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**RESEARCH ARTICLE**

# Neuroscience-Based Cognitive Training for Memory Development in Higher Education Students: Bibliometric and Systematic Review in Scopus

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**ABSTRACT**

The present research aimed to conduct a study of bibliometric and systematic literature trends on neuroscience-based cognitive training for memory development in higher education students in Scopus between 2006 and 2024. With a bibliometric design as a basis and a systematic literature review, this study integrated quantitative and qualitative methods. In the first phase, 54 studies were considered, and in the second phase, 7 articles were considered. The results show that the years 2012, 2016, and 2021 produced a 29.6% increase in scientific productivity, with the United States leading the way with a 35.3% increase. In addition, neurology (28%) and medicine (19%) were the most relevant subject areas. It is concluded that the breadth of subject areas covered, the level of collaboration between authors, contributing countries, and the ease of access to key data from high impact sources are indicators of this progress. They reflect how neuroscience has changed the conception of memory development and its impact on learning. Therefore, this study lays the groundwork for future research through a critical evaluation of systematic and bibliometric studies.

## INTRODUCTION

A novel strategy that has evolved in recent years to maximize mental abilities, especially memory, among college students is neuroscience-based cognitive training (Vladisauskas & Goldín, 2020). However, the need to improve students' cognitive performance becomes paramount as they face an increasingly demanding academic environment (Pastor-Vicedo et al., 2021). In this sense, neuroscience offers a perspective based on brain research, which allows the development of training programs that substantially improve critical cognitive functions, with the primary goal of boosting learning and academic performance (Alcívar-Alcívar & Moya-Martínez, 2020).

On the other hand, students' memory is crucial for their academic success, since it is the basis of all learning (Cobos, 2022). Consequently, in addition to acquiring and storing knowledge, people are also able to retrieve and use it in complicated circumstances thanks to memory (Sánchez-Heredia & Álvarez-Medina, 2022). In that order of ideas, cognitive training based on neuroscience provides methods and exercises aimed at the brain's memory centers, improving the efficiency with which new information is processed and retained in short- and long-term memory (Beroíza-Valenzuela, 2023). In this way, students are able to remember information better and retrieve it when necessary, which translates into improved academic performance (Godoy-Trujillo & Caiza-Quishpe, 2022).

In addition, new research in neuroscience has shown that the brain is plastic or malleable, so it can be molded and strengthened throughout life (Solórzano et al., 2023). Consequently, the concept of cognitive growth has been revolutionized by this potential for neuroplasticity, which has opened new avenues for mental training among college students (Piñera & Ruiz, 2022; Cortes, 2022). Likewise, cognitive training that incorporates neuroscientific concepts can improve not only memory, but also concentration, thinking and problem solving (Arias & Batista, 2021). Which has a multiplier effect, as it helps students succeed academically and, at the same time, lays the foundation for a lifetime of critical thinking outside the classroom (Romero-Carazas et al., 2023).

Moreover, in order to map the existing research landscape and identify gaps or promising avenues for future research, this study is a valuable resource (Barrios & Gutiérrez, 2020). The purpose of this literature review is to shed light on the numerous theoretical and practical developments in neuroscience-based cognitive training that have impacted memory development among college students by analyzing the bibliometric and systematic literature (Calzadilla-Perez, 2023).

In any case, the aim is to identify the most important trends and suggest new research directions to improve the use of neuroscience in higher education (Bueno, 2021). In addition, by analyzing written and other scholarly works, scientists can track the diffusion of knowledge and rank the importance of different publications on a given topic through bibliometric research (Caló, 2022; Leyva et al., 2022).

Likewise, for databases to understand the scientific environment, it is also essential to have an accurate research data collection capability (Sanz, 2022). Consequently, bibliometric indicators are employed, which are ways of gauging the amount of material written on a given topic or group of related topics (García-Villar & García-Santos, 2021; Llerena & Arévalo, 2021).

In this context, this study aims to conduct a survey of bibliometric and systematic literature trends on neuroscience-based cognitive training for memory development in higher education students in Scopus between 2006 and 2024. In this way, it is intended to create a conceptual basis on the theoretical trends of this topic. What are the global trends in Scopus scientific publications on cognitive training and neuroscience for memory development in higher education students by: country of origin, authors, journals or sources, area of knowledge, year of publication and type of document? What are the conceptual aspects, methodologies and most relevant results of the systematic analysis of literature?

## METHODOLOGY

The first step was to develop a bibliometric analysis in Scopus, a database that includes abstracts and citations of peer-reviewed literature. This database allows tracking, analyzing and visualizing academic research (Salinas and Garcia, 2022). As a result, a sufficiently broad theoretical corpus was compiled to address the topic in question.

Boolean operators with English terms were used as a search approach such as cognitive AND training, neuroscience, memory AND Development, higher AND education, during the research period from 2006 to 2024. In addition, bibliometric factors such as year of publication, most relevant authors, source or journal, keywords, country, subject area and type of document were taken into account when selecting the 54 documents for this study (Florez-Fernández & Aguilera-Eguía, 2020). Likewise, the data were analyzed using VOSviewer V_1.6.19 to construct the co-occurrence map of terms, and Excel for the count and descriptive statistics.

The second stage consisted of performing systematic content review, which is a way of organizing statements on a topic by examining the conclusions and findings of scientific studies with the aim of improving scientific knowledge (Codina, 2020). This technique allows finding new research in existing scientific literature, clarifying and streamlining the research process, and exhaustively searching for all available evidence (Berelson, 1952).

A comprehensive analysis of relevant data was performed by searching the Scopus database using the following terms: cognitive training, neuroscience, memory development, higher education (Granda et al., 2003). The qualitative systematic review included seven studies. The relevant papers

selected met the following inclusion criteria: 1) original or review articles, 2) published in English or Spanish and 3) during the period between 2006 and 2024.

## RESULTS

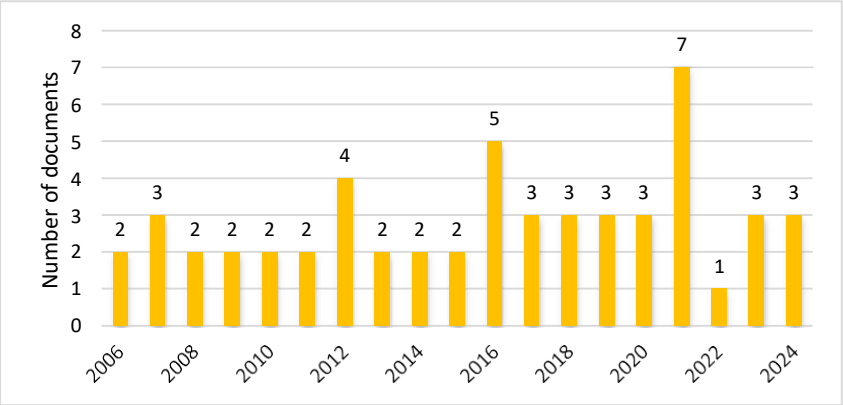
Following the suggestion of Linnenluecke et al. (2020), the main findings of the bibliometric study are presented first. Then, the results of the systematic review are presented, highlighting challenges and possible directions for future studies.

### Bibliometric analysis

For the bibliometric study, which covered the years 2006-2024, we included papers related to neuroscience-based cognitive training for memory improvement in university students. Figure 1 shows that there has been a consistent trend in academic production on this topic since 2006. This pattern persists throughout the research period. However, the years 2012, 2016, and 2021 had the highest number of publications (16 papers in total), representing 29.6% of the total output worldwide.

For its part, considering the importance of neuroscience and the development of students' memory, research in this field has progressed, highlighting the annual production that has made substantial contributions to the advancement of knowledge in this field. This is consistent with previous studies that have demonstrated the importance of the topic (Mendoza et al., 2021; Mármol et al., 2022).

**Figure 1. Research by year**




Credit must be given to pioneering researchers who have made tremendous advances on a global scale studying the effects of neuroscience-based cognitive training on memory development in college students. This research is based on the work of 127 authors from various academic institutions for the selected publications. The top researchers are listed in Table 1, which includes their total number of publications and citations: Kramer, A.F. ranks first with two publications and 1046 citations; Asarnow, R.F. ranks second with one publication and 238 citations. In addition, third place goes for Barrett, J.E., who has one publication and 190 citations.

**Table 1. Authors with the highest scientific productivity.**

| By author | Number | Total citations | H-index |
|---|---|---|---|
| Kramer, A.F. | 2 | 1046 | 109 |
| Alloway, R.G. | 1 | 15 | 8 |
| Alloway, T.P. | 1 | 15 | 36 |
| Almeida, R. | 1 | 31 | 19 |
| Amiel, J.J. | 1 | 14 | 11 |
| Arias Salegio, I.S. | 1 | 2 | 1 |
| Arlinger, S. | 1 | 162 | 34 |
| Asarnow, R.F. | 1 | 238 | 57 |
| Astle, D.E. | 1 | 62 | 26 |
| Aupperle, R.L. | 1 | 62 | 28 |

| | | | |
|---|---|---|---|
| Baars, B.J. | 1 | 16 | 36 |
| Bae, S.R. | 1 | 31 | 2 |
| Ball, C.T. | 1 | 2 | 11 |
| Barrett, J.E. | 1 | 190 | 35 |
| Batista Mainegra, A. | 1 | 2 | 3 |
| Billings, L.M. | 1 | 118 | 11 |

Academic papers published by 27 different nations were considered. According to Figure 2, of the 10 countries that contributed to the scientific production, the United States published the most papers on the subject, with 24 papers (35.3% of the total). It was followed by other nations, such as Canada (with 6 studies, or 8.8% of the total) and the United Kingdom (with 5 studies, or 7.4% of the total). In addition, among the three main languages for academic writing, English represents 77.8%, Spanish 14.8% and Portuguese 7.4%.

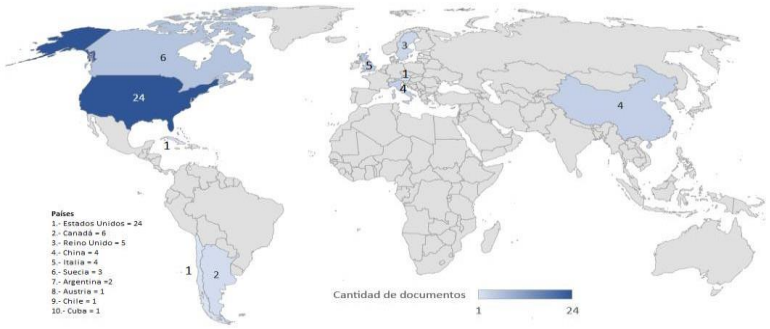



**Figure 2. Scientific production by country.**

Table 2 shows the ten most important journals, compiled after a survey of the most outstanding papers in this discipline. First, Journal of Neuroscience was the top journal in terms of the number of articles produced each year; with three publications and 415 citations. The source with the highest impact factor throughout the research period was Computers and Education, with a value of 3651. In addition, the vast majority of journals are in the highest quartile (Q1). Likewise, with a weighting of 503, the US Journal of Neuroscience obtained the highest H-index.

**Table 2. Most relevant sources or journals.**

| Source or Journal | Number of documents | Citations | Impact factor | Q | H-index | Country |
|---|---|---|---|---|---|---|
| Journal of Neuroscience | 3 | 415 | 2.321 | Q1 | 503 | United States |
| ANAE Approche Neuropsychologique Des Apprentissages Chez L Enfant | 1 | 5 | 0.134 | Q4 | 12 | France |
| Acta Neuropsychologica | 1 | 7 | 0.191 | Q4 | 14 | Poland |
| American Psychologist | 1 | 159 | 3.357 | Q1 | 268 | United States |
| Autism Research | 1 | 7 | 1.686 | Q1 | 93 | United States |
| BMC Complementary Medicine and Therapies | 1 | 4 | 0.673 | Q1 | 113 | United Kingdom |
| BMJ Open | 1 | 5 | 0.971 | Q1 | 160 | United Kingdom |
| British Journal of Music Education | 1 | 0 | 0.399 | Q1 | 28 | United Kingdom |

| | | | | | | |
|---|---|---|---|---|---|---|
| Cold Spring Harbor Protocols | 1 | 16 | 0.401 | Q3 | 66 | United States |
| Computers and Education | 1 | 14 | 3.651 | Q1 | 232 | United Kingdom |

The papers published on the topic of neuroscience-based cognitive training for memory improvement in university students are organized in Table 3 according to publication type and subject area for the years 2006-2024. Regarding the fields supporting the study, neuroscience represents 28% of the fields contributing to scientific knowledge, while medicine contributes 19%. Furthermore, when looking at the division by type of document, scientific articles make up the largest part of the production (78% of the total), followed by book chapters (11%) and books (11%).

**Table 3. Publication of documents by subject area and type.**

| **By area** | **Number** | **%** |
|---|---|---|
| Neuroscience | 24 | 28% |
| Medicine | 16 | 19% |
| Psychology | 15 | 18% |
| Social Sciences | 8 | 9% |
| Computer Science | 5 | 6% |
| Biochemistry, Genetics and Molecular Biology | 4 | 5% |
| Arts and Humanities | 3 | 4% |
| Engineering | 2 | 2% |
| Health Professions | 2 | 2% |
| Agricultural and Biological Sciences | 1 | 1% |
| Other fields | 5 | 6% |
| **Type of document** | **Number** | **%** |
| Article | 42 | 78% |
| Book chapter | 6 | 11% |
| Book | 6 | 11% |

A keyword co-occurrence analysis was performed on the reviewed publications at a level of 3 (n ≥ 3). This analysis included word counts in titles, abstracts, and keyword lists. The most common keywords found in the publications were “cognitive neurosciences,” “brain,” and “neuroscience,” with 32, 29, and 24 occurrences, respectively (Figure 3). Three categories were established for the 22 items, as shown in Table 4.

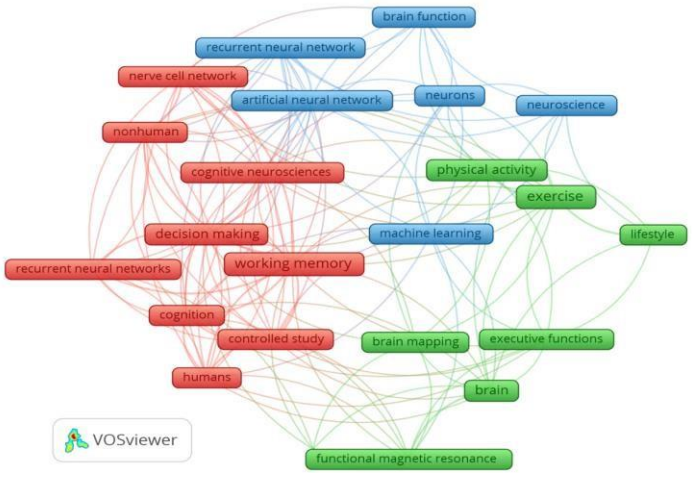



**Figure 3. Keyword co-occurrence analysis.**

On the other hand, VOSviewer facilitates the visualization of clusters of related phrases by means of a color code showing their degree of relatedness. In this context, the red cluster has nine components

and represents 40.9% of all terms related to the topic, containing the term "cognitive neuroscience" with 33 occurrences. The green cluster, which contains the word "brain", appears 29 times, accounting for 31.8% of all occurrences. In addition, the blue cluster contains 27.3% of the words in the study, with "neuroscience" (n=24 occurrences) included.

**Table 4. Cluster analysis related to the study.**

| Cluster | Ítems | Percent | Word | Occurrence |
|---|---|---|---|---|
| C1-Red | 9 | 40.9% | Cognitive neurosciences | 32 |
| C2-Green | 7 | 31.8% | Brain | 29 |
| C3-Blue | 6 | 27.3% | Neuroscience | 24 |
| **Total** | **22** | **100.0%** | | |

## Systematic review analysis

Of all the publications that were eligible for the systematic literature review, which spanned from 2006 to 2024, Table 5 contains the authors' names, research objectives, methodologies, and main findings. Specifically, the research aims to critically and objectively analyze the different aspects of neuroscience-based cognitive training that influence students' memory development at a higher level.

**Table 5. Studies selected for the systematic review.**

| Authors/Year | Objetive | Methodology | Results |
|---|---|---|---|
| Solórzano et al. (2023) | To present the different applications of neuroscience in education and to relate the socioemotional skills that can be enhanced in different experiential contexts. | Study with qualitative approach and scientific research methods such as theoretical and empirical were used. | It was established that this discipline promotes the consolidation of knowledge, increases the curiosity and attention of the student, and allows us to design effective and quality teaching methodologies now and in the future. |
| Maestre et al. (2020) | To conduct a systematic review on implications of working memory in neurodevelopment and learning. | Qualitative methodology of systematic review. | In the educational field, it is evident that working memory plays a fundamental role in learning, this process being affected by stress or poor curricular adaptation to students. |
| Llanga et al. (2019) | To describe memory and cognitive processes that have relevance in students. | Qualitative methodology of literature review. | It was found that psychologists have the need to learn about cognitive processes to help those who have learning difficulties. |
| Barrios & Gutiérrez (2020) | To analyze relevant data in the field of neurosciences that could contribute to the design and implementation of teaching-learning practices and strengthening of social, emotional and cognitive skills. | Qualitative methodology of literature review. | The results indicate the need to include emotions as a fundamental part in the integral formation and offer bases to understand the development and limitations of the neuronal aspects in the educational processes. |
| Calzadilla-Pérez (2023) | To know the current state of development of the Neurosciences of Education. | Qualitative methodology of systematic review. | The results are instituted in the state of the art of 20 years of publications and provide neuroscientific knowledge for teacher training. |
| Soto et al. (2022) | To analyze the link between neuroscience and the education of creative specialties. | The mixed research approach, descriptive scope. | It was established that undergraduate teaching is about arousing attention to knowledge and engaging students effectively within the classroom. |
| Poca (2014) | To make a documentary compilation of neurosciences and learning based on the development of the nervous system in which the important anatomical parts in the learning process will be described. | Qualitative methodology of literature review. | The study shows that neuroscience explains how millions of individual nerve cells in the brain act to produce behavior and how these cells are influenced by the environment, including the behavior of other individuals. |

To provide an overview of current trends and scientific methods in the area of cognitive training and memory in college students, the papers chosen for the systematic review focus primarily on examining the development and influence of research in this area. Most of the studies are qualitative and employ research methods that include research-based, theoretical, conceptual, and quantitative-correlational designs, as well as critical and systematic literature reviews.

## DISCUSSION

This study provides information on the development of the neuroscientific approach in education (Ruiz & Kwan, 2020). Psychological and educational methods dominated early research on memory formation (Castro et al., 2022). However, neuroimaging and brain stimulation are two examples of the more advanced methods that scientists have begun to use to delve deeper into the workings of the brain in their quest to decipher how learning and memory function (Montoya-Restrepo & Montoya, 2023). Because of this, cognitive training programs that are specifically designed for college students have become more accurate and efficient (Madrid & Belandria, 2022).

In that vein, bibliometric data reveal that, with only minor fluctuations in scientific output, the growth of the literature on neuroscience-based cognitive training for memory development in college students has remained stable since 2006. Also, one of the most important authors was the American psychologist Kramer, A.F., who primarily addressed the ways in which physical exercise affects the brain and cognition, and the ways in which adults can benefit from improving their cognitive development to increase their functional capacity. In addition, the top journal was Journal of Neuroscience, which showed a publication trend of 3 articles in neuroscience and medical subject areas.

According to Maestre's (2020) systematic review analysis, educational theorists highlight the centrality of memory to the learning process in many domains, including but not limited to: communication, acquisition of mathematical concepts and signs, and tasks that require focused attention and controlled processing. Consequently, providing teachers with training in neuropsychological issues, memory functioning, and cognitive conditions that align with their developmental stage can ensure that all students are exposed to the same opportunities.

Likewise, in the research conducted by Llanga (2019), he points out that memory affects everything, therefore, it is crucial that the student learns to control its multiple cognitive components in a way that promotes learning. Therefore, memory has been essential to redirect processes towards more constructive purposes (knowledge and education), including the expansion of one's horizons through study and experience.

As for the study by Barrios and Gutiérrez (2020), they state that educational theory and practice can greatly benefit from the knowledge provided by neuroscience. However, this is achieved in the context of formal education where students acquire the necessary skills for their future professional success. Therefore, research in the field of neuroscience on the connection between thought and emotion is important to inform pedagogical methods in higher education.

Similarly, research by Calzadilla-Perez (2023), states that neuro-education, neuroscientific knowledge is the hierarchical object of study, which seeks to enrich its theoretical and conceptual body and in the educational process transfer, improvement and evaluation. Likewise, in the study conducted by Soto et al. (2022), they point out that in terms of neuroscience-based higher education, a thorough examination of the brain-education connection reveals the mechanisms of learning and improvement, which in turn facilitates interactions between teachers and students. Moreover, this is the result of an evolutionary process that extends beyond the mind, as those working in education encounter a dynamic professional landscape that demands their active participation.

On the other hand, Ochoa (2014), states that neuroscience-based connections are mobilized by challenges and difficulties, hence it is crucial that learning processes remain updated or current. Consequently, university teachers could propose organizing their students' courses in such a way that they become engines of neural connections.

Finally, a study by Solórzano et al. (2023) showed that most teachers are incorporating neuroscientific principles into their classes with students, since this discipline promotes the adoption

of cutting-edge tools that inspire and facilitate learning. For such reason, it is essential that higher education maintains its focus on training caring and competent professionals who, along with modern pedagogical practices, incorporate greater metacognition and neuroeducation into their classroom practices, which will ensure that teachers are well prepared to meet the challenges of their work and can demonstrate this preparation in their interactions with students through empathy, curiosity, and critical thinking (Malfert-Gaupp, 2023).

## CONCLUSION

According to the stated objective of the study, the amount of research conducted on neuroscience-based cognitive training for memory development in higher education students have experienced a spike in research activity in recent years.

The bibliometric study found an increase of 29.6% (n=16) between the years 2012, 2016 and 2021, considering all the papers indexed by Scopus during the study period. In terms of production rate (35.3%, n=24), the United States led all nations analyzed, while the percentage of publications edited in English reached 77.8%. In addition, with 3 academic articles, the Journal of Neuroscience was the most prominent source, and Kramer, A.F. was the most referenced author (1046 times). Likewise, 78% of the publications were scientific articles, and 28% were related to neuroscience.

On the other hand, neuroscience-based cognitive training for memory growth has been an effective technique to improve academic performance and cognitive abilities of university students. Consequently, the current state of research can be traced by analyzing the most significant publications and collaborative networks, allowing the identification of trends and possibilities to be developed in this field.

To conclude, it is concluded that progress has been made in the field of neuroscience-based cognitive training for memory improvement in university students. Evidence of this progress is the variety of topics covered, the degree of cooperation between contributing authors and countries, and the accessibility of key data from influential sources. These factors demonstrate how neuroscience has revolutionized the understanding of memory development and its effects on learning. Furthermore, through the use of bibliometrics and a systematic review, this study not only provides a critical assessment, but also lays the groundwork for future studies in this field.

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