Review Article

Access this article online
Quick Response Code:

Website: http://www.braincirculation.org
DOI: 10.4103/bc.bc_72_23

A bibliometric review of unilateral neglect: Trends, frontiers, and frameworks

Wanying Zhao, Linlin Ye, Lei Cao, Weiqun Song

Abstract:

BACKGROUND: Owing to the adverse effects of unilateral neglect (UN) on rehabilitation outcomes, fall risk, and activities of daily living, this field has gradually got considerable interest. Notwithstanding, there is presently an absence of efficient portrayals of the entire research field; hence, the motivation behind this study was to dissect and evaluate the literature published in the field of UN following stroke and other nonprogressive brain injuries to identify hotspots and trends for future research.

MATERIALS AND METHODS: Original articles and reviews related to UN from 1970 to 2022 were retrieved from the Science Citation Index Expanded of the Web of Science Core Collection. CiteSpace, VOSviewer, and Bibliometrix software were used to observe publication fields, countries, and authors.

RESULTS: A total of 1,202 publications were incorporated, consisting of 92% of original articles, with an overall fluctuating upward trend in the number of publications. Italy, the United Kingdom, and the United States made critical contributions, with *Neuropsychologia* being the most persuasive academic journal, and Bartolomeo P. ranked first in both the quantity of publications and co-citations. Keywords were divided into four clusters, and burst keyword detection demonstrated that networks and virtual reality might additionally emerge as frontiers of future development and warrant additional attention.

CONCLUSIONS: UN is an emerging field, and this study presents the first bibliometric analysis to provide a comprehensive overview of research in the field. The insights and guidance garnered from our research on frontiers, trends, and popular topics could prove highly valuable in facilitating the rapid development of this field while informing future research directions.

Keywords:

Bibliometric, hotspots, stroke, trends, unilateral neglect

Introduction

Unilateral neglect (UN) is a well-known dysfunction after unilateral brain injury, affecting 25%–30% of patients with stroke and manifesting as spatial or physical left neglect.[1] In the acute phase, approximately 43% of individuals are afflicted with right hemisphere lesions, and 20% of individuals are affected by left hemisphere lesions.[2] Even after an estimated 3 months of stroke onset, approximately 46% of patients still exhibit symptoms of UN, and approximately 30%–40% of patients do not recover even after 1 year.[3] It is a highly heterogeneous disorder that can affect either body-centric or object-centric frames of reference,[4] leading to a patient's inability to examine, identify, or react to elements of the contralateral body and the surrounding environment.[5] UN is not caused by basic sensory or motor deficits[6] but rather by disruptions in higher-level spatial attention/representation. Moreover, the severity of UN itself, rather than the overall severity, plays a crucial role in determining adverse outcomes in functional recovery and can negatively impact the likelihood of fall risk, length of hospitalization,[7] and the ability to perform activities of daily living. Despite the many approaches currently

Department of Rehabilitation, Xuanwu Hospital, Capital Medical University, Beijing, China

Address for correspondence:
Prof. Weiqun Song, Department of Rehabilitation, Xuanwu Hospital, Capital Medical University, No. 45 Changchun Street, Beijing 100053, China.
E-mail: songwq66@126.com

Submission: 26-08-2023
Revised: 20-12-2023
Accepted: 06-01-2024
Published: 26-06-2024

How to cite this article: Zhao W, Ye L, Cao L, Song W. A bibliometric review of unilateral neglect: Trends, frontiers, and frameworks. Brain Circ 2024;10:94-105.

available for the treatment of UN, there is little consensus on treatment decisions. Treatments can be broadly categorized into top-down and bottom-up approaches[8] with key differences in individual awareness and level of active participation.[9] Given the notable challenges engendered by UN, this domain is attracting increasing scrutiny and interest. Therefore, this study aimed to conduct a bibliometric analysis of UN studies published between 1970 and 2022 and explore the current situation, research hotspots, and emerging patterns in this field.

Materials and Methods

Search strategy

We independently conducted a literature search using the Science Citation Index Expanded (SCIE) of the Web of Science Core Collection (WoSCC) on 19 February, 2023. The search strategy is detailed in Supplementary Table 1, with the publication timeframe set from 1970 to 2022.

Screening strategy

Document types were restricted to original articles and reviews, and the language was restricted to English. Furthermore, irrelevant publications were excluded, which eliminated a large assortment of publications, mainly owing to the broad scope of the search. Finally, 1202 publications were included in the bibliometric analysis [Figure 1].

Data analysis

CiteSpace[10] was applied to the dual-map overlays of journals and keywords with citation bursts. VOSviewer[11] was used to perform a coauthorship analysis of countries and authors, co-citation analysis of journals, and co-occurrence analysis of keywords. R software was used to run Bibliometrix[12] to draw thematic maps of themes and calculate the H- and G-indexes.

Results and Discussion

Publication outputs

From 1970 to 2022, 1,202 publications related to UN were included, comprising 1,102 original articles and 100 reviews, with an annual growth rate of 8.5% and an average number of publications of 23.6 per year during the study period [Figure 2].

Since their initial publication in 1972, studies have not experienced significant growth over the following 18 years, representing a preliminary stage of development. During this period, research efforts focused on exploring the anatomical mechanisms underlying UN, with occasional publications on its assessment and rehabilitation. The earliest citations in the top 100 citations of hemorrhagic stroke date back to 1964,[13] suggesting that the evolution of the UN field may have been influenced by advancements in the stroke niche.

After 1990, the annual publication frequency experienced a fluctuating growth trend, with a maximum of 67 publications per year. However, this number remains low compared with the bibliometric data in the neurology/neurosurgery fields, demonstrating a substantial potential for future progress in this field

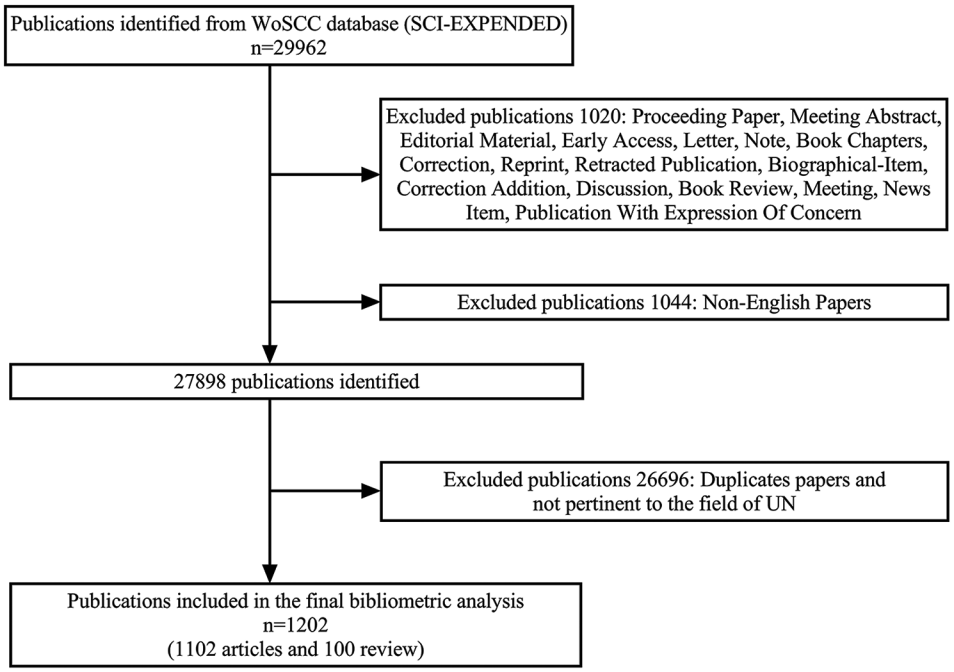

Figure 1: The publication retrieval and filtering process

and emphasizing noteworthy opportunities to continue pursuing valuable research. Overall, the upward trend in annual publications in the field reflects growing interest.

Distribution and coauthorship of countries and institutions

According to the search results, 1,202 publications came from 43 countries [Figure 3a]. Table 1 shows that Italy ranked the highest in publications and second in citations, whereas the United Kingdom (UK) ranked second in publications and first in citations, followed by the United States (US) in publications and third in citations. Figure 3b shows that the overall cooperation network displayed a close relationship, and countries with a high volume of documents became the center of the collaboration network.

Table 2 shows that Università degli Studi di ROMA "La Sapienza" had the most publications, followed by the Kessler Foundation, Université de Genève, and Eberhard Karls Universität Tübingen; these institutions were located in Italy, the US, Switzerland, and Germany. The University College London, located in the UK, ranked the highest in terms of citations.

Among the top 10 countries in the UN field, all except Switzerland were featured in the top 10 countries for stroke research from 2001 to 2011,[14] which shows its relevance. The top three countries were characterized by similar numbers of publications and have not yet produced a clear dominant country; however, the high volume of both publications and collaborations indicated that they are expected to dominate the field in the future. Italy, the UK, the US, Germany, France, and Switzerland cooperated more closely, indicating that the top-ranked countries collaborated more closely. Among the top 10 institutions engaged in UN research, the majority were from Italy (three institutions), the UK (two institutions), and the US (three institutions), signifying their considerable contributions to the field.

Distribution and coauthorship of authors

In total, 3,058 authors contributed to the publications. Table 3 shows that Bartolomeo P. ranked first among all authors, followed by Karnath HO and Vallar G. Among the top 10 authors, Bartolomeo P. had the highest citations and G-index. We overlaid the visual maps of authors with at least seven publications for author collaboration network analysis [Figure 4]. High-volume authors were moderately collaborative within the clusters but less so overall, and they had not yet formed stable author cooperation groups. Two of the

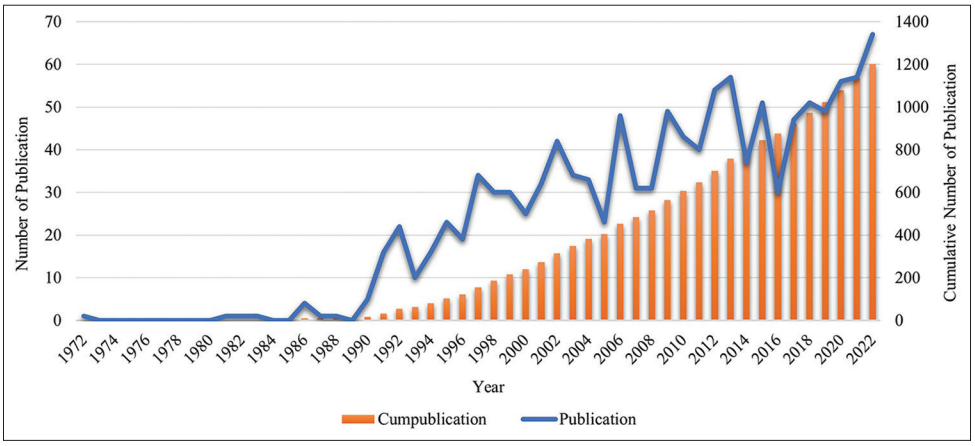

Figure 2: Global trends in the number of annual publications on unilateral neglect research from 1972 to 2022

Table 1: Top 10 countries of origin of publications in the unilateral neglect field

Countries	Publications (ranking)	Citations (ranking)	Average citation/publication	MCP ratio (%)
Italy	256 (1)	11,358 (2)	44.37	21.8
UK	218 (2)	11,773 (1)	54.00	26.8
US	214 (3)	9,933 (3)	46.42	16.4
France	127 (4)	6,462 (4)	50.88	42.6
Germany	127 (4)	4,844 (5)	38.14	30.5
Switzerland	90 (6)	2,557 (6)	28.41	46.7
Canada	66 (7)	1,388 (7)	21.03	12.5
Japan	63 (8)	784 (12)	12.44	7.6
The Netherlands	51 (9)	991 (10)	19.43	18.2
China	40 (10)	537 (16)	13.43	7.9

Calculated from the corresponding author's country only. MCP: Multiple-country publication

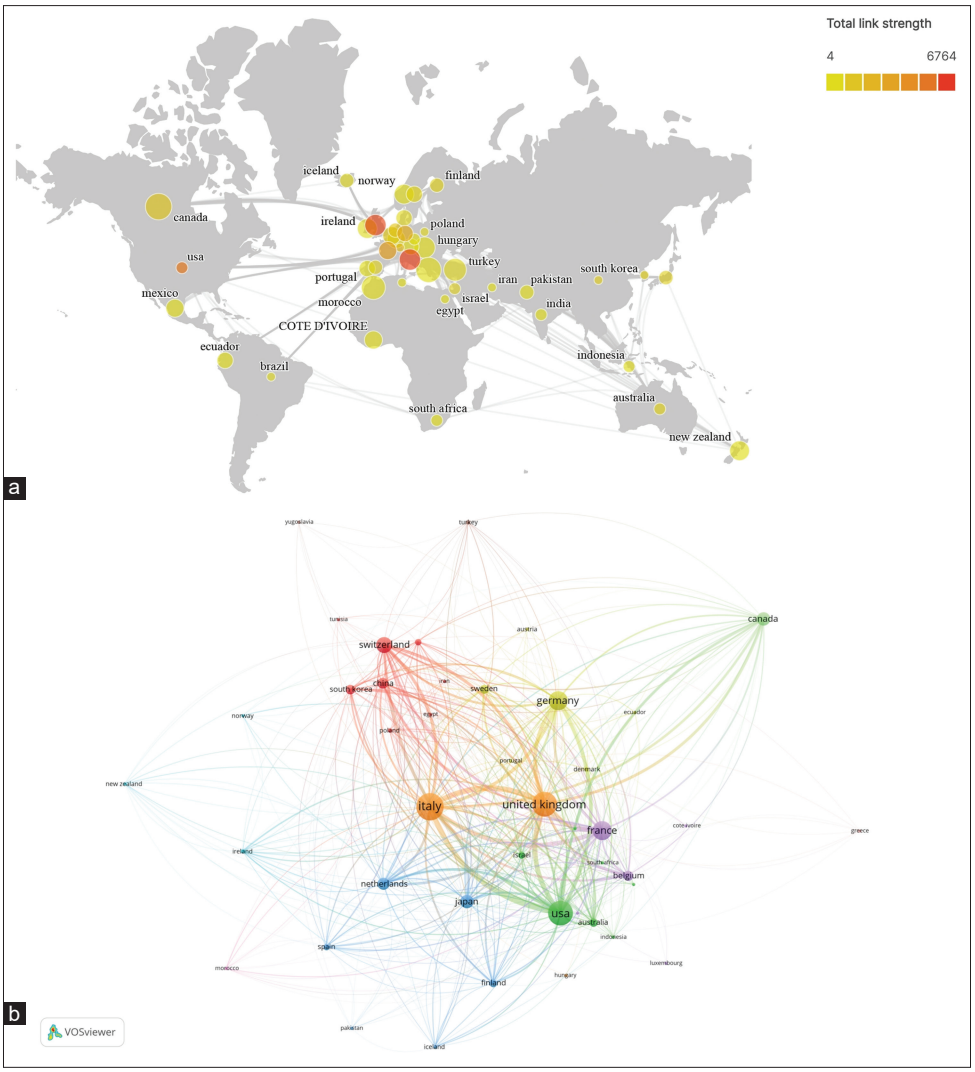

Figure 3: (a) A world map showing the geographical distribution of unilateral neglect and research collaboration among countries. (b) Network visualization map of international collaboration among countries

Table 2: Top 10 institutions of origin of publications in the unilateral neglect field

Institutions	Ranking based on publications	Publications	Ranking based on citations	Citations	Countries
Università degli Studi di ROMA "La Sapienza"	1	43	5	1,800	Italy
Kessler Foundation	2	36	3	595	US
Université de Genève	2	36	17	1,056	Switzerland
Eberhard Karls Universität Tübingen	2	36	38	2,186	Germany
University of Oxford	5	32	10	1,300	UK
Università degli Studi di MILANO-BICOCCA	6	31	18	1,043	Italy
UCL	7	30	1	3,026	UK
IRCCS	8	29	23	835	Italy
Universiteit Utrecht	9	26	49	516	The Netherlands
Johns Hopkins University	10	25	11	1,280	US
University of Florida	10	25	50	508	US

UCL: University College London

clusters (dark blue and light blue) appeared late in the average appearing year (AAY) overall, with Kaufmann BC, Lasaponara S, Nef T, Mancuso M, and Chen P. being the five authors with a later average appearance.

Notably, 64% of these authors did not occupy the top 10 positions in terms of citations, suggesting that they are expected to prioritize both the quantity and quality of their articles. Bartolomeo P. and Karnath HO deserve special

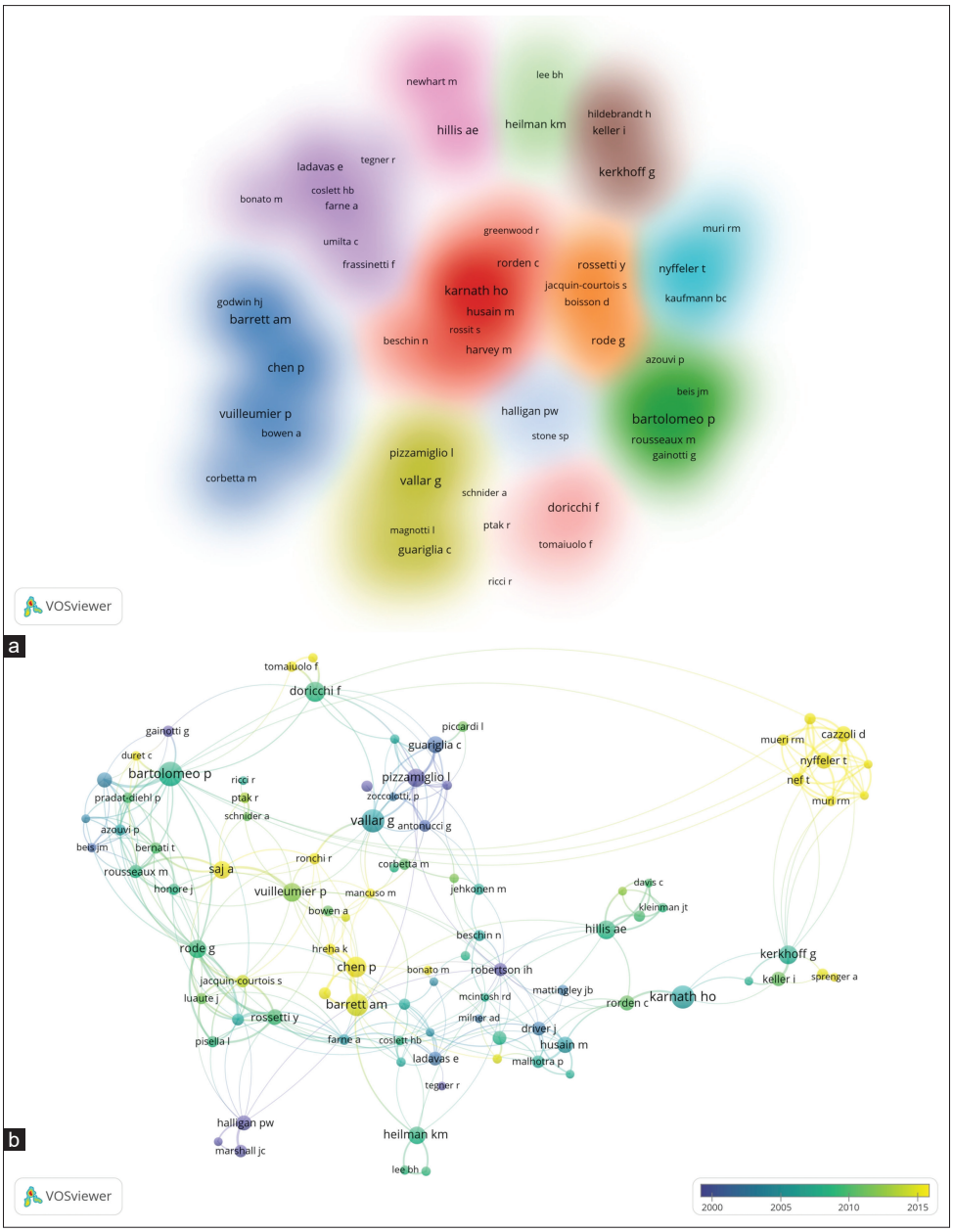

Figure 4: (a) Map showing research collaboration between authors. (b) Network visualization map of author coauthorship analysis. The color of each node represents the average appearing year for the author, depending on the color gradient shown at the bottom right

mention, as they were among the top in publication and citation statistics, and H- and G-indexes, and their numerical values were similar, underscoring the importance of their contributions to the field. Some scholars believed that collaborative authorship could enhance the quantity and quality of future studies;[15] however, there has been less overall collaboration among authors in this field, and a stable group of authors has not yet been formed. Therefore, greater emphasis should be placed on authorship.

Distribution of source journals and subject categories

Collectively, these publications were published in 199 journals. Table 4 lists the top 10 most productive journals, mainly in subject categories, including neuroscience, neurology, psychology, and rehabilitation. Among them, *Neuropsychologia* had the most publications, followed by *Cortex* and *Neuropsychological Rehabilitation*. Moreover, *Neuropsychologia* ranked first in terms of citations, H-index, and G-index, establishing it as the most influential journal in this field for distributing a substantial volume of high-quality content.

Figure 5a presents a network visualization of the co-citation analysis for journals with a minimum citation count of 300. A tight connection network was formed between journals, and the connections between different clusters were also extensive. *Neuropsychologia*, *Brain*,

Neurology, *Cortex*, and *Journal of Neurology Neurosurgery and Psychiatry* ranked in the top five in terms of total connection strength.

Figure 5b shows the four core citation paths. Publications in the fields of neurology, sports, and ophthalmology were influenced by the molecular, biology, and genetics fields ($z = 3.45$, $f = 13122$) and psychology, education, and social fields ($z = 5.55$, $f = 20322$). In addition, publications in the fields of molecular, biology, and immunology were influenced by psychology, education, and social fields ($z = 1.70$, $f = 7146$), and publications in the fields of psychology, education, and health were affected by psychology, education, and social fields ($z = 1.75$, $f = 7308$).

Top-cited documents

Table 5 shows that the most cited publication was "Spatial neglect and attention networks," authored by Corbetta and Shulman and published in the Annual Review of Neuroscience (IF = 15.553) in 2011, which maintained the highest average annual citations too. Corbetta *et al*. proposed an intricate functional anatomical network of UN that represents a fundamental node for UN anatomy research.

The research publications with the most citations were related to the anatomical basis (eight publications) and rehabilitation (two publications); one of the publications also involved the subtypes of UN.

Table 3: Top 10 (by quantity) authors in the unilateral neglect field

Authors	Publications (ranking)	Citations (ranking)	H-index	G-index
Bartolomeo P	43 (1)	2,841 (1)	26	43
Karnath HO	39 (2)	2,789 (2)	27	39
Vallar G	39 (2)	2,213 (7)	23	39
Barrett AM	36 (4)	998 (31)	18	31
Chen P	31 (5)	669 (54)	12	21
Doricchi F	29 (6)	1,200 (22)	16	29
Vuilleumier P	27 (7)	1,541 (13)	17	27
Hillis AE	26 (8)	1,373 (19)	17	26
Kerkhoff G	26 (8)	1,073 (26)	19	26
Pizzamiglio L	25 (10)	1,553 (12)	19	25
Rode G	25 (10)	2,407 (6)	19	25

Co-occurrence analysis of keywords

A total of 2,854 keywords were extracted, creating a visual map of high-frequency keywords with more than 20 occurrences [Figure 6a]. Among them, the 10 most frequent keywords included "stroke," "unilateral neglect," "hemispatial neglect," "visual neglect," "attention," "spatial neglect," "rehabilitation," "visuospatial neglect," "unilateral spatial neglect," and "recovery." According to the clustering of co-occurring keywords in Figure 6a, the following four clusters were broadly defined: cluster 1 (red, "unilateral neglect," 36 items), cluster 2 (green, "rehabilitation," 33 items), cluster 3 (blue, "anatomy," 19 items), and cluster 4 (yellow, "transcranial magnetic stimulation," 5 items). Figure 6b shows that from an overall perspective, the recent keywords in clusters 2 and 4 in this field accounted for a high proportion and were newer than those in other clusters. Furthermore, Figure 6c shows that anatomical research belonged to the motor and well-developed research topics, whereas rehabilitation research belonged to emerging or potentially declining themes. Figure 6d shows a visual map of the AAY for high-frequency keywords, which displayed neuroanatomy (cluster 2, AAY for 2017.5), virtual reality (VR) (cluster 2, AAY for 2017.3), and theta-burst stimulation (cluster 4, AAY for 2017.3) as the three most recently appearing keywords.

On the basis of the characteristics of UN keyword clustering, this study developed four aspects for analysis.

Cluster 1: UN is referred to various manifestations, including visual neglect, hemispatial neglect, and spatial neglect. UN is a prevalent attention disorder after stroke and can manifest as personal, peripersonal, and extrapersonal neglect. Personal space pertains to the body's surface,[16] peripersonal space encompasses the three-dimensional area within the arm's reach, and extrapersonal space refers to the space beyond the arm's distance.[17] Among them, motor neglect, referring to the

Table 4: Top 10 journals of origin of publications in the unilateral neglect field

Journals	Publications	Citations	H-index	G-index	Impact factor 2022
Neuropsychologia	143 (1)	5,746 (1)	44	68	3.054
Cortex	84 (2)	2,837 (3)	31	51	4.644
Neuropsychological Rehabilitation	65 (3)	1,451 (8)	22	36	2.928
Archives of Physical Medicine and Rehabilitation	37 (4)	2,272 (6)	27	37	4.060
Brain	36 (5)	4,688 (2)	30	36	15.255
Neurocase	36 (5)	461 (25)	10	21	0.781
Frontiers in Human Neuroscience	32 (7)	1,198 (10)	18	32	3.473
Neurology	29 (8)	2,740 (4)	26	29	11.800
Journal of Neurology Neurosurgery and Psychiatry	29 (8)	2,440 (5)	24	29	13.654
Journal of Clinical and Experimental Neuropsychology	29 (8)	1,054 (11)	15	29	2.283

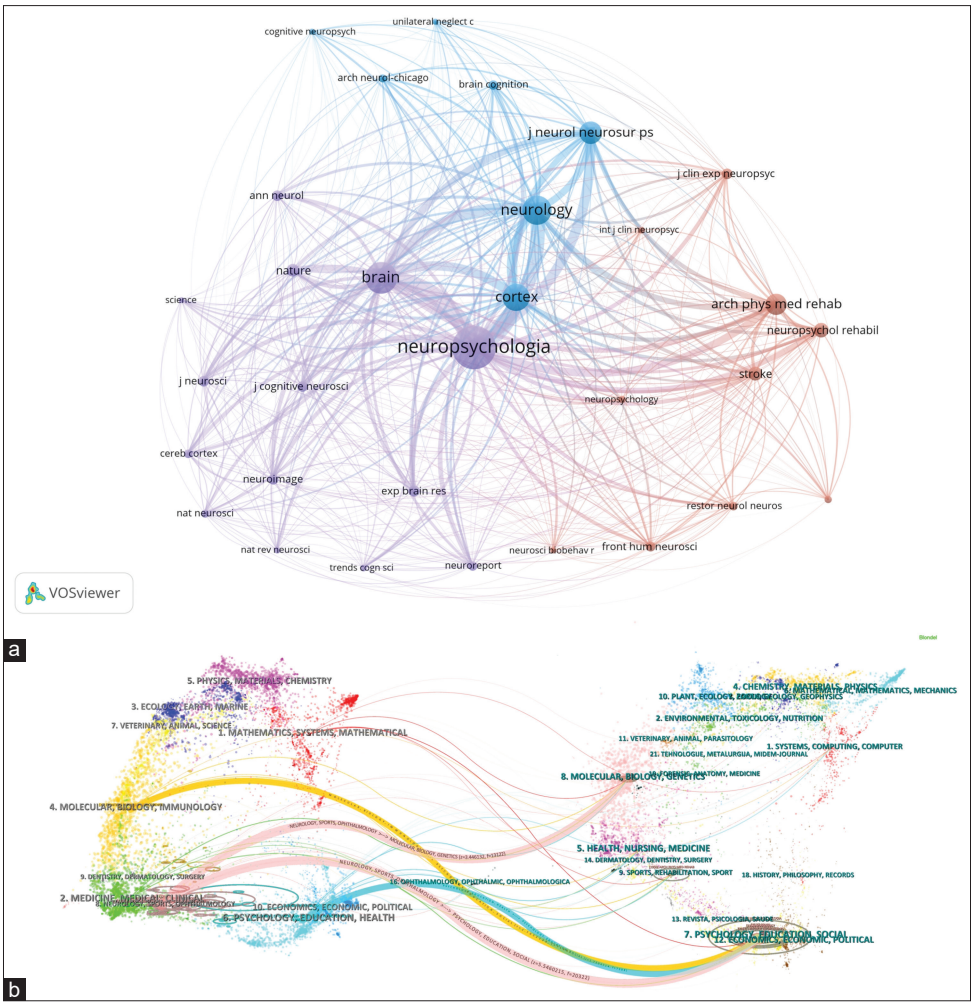

Figure 5: (a) Network visualization map of journal co-citation analysis. (b) The dual-map overlay of unilateral neglect field. In the dual map, the citing journals appear on the left side of the map, and the cited journals are on the right

Table 5: Top 10 cited publications in the unilateral neglect field

Title	Authors	Year	Journal	Citations (ranking)	Citations per year
Spatial neglect and attention networks	Corbetta M, Shulman GL	2011	*Annual Review of Neuroscience*	785 (1)	60.38
Breakdown of functional connectivity in frontoparietal networks underlies behavioral deficits in spatial neglect	He BJ, Snyder AZ, Vincent JL *et al*.	2007	*Neuron*	705 (2)	41.47
The anatomy of unilateral neglect after right-hemisphere stroke lesions	Vallar G, Perani D	1986	*Neuropsychologia*	626 (3)	16.47
The anatomy of visual neglect	Mort DJ, Malhotra P, Mannan SK *et al*.	2003	*Brain*	622 (4)	29.62
Prism adaptation to a rightward optical deviation rehabilitates left hemispatial neglect	Rossetti Y, Rode G, Pisella L *et al*.	1998	*Nature*	614 (5)	23.62
Neural basis and recovery of spatial attention deficits in spatial neglect	Corbetta M, Kincade MJ, Lewis C *et al*.	2005	*Nature Neuroscience*	607 (6)	31.95
Phasic alerting of neglect patients overcomes their spatial deficit in visual awareness	Robertson IH, Mattingley JB, Rorden C *et al*.	1998	*Nature*	411 (7)	15.81
Left neglect for near but not far space in man	Halligan PW, Marshall JC	1991	*Nature*	407 (8)	12.33
Nonspatially lateralized mechanisms in hemispatial neglect	Husain M, Rorden C	2003	*Nature Reviews Neuroscience*	407 (8)	19.38
Hemispatial neglect	Buxbaum LJ, Ferraro MK, Veramonti T *et al*.	2004	*Neurology*	404 (10)	20.20

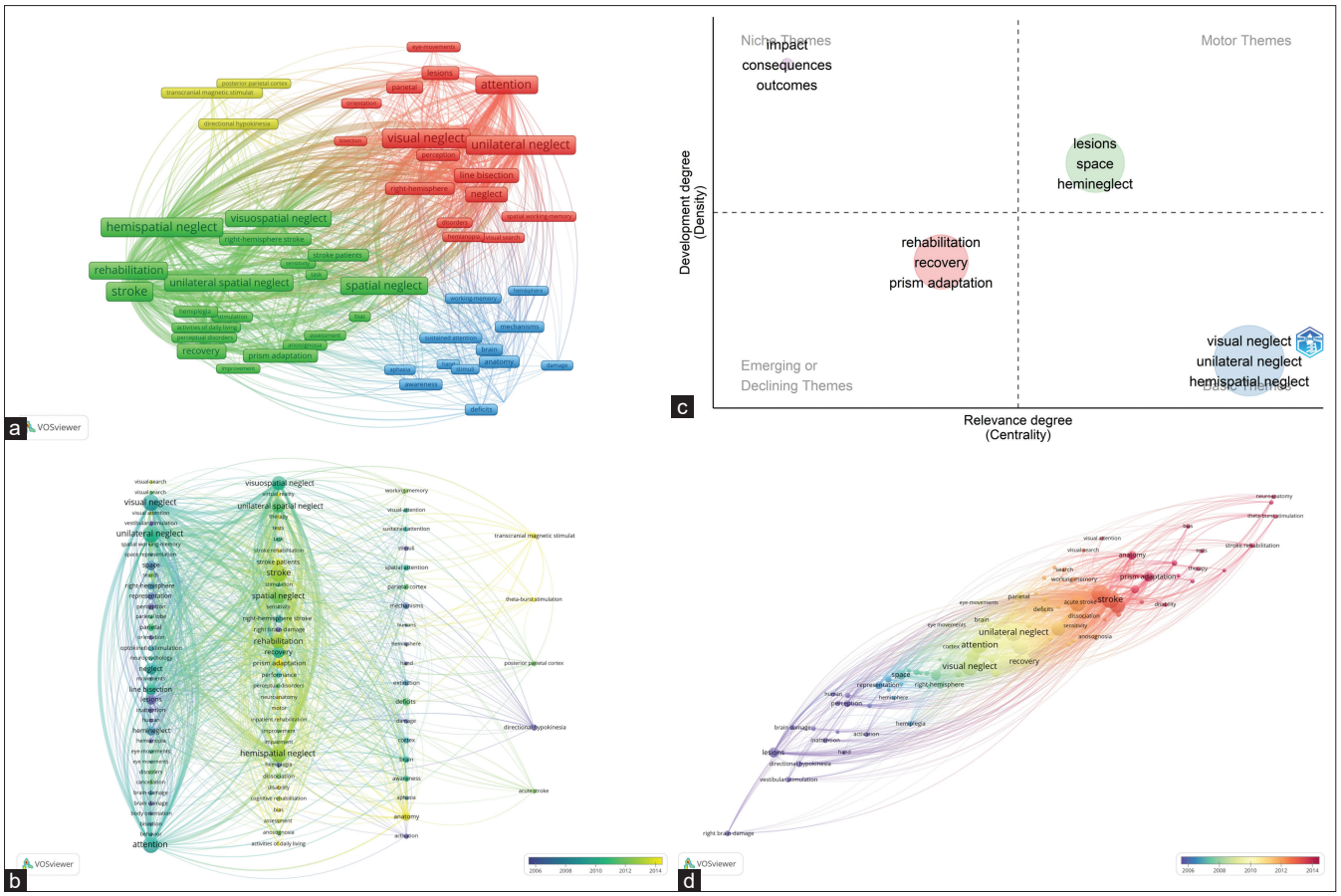

Figure 6: (a) Network visualization map of co-occurring keywords. (b) Visualization map of co-occurring keywords. (c) Thematic map of themes. The horizontal axis is the centrality, and the vertical axis is the density. (d) Average year publication for keywords with high occurrences

inability of patients to fully use their contralateral limbs without basic motor impairment,[18] has emerged as a recent research hotspot. However, the lesion correlation and relationship with UN remain undetermined,[19] warranting further exploration. Moreover, there are numerous standardized and nonstandardized methods for UN assessment. Among these, the line bisection and cancellation tasks are highly dependable and frequently employed in evaluation tests. Nonetheless, standardized testing may be inadequate to identify contralateral spatial disorders during the subacute and chronic phases of the disease. Therefore, it is imperative to employ more suitable and rigorous tasks to determine the presence of these disorders.[20]

Cluster 2: Rehabilitation has emerged as a prominent research topic and is gaining considerable attention in the upcoming stages. Existing treatment methods can be broadly classified into categories, such as pharmacotherapy, visual intervention therapy, prism adaptation technology, body awareness intervention, psychological function intervention, motor intervention, noninvasive brain stimulation, electrical stimulation, and acupuncture,[21] all aiming to mitigate the adverse effects of cognitive impairment on daily activities, social participation, and quality of life. Several reviews[22,23] or meta-analyses[21,24] summarizing and evaluating these treatment approaches, visual scanning training, prism therapy,[25] and limb activation[26] are considered the most recommended approaches for conducting therapeutic studies and standardizing clinical care. The emergence of novel therapeutic treatments, e.g., VR and robotics, has led to increased research focus, and optimal treatment measures are still under exploration.

Cluster 3: Anatomy holds a critical position in the UN field. Owing to cortical lesions caused by stroke, UN has traditionally been linked with the parietal lobe sign,[27] and studies have further identified frontal[28] and subcortical gray matter nuclei[29] damage. On the basis of clinical evidence and neuroimaging findings, studies have pointed to lesions in various cortical regions, e.g., the temporoparietal junction,[27] posterior parietal lobe,[30] and angular gyrus.[31] However, the results of these studies are partially conflicting, suggesting that these regions may affect network-based attention circuit dysfunction rather than playing unique roles.[32] With the development and numerous applications of functional imaging, Corbetta and Shulman[33] proposed a fine-grained functional anatomical network for UN,

demonstrating separate but interacting subnetworks of visuospatial attention. Additional studies have found that neglect symptoms arise from various brain regions, and intrahemispheric disruptions affect the frontoparietal network; yet, the specifics of the potential mechanisms underlying these effects remain unclear. New neuroimaging and stimulation techniques may provide unique opportunities to reveal essential evidence and potential mechanisms.

Cluster 4: Transcranial magnetic stimulation (TMS) is a type of rehabilitation therapy first introduced by Barker *et al*.[34] in England in 1985 and encompasses three primary stimulation modes: single-pulse TMS, paired TMS, and repetitive TMS (rTMS). Among these, rTMS technology has matured alongside the development of machines and has become a new research hotspot that offers great promise for disease assessment and rehabilitation therapy. Although some studies[35,36] and meta-analyses[37] have shown that rTMS has a positive effect on UN rehabilitation, there is a lack of uniform agreement regarding the parameters of frequency, intensity, and location of rTMS that achieve the best therapeutic effect, thus highlighting the need for further in-depth research.

Research hotspot tendencies

Figure 7 shows the top 37 keywords with the highest number of citation bursts between 1972 and 2022. Notably, the term "lesion" had the highest burst strength of 20.85. Furthermore, recent keyword bursts focused on "transcranial magnetic stimulation," "virtual reality," "neuroanatomy," "network," "connectivity," "stroke patient," "therapy," and "predictor," which were still ongoing.

Burst keywords can predict emerging trends within a field to some extent. This study revealed that most research hotspots in this field have focused on anatomical research and rehabilitation therapy. The direction of anatomical research has evolved from right brain damage, right hemisphere, brain damage, and laterality, gradually progressing to the posterior parietal cortex and left hemisphere. Currently, its research frontier is focused on networks and connectivity, indicating a progression from initial lesion area research to the current network research. It has been hypothesized that advancements in neuroimaging and brain stimulation have contributed to the development of functional anatomy. Visuospatial attention predominantly relies on the frontoparietal network,[38] which is connected by three branches of the superior longitudinal fascia (SLF I-III),[39] exhibiting anatomical features of hemispheric asymmetry and ventral-dorsal gradient asymmetry,[40] and a ventral network connected by the inferior fronto-occipital fascicle (IFOF).[41] Numerous studies and evidence have suggested that network dysfunction in the SLF II-III and IFOF networks is an important marker of many signs of UN.[42] In addition, the network-based nature of UN has potential implications for compensatory mechanisms for spontaneous recovery or rehabilitation treatment.[43] Thus far, the neuroanatomical basis of heterogeneity in UN remains uncertain and requires more in-depth research and exploration. The superior temporal resolution of electroencephalography provides a promising opportunity to elucidate the functional relationship between pertinent anatomical regions of UN.[44]

Within the realm of UN rehabilitation research, various stages of development and innovation have led to the emergence of explosive technological advancements, such as early vestibular stimulation, optokinetic stimulation, prism adaptation, and, most recently, TMS and VR. VR has demonstrated great promise in offering a computer-based, multisensory, real-time, and interactive environment for patients to safely interact with real-world environments.[45] VR can be used not only during hospitalization but also as rehabilitation therapy at home, offering flexibility and convenience for more frequent, repetitive exercises. On the basis of the extent to which patients are fully engaged in the virtual environment, VR can be categorized into three types: nonimmersive VR (NIVR), semi-immersive VR (SIVR), and immersive VR (IVR).[46] Several meta-analyses[47-49] have demonstrated the effectiveness of VR, indicating that VR has substantial potential and numerous benefits for UN rehabilitation. Furthermore, VR interventions have been shown to induce changes in neural plasticity and enhance cortical connectivity.[50] In a recent study,[51] the therapeutic effects of various forms of VR were examined, revealing that all three treatments exhibited positive therapeutic effects. Over time, research on VR treatment has transitioned from NIVR to SIVR, with an emphasis on IVR. With the progressive evolution of technology, VR headsets and controllers have become increasingly popular and affordable. Concurrently, IVR offers prospects for an ecologically sound, well-organized, and user-centric setting in contrast to alternative modalities. Therefore, VR holds considerable promise for clinical implementation and requires further investigation and advancement.

Limitations

This study only accessed the SCIE database and did not consider gray literature or publications in languages other than English. As such, the analysis results presented may not encompass all the data pertinent to this field and could potentially be biased. The relatively small size of the dataset returned by the search criteria prevented a comprehensive analysis of trends and developments in the research topics. In the future, more data will be required for further analysis. Furthermore,

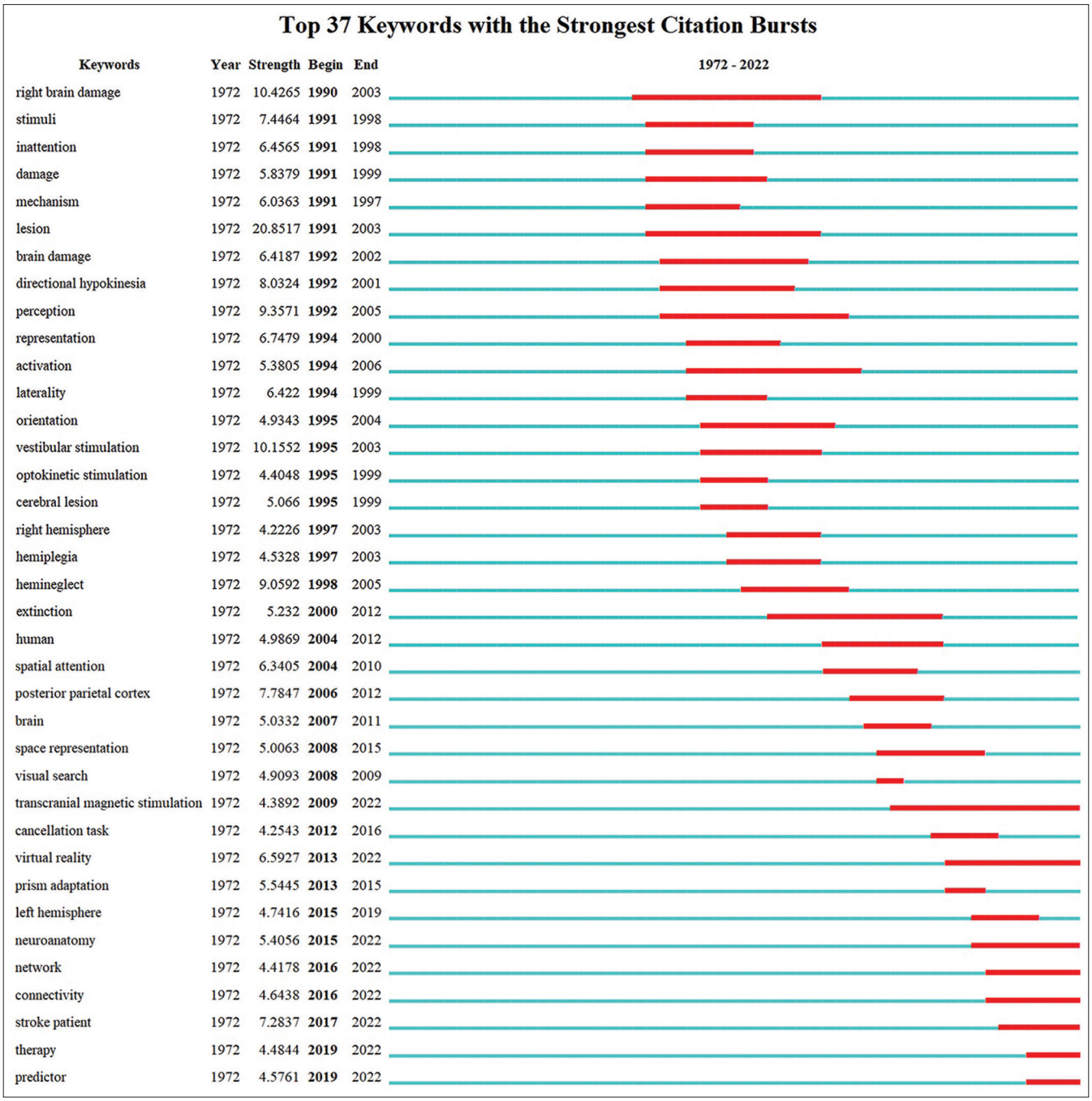

Figure 7: The top 37 keywords with the strongest citation bursts during 1972–2022

publications published in 2023 were excluded due to insufficient data.

Conclusions

This study revealed the research status, trends, hotspots, and cooperative networks in UN research through bibliometric analysis, and it visualized a network map of the data extracted from the WoSCC database. In general, this is an upcoming field with prominent contributions from Italy, the UK, and the US. The Università degli Studi di ROMA "La Sapienza" emerged as the most prolific institution in this field, and *Neuropsychologia* was identified as the most influential academic journal. In addition, VOSviewer divided keywords into four clusters. In recent years, rehabilitation therapy has been considered a research hotspot; however, several research directions, such as TMS, VR, neuroanatomy, networks, connectivity, patients with stroke, therapy, and predictors, warrant further investigation. Ultimately, this study provides a comprehensive overview of trends in UN research and offers potential pathways for future development in this important field.

Author contributions

WZ: Concepts, design, definition of intellectual content, literature search, data acquisition, data analysis, statistical analysis, manuscript preparation, manuscript editing and manuscript review; LY: Design, definition of intellectual content, literature search, data acquisition, data analysis, statistical analysis, manuscript editing and manuscript review; LC: Concepts, design, data acquisition, data analysis, statistical analysis, manuscript preparation and mmanuscript review; WS: Concepts, design, definition of intellectual content, literature search, data acquisition, data analysis, statistical analysis, manuscript preparation, manuscript editing, manuscript review and guarantor.

Ethical statement

Not applicable.

Data availability statement

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Financial support and sponsorship

This study was supported by the National Natural Science Foundation of China (82002386, 82272593) and the Beijing Hospital Management Center Cultivation Program (PX2021037).

Conflicts of interest

There are no conflicts of interest.

References

1. Corbetta M, Kincade MJ, Lewis C, Snyder AZ, Sapir A. Neural basis and recovery of spatial attention deficits in spatial neglect. Nat Neurosci 2005;8:1603-10.
2. Ringman JM, Saver JL, Woolson RF, Clarke WR, Adams HP. Frequency, risk factors, anatomy, and course of unilateral neglect in an acute stroke cohort. Neurology 2004;63:468-74.
3. Nijboer TC, Kollen BJ, Kwakkel G. Time course of visuospatial neglect early after stroke: A longitudinal cohort study. Cortex 2013;49:2021-7.
4. Demeyere N, Gillebert CR. Ego- and allocentric visuospatial neglect: Dissociations, prevalence, and laterality in acute stroke. Neuropsychology 2019;33:490-8.
5. Heilman KM, Valenstein E, Watson RT. Neglect and related disorders. Semin Neurol 2000;20:463-70.
6. Vossel S, Eschenbeck P, Weiss PH, Fink GR. The neural basis of perceptual bias and response bias in the Landmark task. Neuropsychologia 2010;48:3949-54.
7. Chen P, Hreha K, Kong Y, Barrett AM. Impact of spatial neglect on stroke rehabilitation: Evidence from the setting of an inpatient rehabilitation facility. Arch Phys Med Rehabil 2015;96:1458-66.
8. Frassinetti F, Angeli V, Meneghello F, Avanzi S, Làdavas E. Long-lasting amelioration of visuospatial neglect by prism adaptation. Brain 2002;125:608-23.
9. Gammeri R, Iacono C, Ricci R, Salatino A. Unilateral spatial neglect after stroke: Current insights. Neuropsychiatr Dis Treat 2020;16:131-52.
10. Chen C. Searching for intellectual turning points: Progressive knowledge domain visualization. Proc Natl Acad Sci U S A 2004;101 Suppl 1:5303-10.
11. van Eck NJ, Waltman L. Software survey: VOSviewer, a computer program for bibliometric mapping. Scientometrics 2010;84:523-38.
12. Aria M, Cuccurullo C. Bibliometrix: An R-tool for comprehensive science mapping analysis. J Informetr 2017;11:959-75.
13. Kim Y, Yoon DY, Kim JE, Park KM, Lee JH, Song HK, *et al.* Citation classics in stroke: The top-100 cited articles on hemorrhagic stroke. Eur Neurol 2017;78:210-6.
14. Asplund K, Eriksson M, Persson O. Country comparisons of human stroke research since 2001: A bibliometric study. Stroke 2012;43:830-7.
15. Wu H, Li Y, Tong L, Wang Y, Sun Z. Worldwide research tendency and hotspots on hip fracture: A 20-year bibliometric analysis. Arch Osteoporos 2021;16:73.
16. Zebhauser PT, Vernet M, Unterburger E, Brem AK. Visuospatial neglect – A theory-informed overview of current and emerging strategies and a systematic review on the therapeutic use of Non-invasive brain stimulation. Neuropsychol Rev 2019;29:397-420.
17. Cox JA, Aimola Davies AM. Keeping an eye on visual search patterns in visuospatial neglect: A systematic review. Neuropsychologia 2020;146:107547.
18. Laplane D, Degos JD. Motor neglect. J Neurol Neurosurg Psychiatry 1983;46:152-8.
19. Toba MN, Pagliari C, Rabuffetti M, Nighoghossian N, Rode G, Cotton F, *et al.* Quantitative assessment of motor neglect. Stroke 2021;52:1618-27.
20. Ricci R, Salatino A, Caldano M, Perozzo P, Cerrato P, Pyasik M, *et al.* Phantom touch: How to unmask sensory unawareness after stroke. Cortex 2019;121:253-63.
21. Longley V, Hazelton C, Heal C, Pollock A, Woodward-Nutt K, Mitchell C, *et al.* Non-pharmacological interventions for spatial neglect or inattention following stroke and other non-progressive brain injury. Cochrane Database Syst Rev 2021;7:CD003586.
22. Azouvi P, Jacquin-Courtois S, Luauté J. Rehabilitation of unilateral neglect: Evidence-based medicine. Ann Phys Rehabil Med 2017;60:191-7.
23. Corbetta M. Hemispatial neglect: Clinic, pathogenesis, and treatment. Semin Neurol 2014;34:514-23.
24. Li J, Li L, Yang Y, Chen S. Effects of prism adaptation for unilateral spatial neglect after stroke: A systematic review and meta-analysis. Am J Phys Med Rehabil 2021;100:584-91.
25. Luauté J, Halligan P, Rode G, Rossetti Y, Boisson D. Visuo-spatial neglect: A systematic review of current interventions and their effectiveness. Neurosci Biobehav Rev 2006;30:961-82.
26. Riestra AR, Barrett AM. Rehabilitation of spatial neglect. Handb Clin Neurol 2013;110:347-55.
27. Vallar G, Perani D. The anatomy of unilateral neglect after right-hemisphere stroke lesions. A clinical/CT-scan correlation study in man. Neuropsychologia 1986;24:609-22.
28. Husain M, Kennard C. Visual neglect associated with frontal lobe infarction. J Neurol 1996;243:652-7.
29. Karnath HO, Himmelbach M, Rorden C. The subcortical anatomy of human spatial neglect: Putamen, caudate nucleus and pulvinar. Brain 2002;125:350-60.
30. Azouvi P, Samuel C, Louis-Dreyfus A, Bernati T, Bartolomeo P, Beis JM, *et al.* Sensitivity of clinical and behavioural tests of spatial neglect after right hemisphere stroke. J Neurol Neurosurg Psychiatry 2002;73:160-6.
31. Hillis AE, Newhart M, Heidler J, Barker PB, Herskovits EH, Degaonkar M. Anatomy of spatial attention: Insights from perfusion imaging and hemispatial neglect in acute stroke. J Neurosci 2005;25:3161-7.
32. Bartolomeo P. The quest for the 'critical lesion site' in cognitive deficits: Problems and perspectives. Cortex 2011;47:1010-2.

33. Corbetta M, Shulman GL. Spatial neglect and attention networks. Annu Rev Neurosci 2011;34:569-99.
34. Barker AT, Jalinous R, Freeston IL. Non-invasive magnetic stimulation of human motor cortex. Lancet 1985;1:1106-7.
35. Brighina F, Bisiach E, Oliveri M, Piazza A, La Bua V, Daniele O, *et al.* 1 Hz repetitive transcranial magnetic stimulation of the unaffected hemisphere ameliorates contralesional visuospatial neglect in humans. Neurosci Lett 2003;336:131-3.
36. Kim BR, Chun MH, Kim DY, Lee SJ. Effect of high- and low-frequency repetitive transcranial magnetic stimulation on visuospatial neglect in patients with acute stroke: A double-blind, sham-controlled trial. Arch Phys Med Rehabil 2013;94:803-7.
37. Salazar AP, Vaz PG, Marchese RR, Stein C, Pinto C, Pagnussat AS. Noninvasive brain stimulation improves hemispatial neglect after stroke: A systematic review and meta-analysis. Arch Phys Med Rehabil 2018;99:355-66.e1.
38. Corbetta M, Patel G, Shulman GL. The reorienting system of the human brain: From environment to theory of mind. Neuron 2008;58:306-24.
39. Makris N, Kennedy DN, McInerney S, Sorensen AG, Wang R, Caviness VS Jr., *et al.* Segmentation of subcomponents within the superior longitudinal fascicle in humans: A quantitative, *in vivo*, DT-MRI study. Cereb Cortex 2005;15:854-69.
40. Thiebaut de Schotten M, Dell'Acqua F, Forkel SJ, Simmons A, Vergani F, Murphy DG, *et al.* A lateralized brain network for visuospatial attention. Nat Neurosci 2011;14:1245-6.
41. Catani M, Howard RJ, Pajevic S, Jones DK. Virtual *in vivo* interactive dissection of white matter fasciculi in the human brain. Neuroimage 2002;17:77-94.
42. Bartolomeo P. Visual and motor neglect: Clinical and neurocognitive aspects. Rev Neurol (Paris) 2021;177:619-26.
43. Bartolomeo P. From competition to cooperation: Visual neglect across the hemispheres. Rev Neurol (Paris) 2021;177:1104-11.
44. Yordanova J, Kolev V, Verleger R, Heide W, Grumbt M, Schürmann M. Synchronization of fronto-parietal beta and theta networks as a signature of visual awareness in neglect. Neuroimage 2017;146:341-54.
45. Pedroli E, Serino S, Cipresso P, Pallavicini F, Riva G. Assessment and rehabilitation of neglect using virtual reality: A systematic review. Front Behav Neurosci 2015;9:226.
46. Bamodu O, Ye XM. Virtual reality and virtual reality system components. Adv Mater Res 2013;765-7:1169-72.
47. Ogourtsova T, Souza Silva W, Archambault PS, Lamontagne A. Virtual reality treatment and assessments for post-stroke unilateral spatial neglect: A systematic literature review. Neuropsychol Rehabil 2017;27:409-54.
48. Martino Cinnera A, Bisirri A, Chioccia I, Leone E, Ciancarelli I, Iosa M, *et al.* Exploring the potential of immersive virtual reality in the treatment of unilateral spatial neglect due to stroke: A comprehensive systematic review. Brain Sci 2022;12:1589.
49. Kaiser AP, Villadsen KW, Samani A, Knoche H, Evald L. Virtual reality and eye-tracking assessment, and treatment of unilateral spatial neglect: Systematic review and future prospects. Front Psychol 2022;13:787382.
50. Hao J, Xie H, Harp K, Chen Z, Siu KC. Effects of virtual reality intervention on neural plasticity in stroke rehabilitation: A systematic review. Arch Phys Med Rehabil 2022;103:523-41.
51. Salatino A, Zavattaro C, Gammeri R, Cirillo E, Piatti ML, Pyasik M, *et al.* Virtual reality rehabilitation for unilateral spatial neglect: A systematic review of immersive, semi-immersive and non-immersive techniques. Neurosci Biobehav Rev 2023;152:105248.

Supplementary Table 1: Search strategy

Number	Retrieval type
1	TS=(stroke or poststroke or "poststroke" or cerebrovasc* or brainvasc* or cerebral vasc* or cva* or apoplexy* or SAH)
2	TS=((brain* or cerebr* or cerebell* or intracran* or intracerebral) NEAR/5 (isch*emi* or infarct* or thrombo* or emboli* or occlus*))
3	TS=((brain* or cerebr* or cerebell* or intracerebral or intracranial or subarachnoid) NEAR/5 (haemorrhage* or hemorrhage* or haematoma* or hematoma* or bleed*))
4	TS=(hemipleg* or hemipar* or paresis or paretic)
5	TS=((brain or head or intracran* or cerebr* or cerebell*) NEAR/5 (injur* or contusion* or hypoxi* or damage* or inflamm* or concussion or trauma$ or fractur* or neoplasm* or lesion* or tumor* or tumour* or cancer* or infection*))
6	#5 OR #4 OR #3 OR #2 OR #1
7	TS=(hemineglect or hemi-neglect)
8	TS=((unilateral or spatial or hemi*spatial or visual) NEAR/5 (neglect))
9	TS=(perception or inattention or hemi-inattention or attention or extinction)
10	TS=((perceptual or perception or visuo*spatial or visuo*perceptual or attention*) NEAR/5 (disorder* or deficit* or impairment* or abilit* or problem*))
11	#7 OR #8 OR #9 OR #10
12	#11 AND #6