The institutions with the most papers are Zheijang University and the Università Cattolica del Sacro Cuore. The countries that have published the most are R. China and Italy. Most of the papers are research articles. The scientific journals that have published the most on neuromanagement are Frontiers in Neuroscience, Neuropsychological Trends and Neuroreport.

Most articles have between 1 and 15 citations. The articles “Event related potential P2 correlates of implicit aesthetic experience”, “N400 as an index of uncontrolled categorization processing in brand extension” and “The neuroscience of high-trust organizations” with 62, 40 and 38 citations stand out with the highest number of citations, respectively, whose authors are Wang, Huang, Ma and Li (2012), Wang, Ma and Wang (2012) and Zak (2018).

It can be seen that the topics that have been studied experimentally using ERP are leadership, motivation and communication through hyperscanning. Other topics widely covered are marketing topics such as the study of brand expansion and ethnocentrism in the recommendation of brands through ERP, the perception of price, satisfaction and the intention to repeat a tourist destination.

I have to say that the wide use of electroencephalography is normal due to its cost, versatility, safety and non-invasiveness, in addition to offering very valuable information in the field of neuromanagement. To which is added the possibility of combining with the meters of the peripheral psychophysiological variables, thus forming a perfect combination for the evaluation of valence and emotional arousal. If it is also combined with the eye tracker, whether on a table or with glasses, we get a very powerful tool to carry out infinite neuromanagement studies. On the contrary, there are other tools such as functional magnetic resonance, fNIRS or PET, which do not have as many advantages.

There is another block of 19 articles that are theoretical works on different applications of neuroscience to different topics and their importance, and even psychological techniques to improve business performance.

Topics related to the perception of risk, work stress and mental fatigue, the attraction of objects, the feeling of justice in the face of certain offers, the shape of the signals most associated with the indication of danger and even a technique that combines mindfulness with EEG to control stress.

It is possible to verify how the experimental studies carried out and collected in this article cover a wide range of practical applications in the field of companies and organizations.

From the study of operational marketing variables such as the influence of ethnic origin on brand advice, price perception, user experience satisfaction and intention to repeat it, product design, product perception, the acceptance of brand extension, the preference for known or unknown brands and other infinite applications that could be applied to marketing activity, even applications focused on human resources management, work organization or leadership, among others. In the articles included in this paper, you can find studies on the level of stress, fatigue and accident risks, the perception of economic risk and its tendency towards collaboration between businessmen, the relationship between employees and bosses depending on the different types of leadership, the load of mental health of employees, decision-making, moral decisions, motivation, equipment usability or stress control, to which infinite applications could be included again.

Therefore, after what has been analyzed in this article and checking the potential of applications that it may have, it is possible to affirm that neuromanagement is a tool whose use is in its infancy and that must be greatly developed in order to improve the efficiency and effectiveness of companies, and improve the quality of physical and mental life of human beings.

It must be intensively developed in different applications in order to generate more sustainable happiness over time in the employees of the companies and in the consumers, converting the companies, making them more responsible towards what they feel, want and motivating the human beings who work, direct or buy in them.

6. Limitations and future research

The limitations of this work are the limited number of databases used (WOS and Scopus) for searching documents. This can cause us to leave out references that are not contemplated in

these databases, since despite being two of the most important at the international level, they do not contain all the references.

We encountered several difficulties due to the biases inherent in analyses of this type. The research has been carried out only in the Web of Science (WOS) and Scopus databases, to limit the amount of work and the size of the article; and we found the Google Scholar databases differ from those of WoS and Scopus. In the future, it is desirable to carry out the same study in other databases, with the aim of creating a paper guide as broad as possible that will help researchers to select the articles that are of interest to them and to appreciate the state of knowledge. A comparison of the databases enabled us to extract interesting complementary results.

For an even more exhaustive study in the future, text mining should be used.

The authors declare that they have no conflict of interest.

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Figures

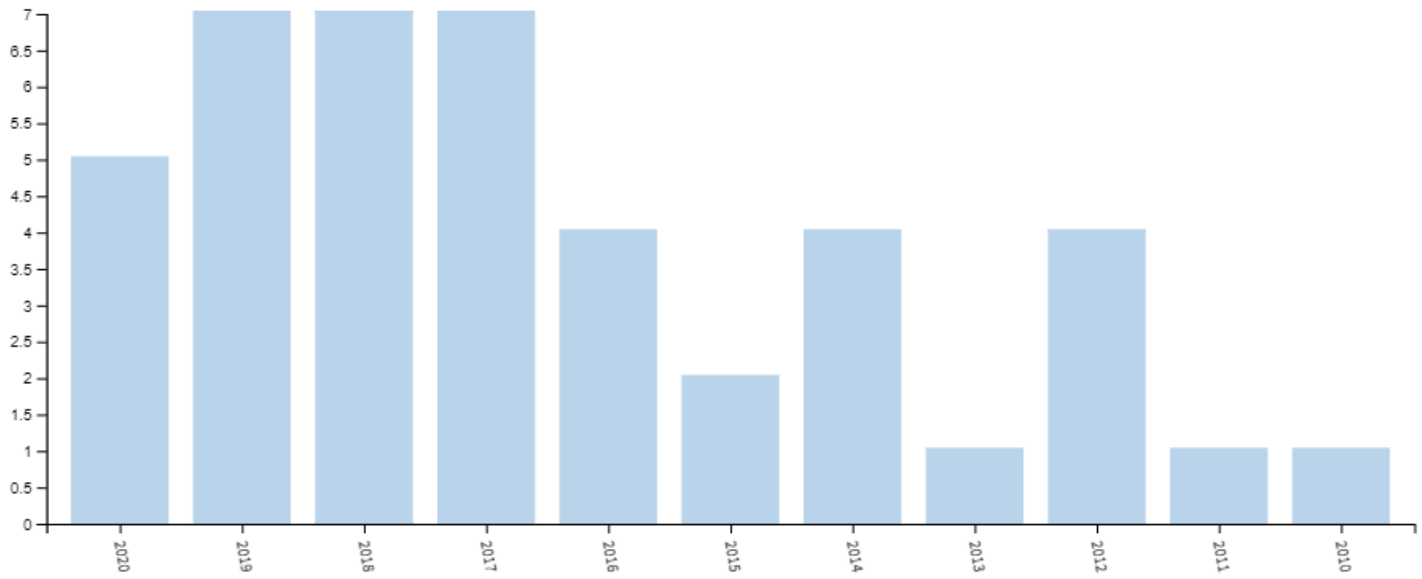

Figure 1

Number of annual publications on neuromanagement in WOS. Source: Source: Web of Science.

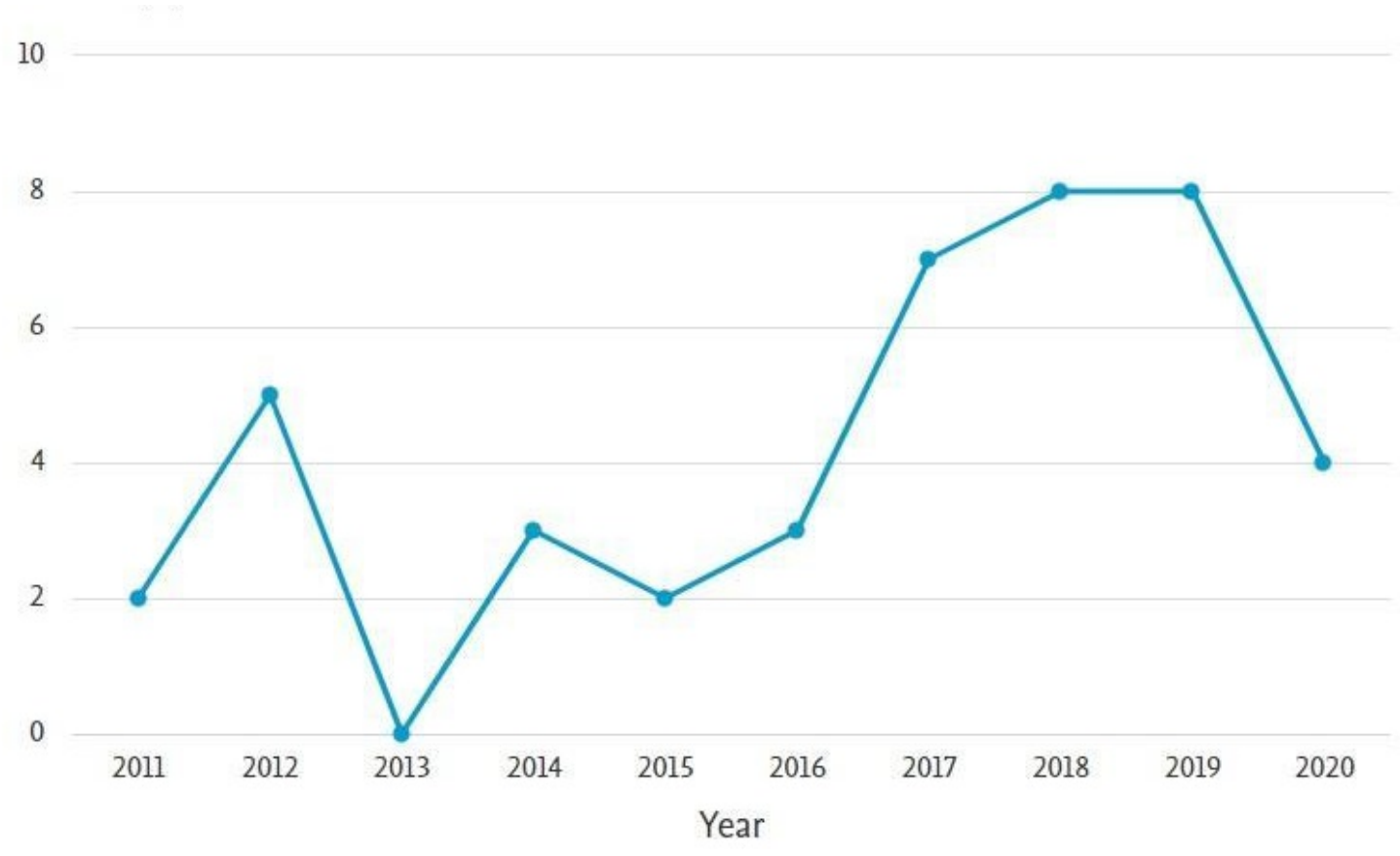

Figure 2

Number of annual publications on neuromanagement in SCOPUS. Source: SCOPUS.

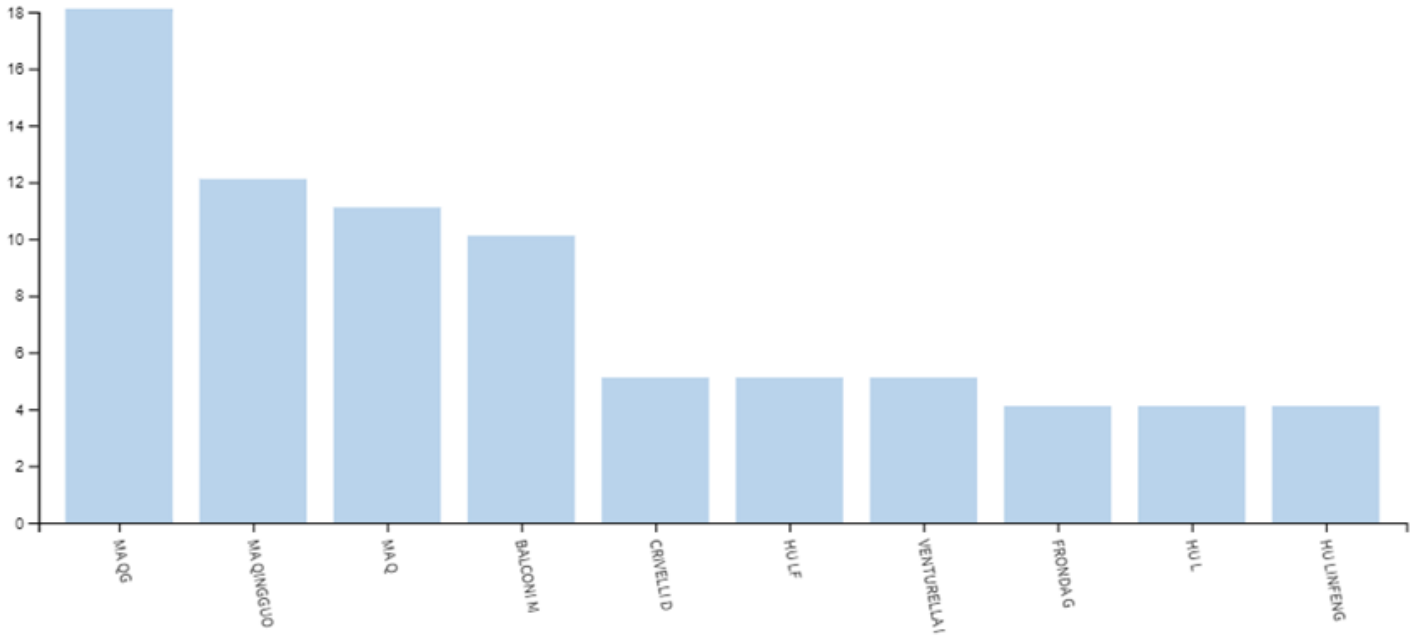

Figure 3

Authors with more scientific elaboration on neuromanagement in WOS. Source: Web of Science.

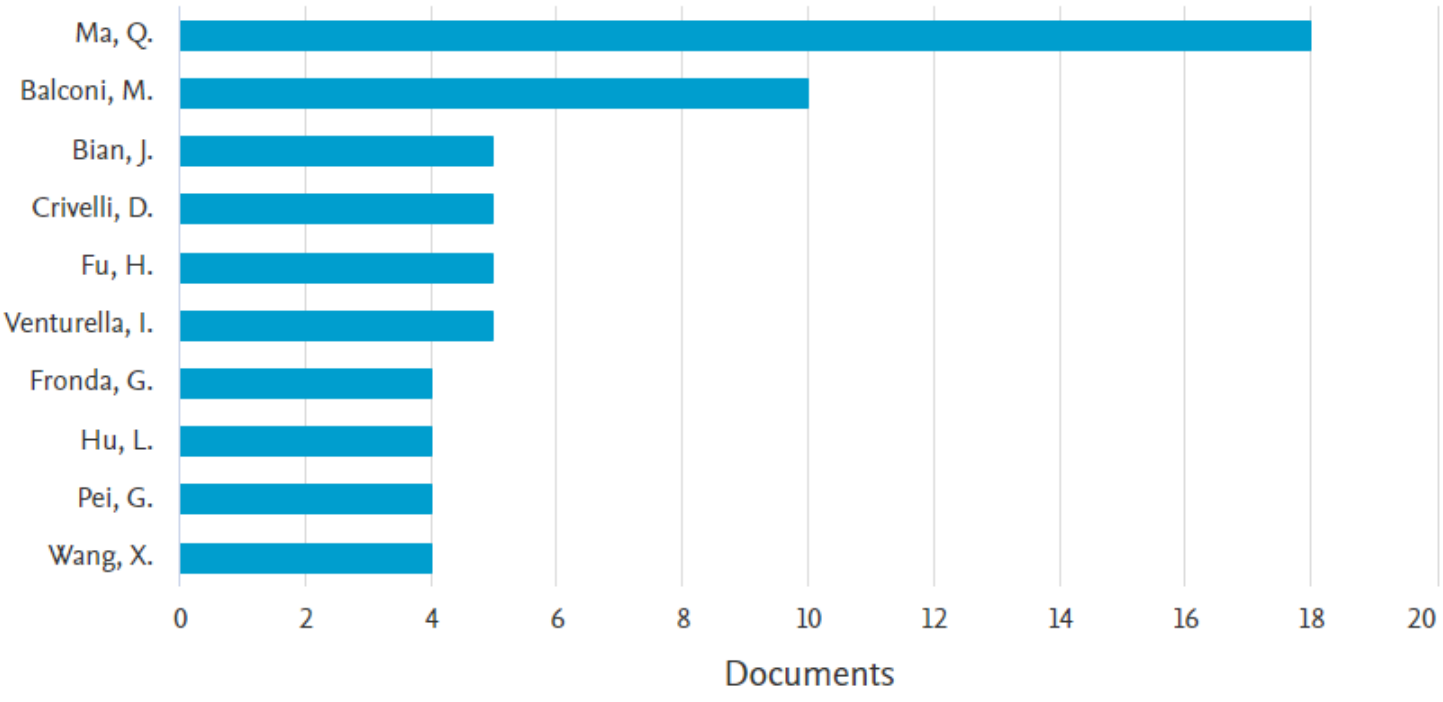

Figure 4

Authors with more scientific elaboration on neuromanagement in Scopus Fuente: Scopus.

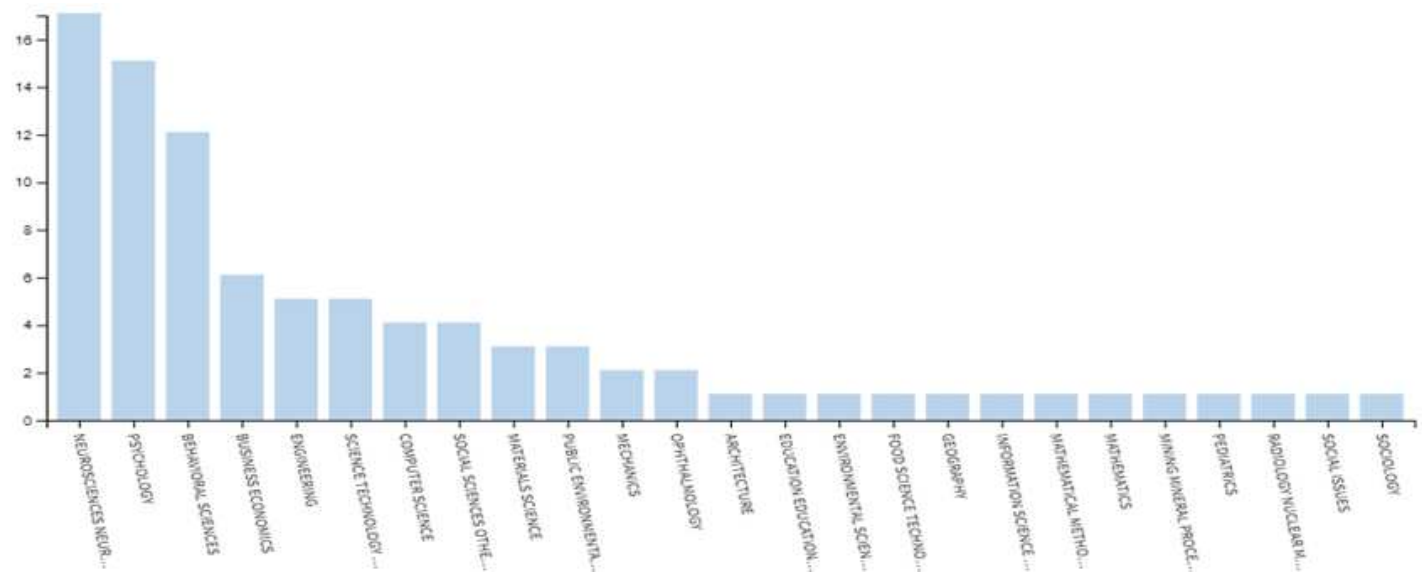

Figure 5

Areas of knowledge on neuromanagement in WOS. Source: Web of Science.

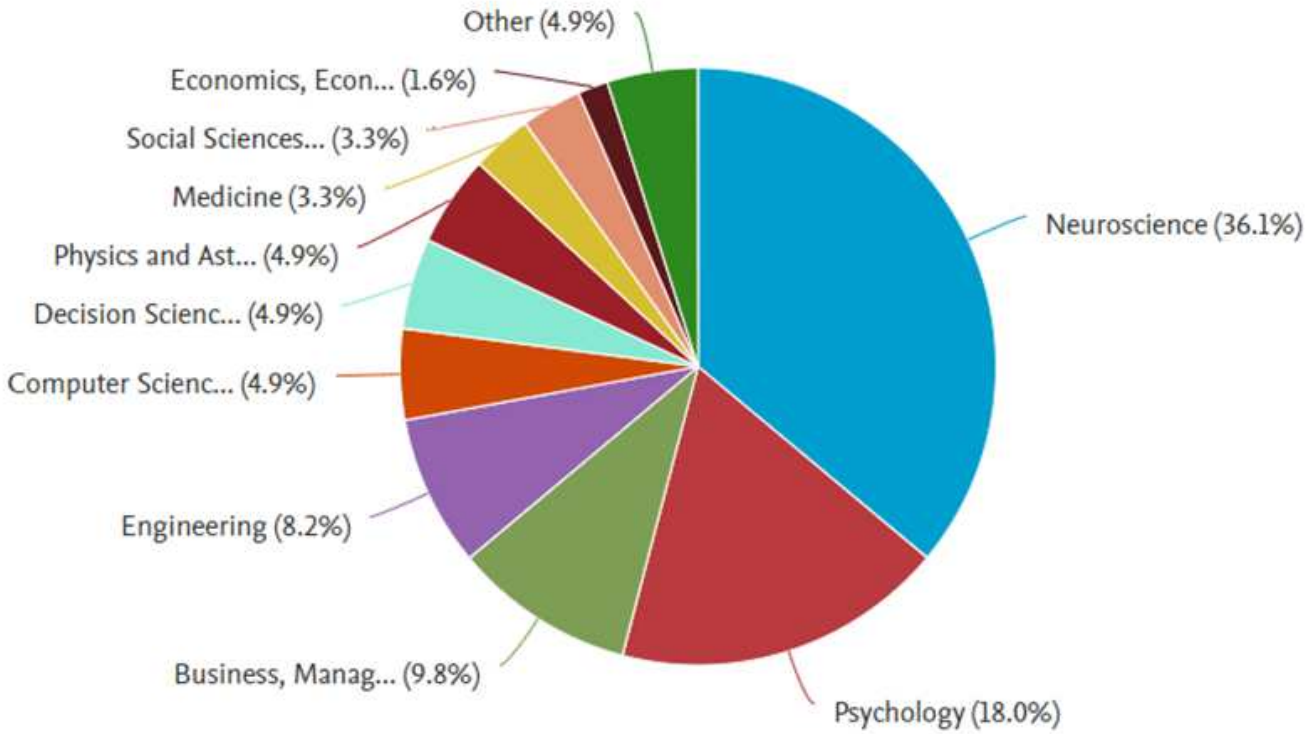

Figure 6

Areas of knowledge on neuromanagement in Scopus. Source: Scopus.

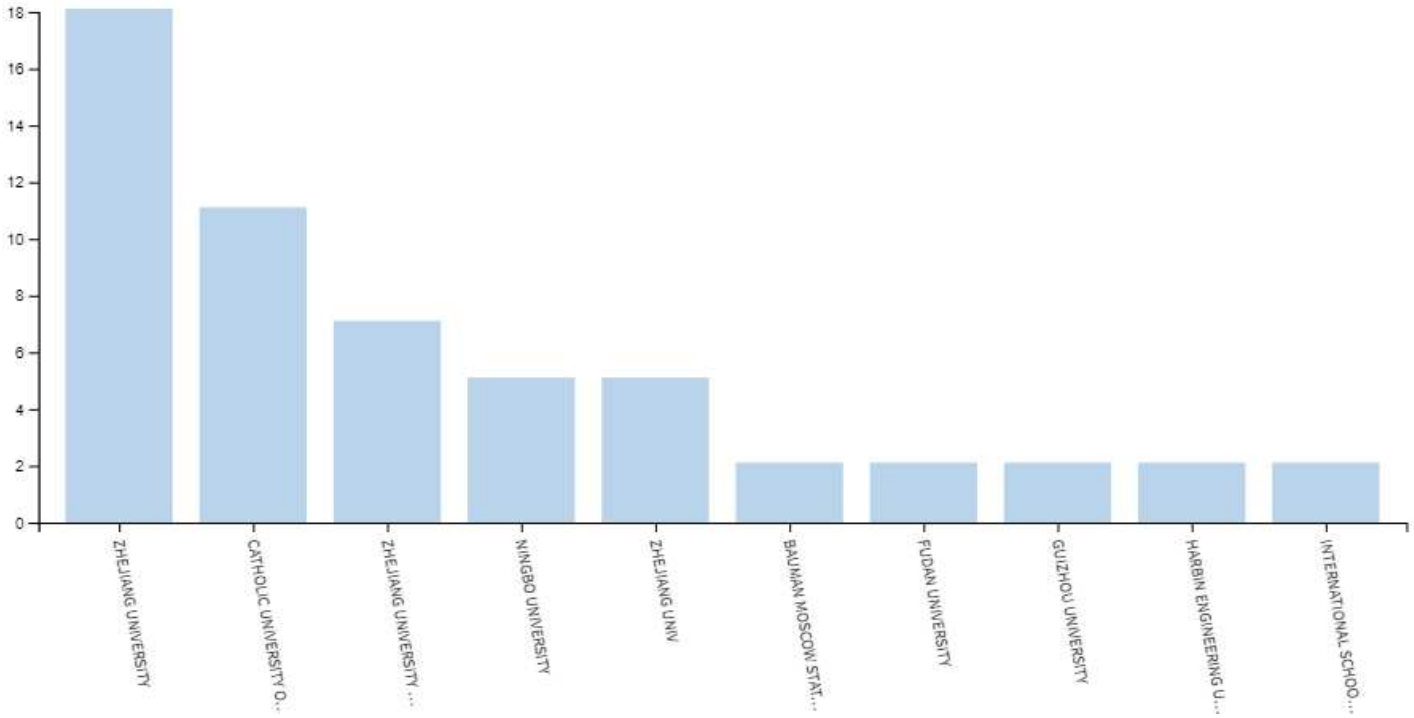

Figure 7

Institutions with the greatest scientific production on neuromanagement in WOS. Source: WOS.

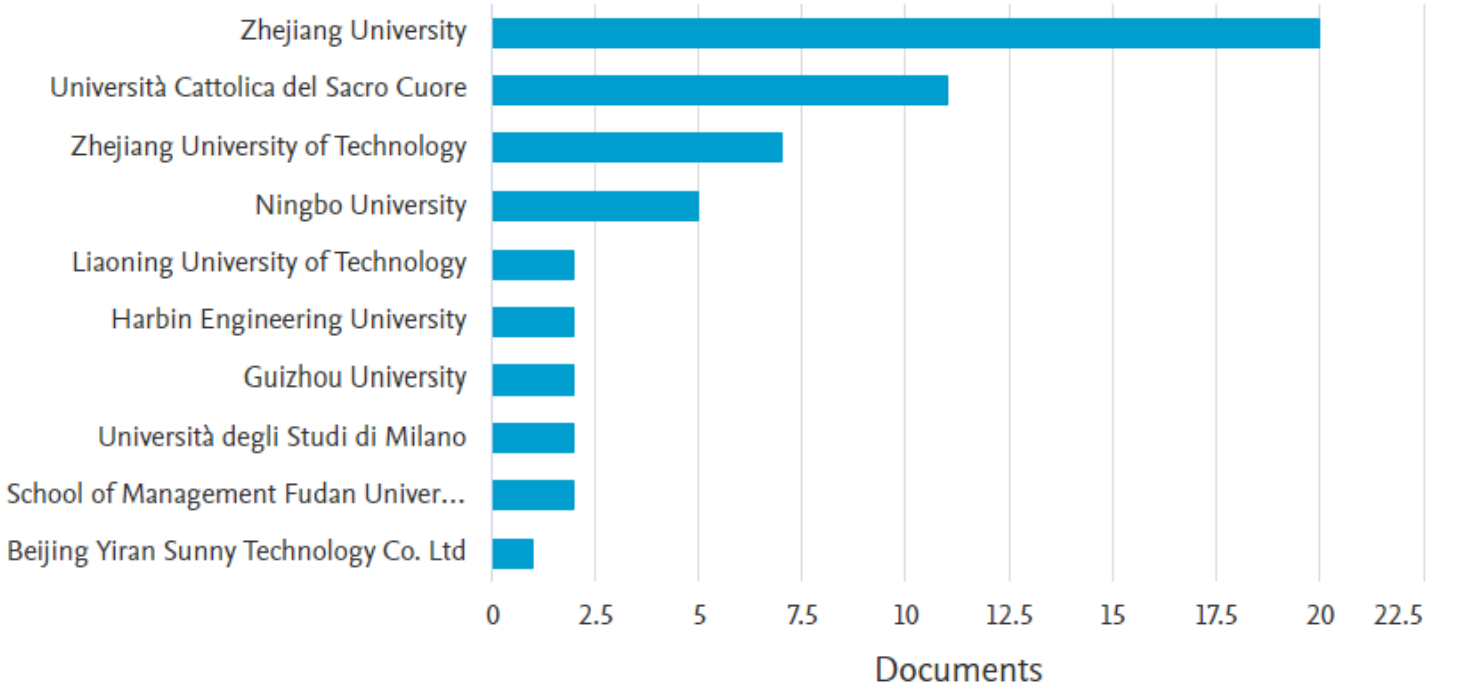

Figure 8

Institutions with the greatest scientific production on neuromanagement in Scopus. Source: Scopus.

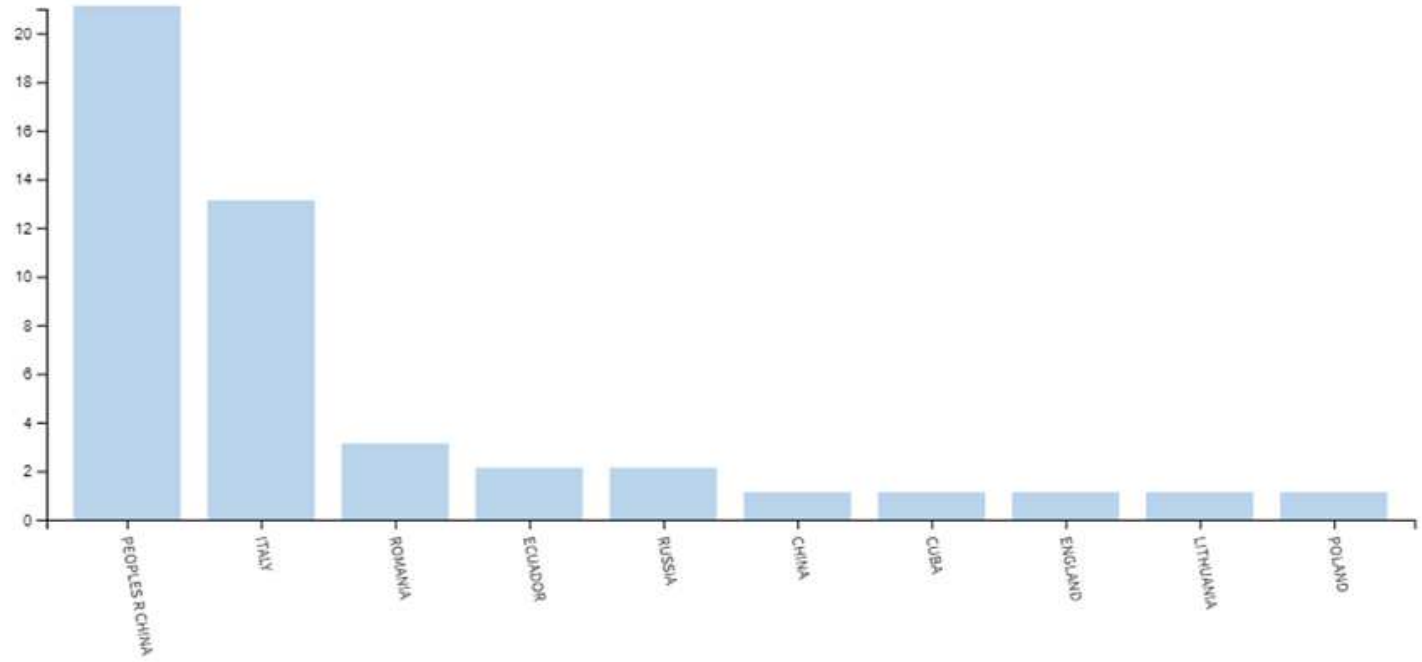

Figure 9

Number of publications by country in WOS. Source: WOS.

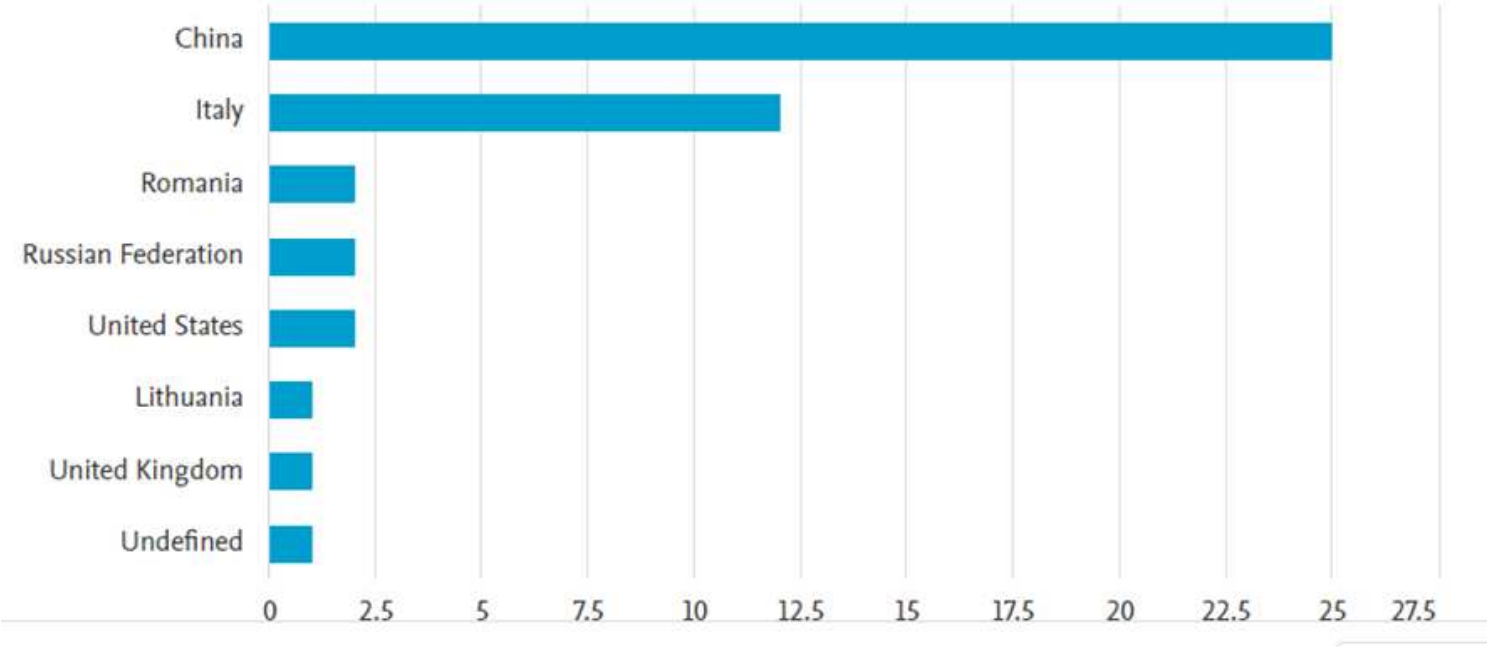

Figure 10

Number of publications by country in Scopus. Source: Scopus.

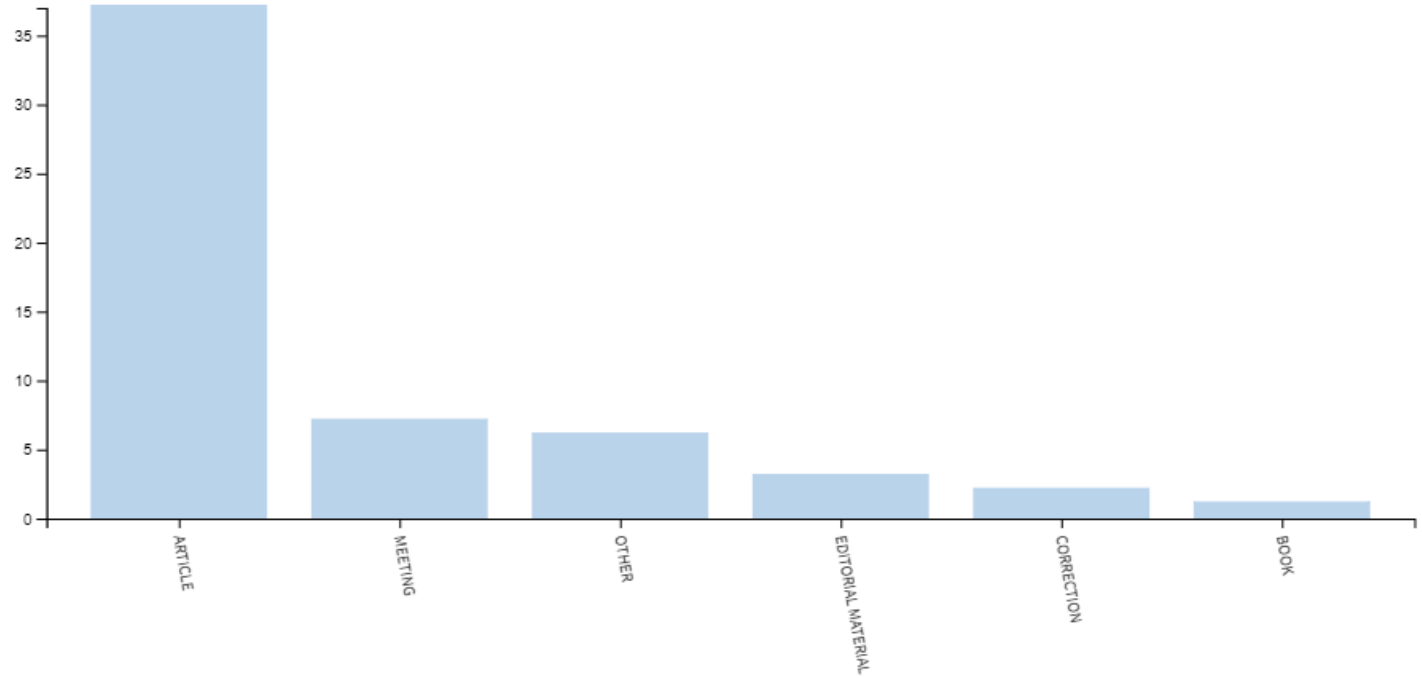

Figure 11

Types of documents published in WOS. Source: WOS.

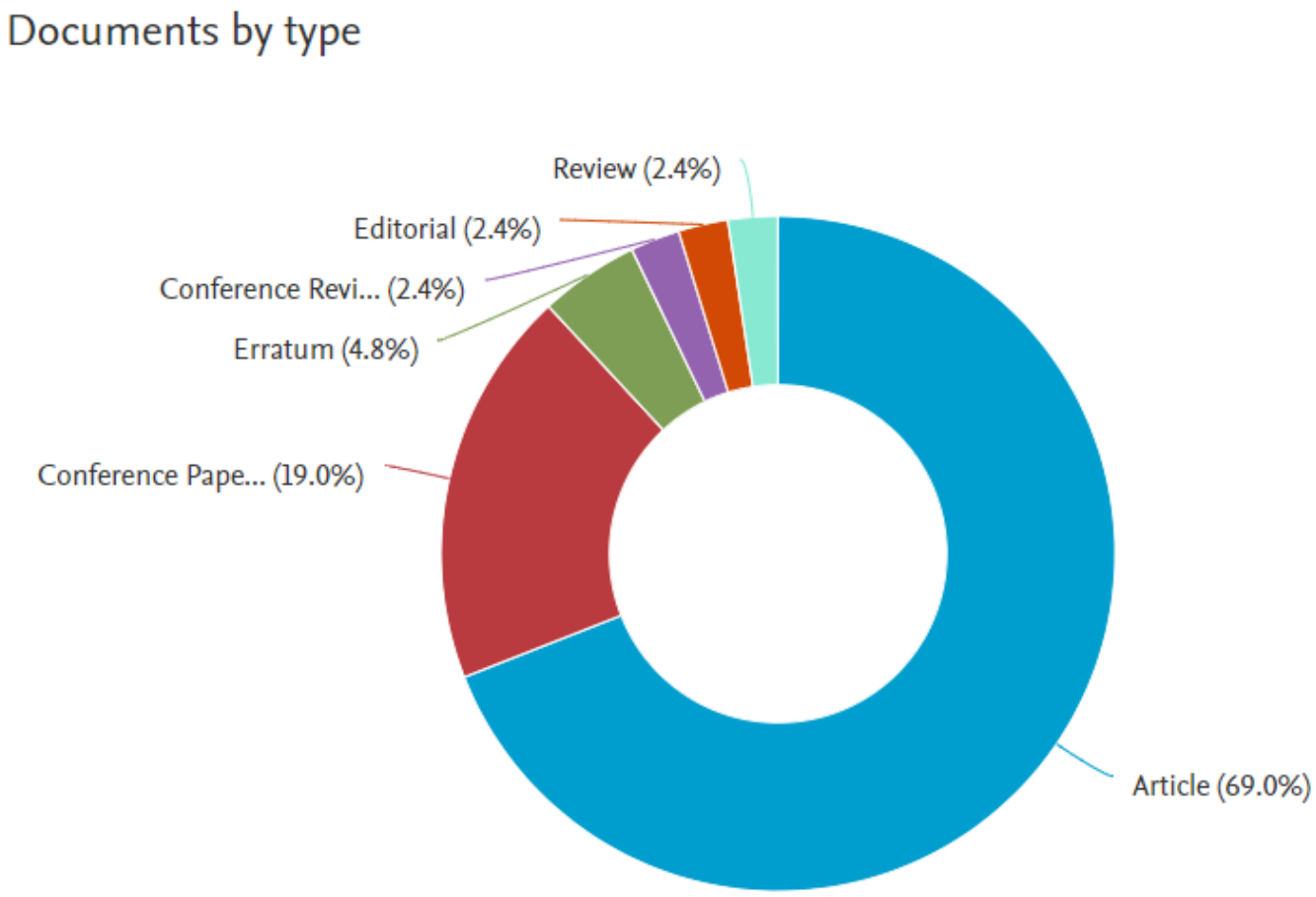

Figure 12

Types of documents published in Scopus. Source: Scopus.

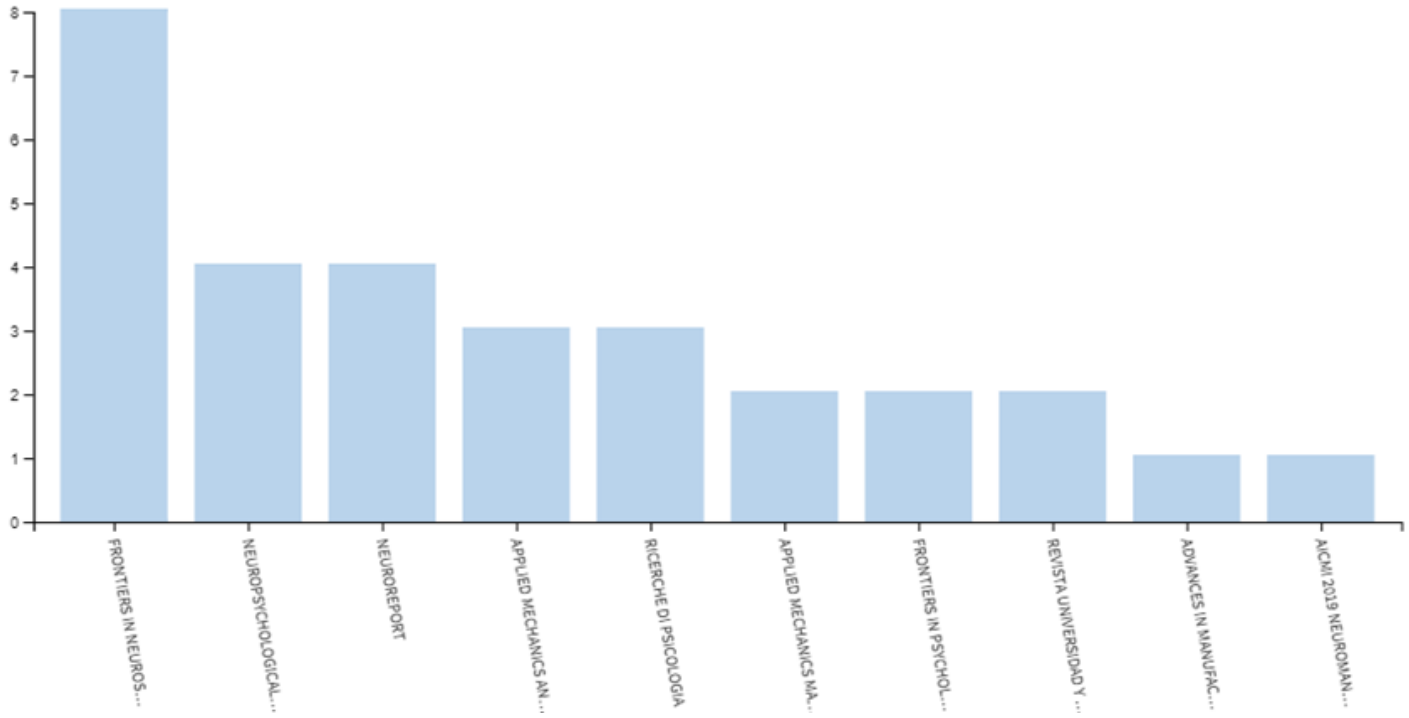

Figure 13

Number of publications in the journals collected in WOS. Source: WOS.

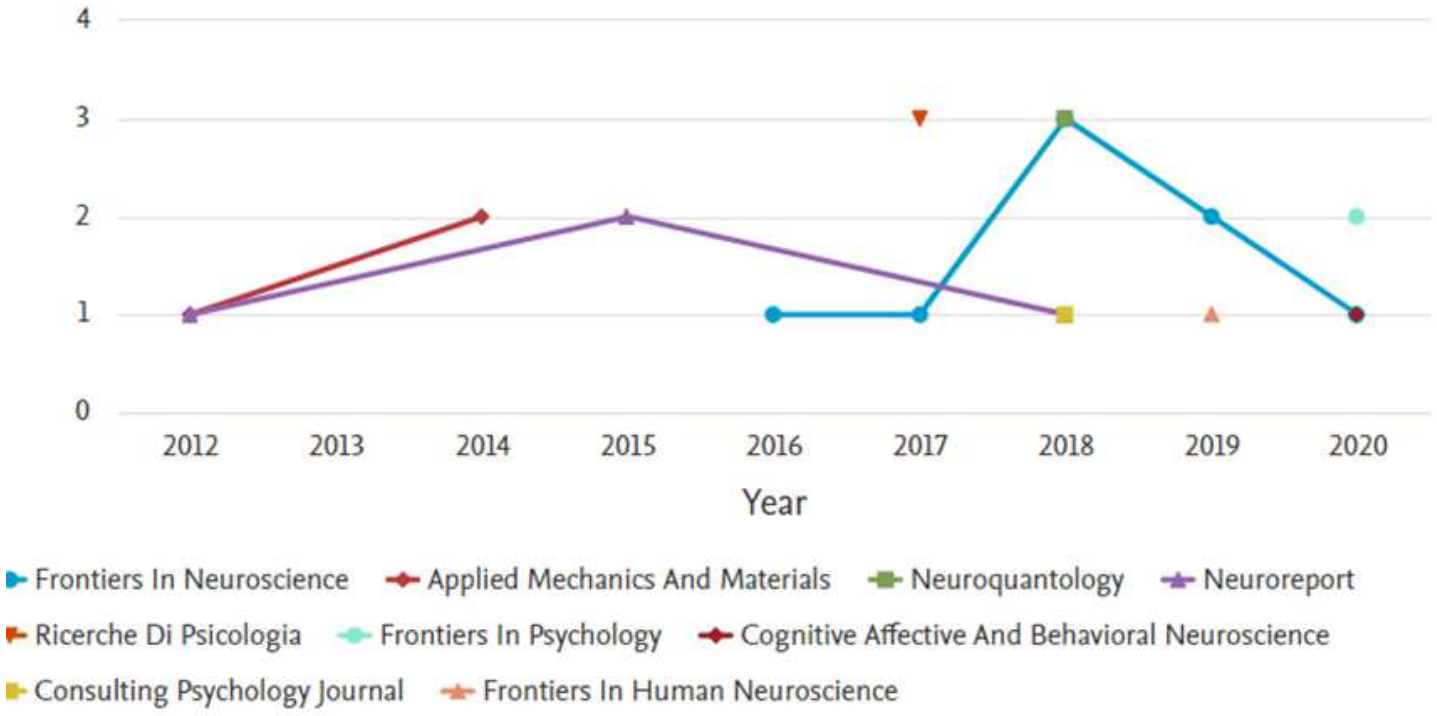

Figure 14

Number of publications in the journals collected in Scopus. Source: Scopus.

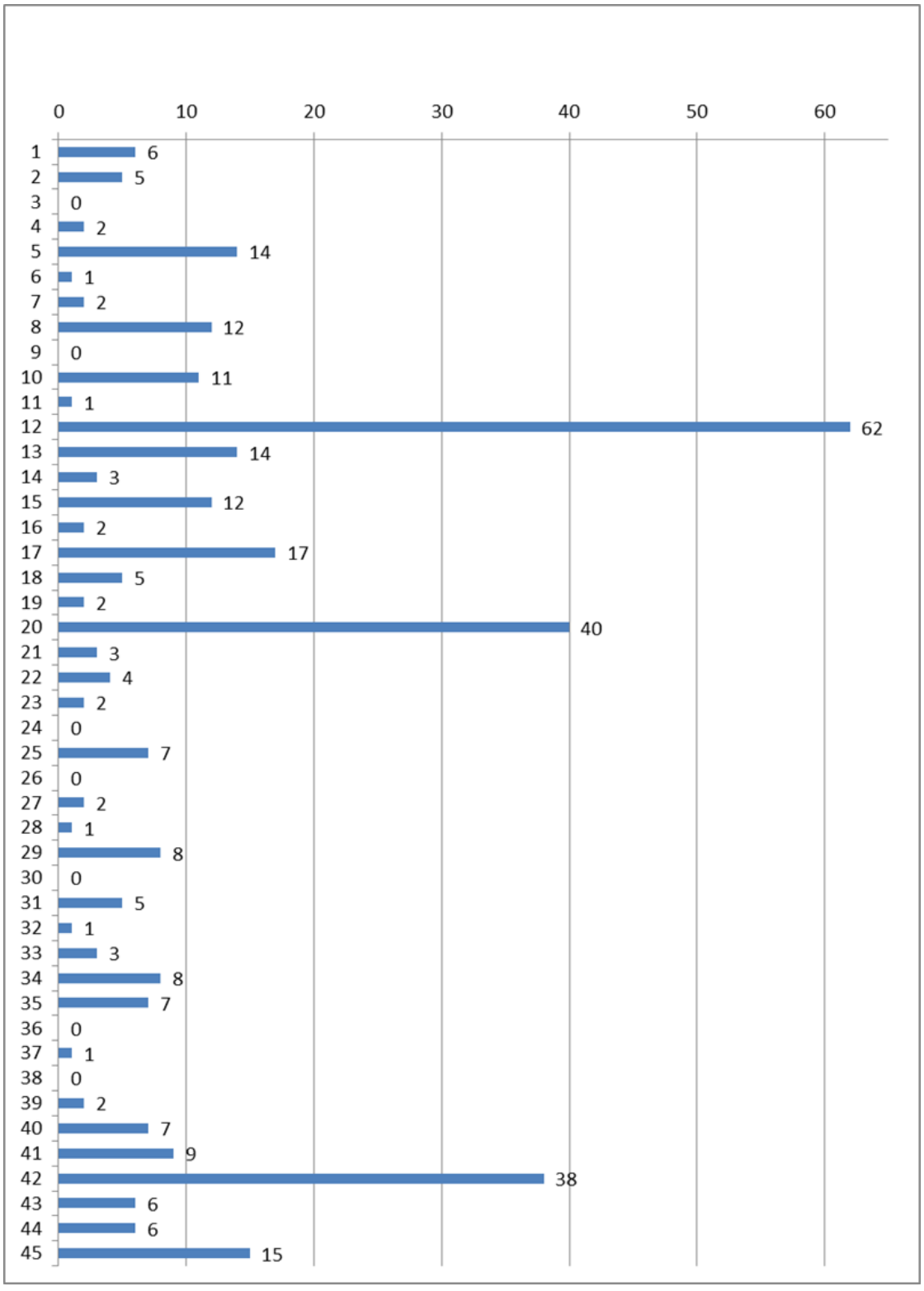

Figure 15

The number of citations that each works. Source: (Regaña, 2021)