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Mapping Time Perception Research in Cognitive Aging and Early Cognitive Decline: A Bibliometric Analysis

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Abstract

BACKGROUND/AIMS: Time perception is a core cognitive function that relies on distributed neurocognitive systems and may be sensitive to early changes across the cognitive aging continuum, including subjective cognitive decline (SCD) and mild cognitive impairment (MCI). Despite growing interest, the knowledge structure and thematic organization of research linking time perception to age-related cognitive vulnerability have not been quantitatively mapped. This study aimed to characterize publication trends, disciplinary distribution, geographic contributions, and conceptual themes in the literature on time perception in cognitive aging, SCD, and MCI using bibliometric methods.

MATERIALS AND METHODS: A bibliometric analysis was conducted using the Web of Science Core Collection. A targeted query combined time-perception constructs in the title field with constructs related to aging, SCD, MCI, and dementia in the topic field. Records were exported in plain-text format and descriptively analyzed with respect to annual production, document types, countries, institutions, and research areas. The thematic structure of the field was examined using a frequency-based analysis of title-derived terms.

RESULTS: The final dataset included 64 records published between 1984 and 2025. Publication output remained limited until the mid-2000s and then expanded markedly after 2015, with peak activity concentrated in the last decade. Research output showed a geographically uneven distribution, led by the United States (n=17), France (n=10), China (n=7), Italy (n=6), and Canada and the Netherlands (n=5 each). Research areas were highly interdisciplinary, with the highest representation in neurosciences/neurology and psychology (n=25 each), followed by geriatrics/gerontology (n=11) and psychiatry (n=8). Frequency-based analysis of title-derived terms showed that the literature is centered on core timing concepts, such as time perception and time estimation, with additional emphasis on Alzheimer's disease, memory, and age-related constructs.

CONCLUSION: Research on time perception in cognitive aging and early cognitive decline has expanded rapidly over the last decade and is primarily anchored in neuropsychology and cognitive neuroscience. Thematic mapping suggests that timing paradigms form the conceptual core of the field, whereas clinically framed work on early cognitive decline remains comparatively limited. These findings highlight the need for further methodologically standardized and empirically oriented research in preclinical and prodromal cognitive states.

Keywords: Time perception, interval timing, cognitive aging, cognitive decline, bibliometric analysis

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INTRODUCTION

Time perception-the ability to estimate, reproduce, and compare temporal intervals-represents a fundamental component of human cognition that underpins goal-directed behavior, prospective memory, decision-making, and adaptive interaction with the environment.[1] Rather than reflecting a unitary faculty, temporal processing emerges from distributed neural systems involving fronto-striatal and fronto-parietal networks, cerebellar contributions, and neuromodulatory mechanisms.[2] As a result, temporal judgments are intrinsically linked to attentional allocation, working memory maintenance, and executive control. Alterations in these cognitive systems due to aging or neurodegenerative processes are therefore expected to manifest as measurable changes in interval timing and subjective temporal experience.[1-3]

Cognitive aging encompasses a heterogeneous continuum ranging from normative age-related changes to prodromal and syndromic forms of cognitive impairment. Within this framework, subjective cognitive decline (SCD) is commonly conceptualized as a preclinical state characterized by self-perceived cognitive worsening in the absence of clear objective deficits, whereas mild cognitive impairment (MCI) denotes objectively measurable cognitive impairment with relative preservation of daily functioning and an increased risk of progression to dementia.[4,5]

Because time perception tasks impose simultaneous demands on attention, working memory, and monitoring processes, they have been proposed as potentially sensitive behavioral probes of early neurocognitive vulnerability.[3] A growing empirical literature has applied time estimation, reproduction, bisection, and judgment paradigms to older adults and clinical populations along the Alzheimer's disease continuum.[6] Nevertheless, findings remain heterogeneous, reflecting substantial variability in experimental paradigms, temporal scales, analytic metrics, and clinical characterization.[7]

Despite this expanding literature, the intellectual and thematic structure of research at the intersection of time perception, cognitive aging, and early cognitive decline has not been systematically mapped. Studies are dispersed across multiple disciplines, often progressing in parallel rather than through integrative conceptual frameworks, complicating the identification of dominant research themes and underexplored areas. In such contexts, bibliometric science-mapping approaches offer a valuable methodological framework by quantitatively characterizing publication trends, citation structures, and conceptual networks within a defined research domain.[8,9]

Accordingly, this study conducted a bibliometric analysis of publications addressing time perception in cognitive aging and early cognitive decline, using data indexed in the Web of Science (WoS) Core Collection and identified through a targeted search strategy that yielded 64 records. The objectives are to characterize (i) temporal trends in publication output, (ii) the disciplinary and source distribution of the literature, and (iii) the thematic structure of the field, using a frequency-based analysis of title-derived terms.

MATERIALS AND METHODS

Literature Source

This bibliometric study was conducted using the WoS Core Collection (Clarivate Analytics), selected because of its standardized indexing structure, citation-tracking capability, and wide use in bibliometric and science-mapping research. Only records indexed in the WoS Core Collection were considered. The exact database search was performed on February 2, 2026.

Search Strategy

A targeted search strategy was developed to identify publications addressing time perception in the context of cognitive aging and early cognitive decline. To improve conceptual specificity and reduce retrieval of unrelated basic timing literature, time-perception-related terms were restricted to the title (TI) field, whereas aging- and cognition-related constructs were searched in the topic (TS) field, which includes the title, abstract, and keywords indexed in WoS. No restriction on publication year was applied, and only English-language records were included. Records were exported in plain-text format with cited references. The final search query was as follows:

TI =("time perception" or "interval timing" or "duration perception" or "time estimation" or "time reproduction" or "time bisection" or "temporal judgment") and TS =("cognitive aging" or "older adults" or elderly or geriatric* or "mild cognitive impairment" or MCI or "subjective cognitive decline" or SCD or dementia or Alzheimer*)

This title-restricted approach was chosen to maximize specificity and yield a more focused dataset. As a trade-off, this strategy may have reduced sensitivity by excluding potentially relevant studies whose time-perception-related concepts appeared only in abstracts or keywords.

Eligibility Criteria

Eligible records included publications relevant to time perception or interval timing in older adults or in the context of early cognitive decline, including SCD and MCI. No additional post-hoc manual relevance screening beyond the predefined query was applied, consistent with a reproducible bibliometric approach. Because WoS document-type labels may overlap within the same record, document-type classifications were interpreted descriptively rather than as mutually exclusive categories. This is particularly relevant for records indexed simultaneously, for example, as "article; proceedings paper" or "article; early access".

Data Extraction and Preprocessing

All retrieved records were exported from WoS in plain-text format, including full bibliographic information and cited references. Extracted variables included publication year, document type, journal title, authors, affiliations, countries/regions, WoS research areas, titles, and citation counts. For title-based thematic analyses, titles were normalized by lowercasing and harmonizing common lexical variants. Duplicate term occurrences within the same record were removed to avoid artificial inflation of frequencies.

Ethical Consideration

This study is a bibliometric analysis based exclusively on publicly available bibliographic records. It did not involve human participants, patient-level data, identifiable personal information, or animal experiments. Therefore, ethics committee approval and informed consent were not required.

Statistical Analysis

Descriptive statistics were used to summarize annual publication output, document types, countries, institutions, and WoS research

areas. Citation impact was reported using total citation counts and, where appropriate, measures of central tendency.

To characterize the thematic structure of the field, a frequency-based analysis of title-derived terms was performed. Unigrams and bigrams were extracted from publication titles following standard text preprocessing, including lowercasing, punctuation removal, and stop-word filtering. Term frequencies were summarized descriptively, and the most frequent title-derived terms were visualized to provide an overview of the dominant concepts represented in the dataset.

Analyses and visualizations were conducted using WoS export files, reproducible computational scripts, and established bibliometric tools, including R, bibliometrix, and VOSviewer.[8,9] Graphical outputs included annual publication and citation trends, research- area and productivity distributions, and frequency-based visualizations of title-derived terms. All figures were generated at publication-ready resolution. In addition, a title-term co-occurrence network was generated to provide a complementary visualization of thematic relationships among frequently occurring terms. In this network, node size reflected term occurrence frequency, edge thickness reflected co-occurrence strength, and node color indicated mean publication year.

RESULTS

Study Selection and Dataset Characteristics

A total of 64 records were retrieved from the WoS Core Collection, using a predefined query that combined time-perception terms in the title field and cognitive aging/SCD/MCI-related terms in the topic field. The retrieved literature spanned 1984-2025, indicating a long but relatively sparse historical record, with a marked intensification in recent years. The dataset accumulated 1,707 citations across all documents, with a median citation count of 10.5 per record, suggesting that the field is supported by a small number of highly cited contributions alongside many modestly cited publications.

Annual Publication and Citation Trends

The annual publication profile indicates a prolonged period of limited scientific output from the mid-1980s through the early 2000s, during which annual output rarely exceeded a single paper. Publication activity increased gradually beginning around 2008 and rose more markedly after 2015; the highest annual outputs were concentrated between 2018 and 2024, reflecting a recent intensification of scholarly attention to the topic. Citation dynamics closely tracked this expansion but followed a steeper trajectory: annual citation counts remained minimal until the mid-2000s, increased steadily thereafter, and accelerated substantially after 2015, reaching their highest levels between 2019 and 2023 (Figure 1). The decline observed in the most recent year is best interpreted as a citation-lag effect, because newly published articles have had limited time to accrue citations.

Document Type Distribution

The literature was dominated by articles. A smaller number of records were also indexed as meeting papers, review articles, or early access items. Because WoS document-type labels may overlap within the same record, document-type categories were interpreted descriptively rather than as mutually exclusive counts.

Source Journals

Publications were distributed across 53 journals, indicating a broad disciplinary spread rather than concentration in a single outlet. The most frequent source titles were the Journal of the International Neuropsychological Society and Brain and Cognition (3 records each), followed by Neurobiology of Aging, Frontiers in Aging Neuroscience, Memory, Scientific Reports, Heliyon, Epidemiology and Infection, and International Journal of Aging & Human Development (2 records each) (Figure 2).

Geographic Distribution of Publications

Research output showed a geographically uneven distribution, with major contributions from North America, Western Europe, and parts of Asia. The United States contributed the largest share (17/64 records; 26.6%), followed by France (10/64; 15.6%), China (7/64; 10.9%), Italy (6/64; 9.4%), and Canada and the Netherlands (5/64; 7.8% each). Additional contributions were received from South Korea, Japan, England, Germany, Spain, Taiwan, Türkiye, Australia, and Portugal (Figure 3).

Institutional Contributions

Institution-level analyses indicated that a small number of organizations contributed multiple records, while most institutions contributed only one or two. Overall, the distribution suggested a dispersed research field rather than a strong dominance by a single center (Figure 4).

Research Area Classification

WoS research area assignments demonstrated a multidisciplinary profile. The most represented categories were neurosciences/neurology (n=25) and psychology (n=25), followed by geriatrics/gerontology (n=11) and psychiatry (n=8). Smaller, but notable, contributions were observed in science & technology—other topics (n=6) and behavioral sciences (n=4), as well as several additional categories, including engineering; public, environmental & occupational health; pharmacology & pharmacy; physiology; rehabilitation; biochemistry & molecular biology; and biophysics. Because WoS research area assignments may overlap across records, these categories should be interpreted as descriptive rather than mutually exclusive (Figure 5).

Title-Derived Term Frequency Analysis and Thematic Structure

To characterize the thematic structure of the field, a frequency-based analysis of title-derived terms was performed across the 64 records. The most common terms included “perception” (n=32), “time perception” (n=31), “time estimation” (n=25), and “estimation” (n=25). Additional terms related to Alzheimer’s disease, memory, and age-related concepts. These findings suggest that the literature is organized primarily around core timing paradigms, with further extensions toward aging-related cognitive constructs and neurodegenerative disease contexts (Figure 6). A complementary title-term co-occurrence network further illustrates the relational structure among core timing concepts and their links to aging- and disease-related terms, supporting the interpretation that the field is organized around shared temporal-processing paradigms (Figure 7).

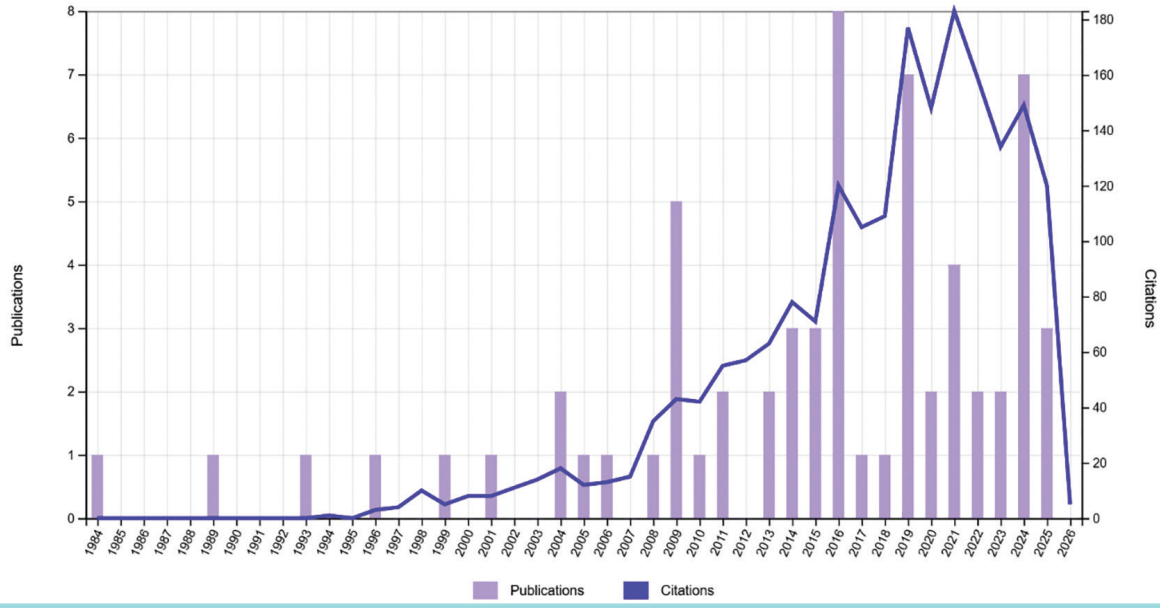

Figure 1. Annual trends in scientific output and citation activity related to time perception in cognitive aging and early cognitive decline. Bars represent the number of publications per year, while the line indicates the total number of citations received annually. The figure illustrates the prolonged period of low publication activity followed by a marked increase after 2015, along with a parallel acceleration in citation counts.

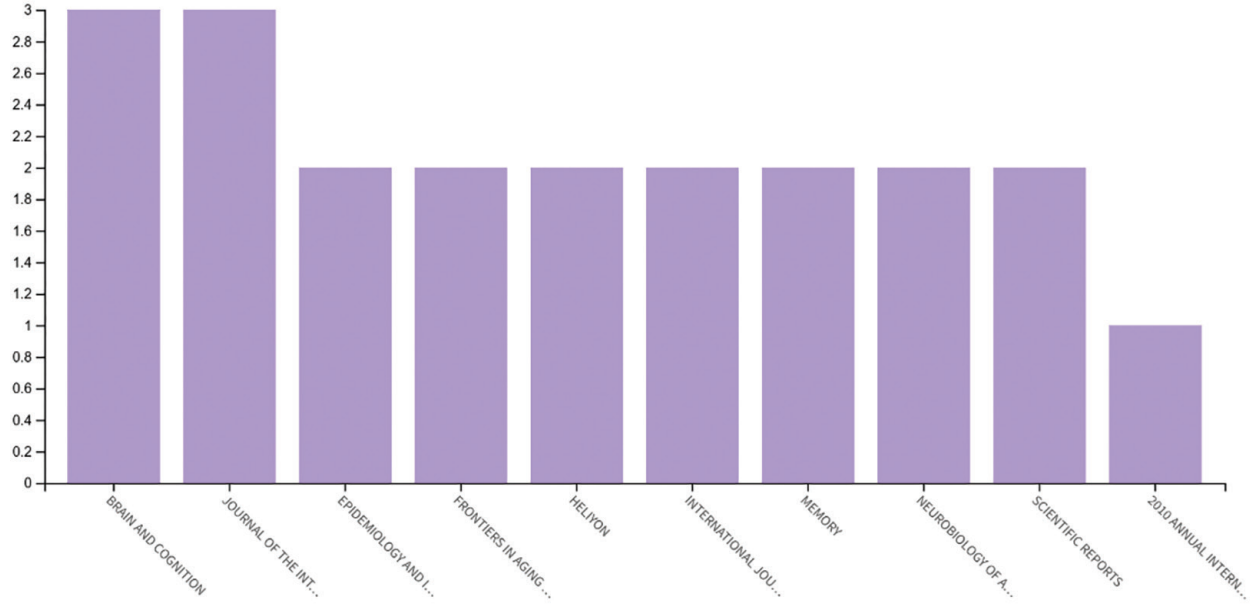

Figure 2. Distribution of source journals contributing to publications on time perception in cognitive aging and early cognitive decline. The figure displays the journals with the highest number of publications, highlighting the multidisciplinary dissemination of research across neuropsychology, neuroscience, aging, and general science journals.

DISCUSSION

This bibliometric analysis mapped the evolution, thematic focus, and disciplinary profile of research examining time perception in cognitive aging and early cognitive decline, including SCD and MCI. Overall, the findings indicate a field that has clearly expanded over the last decade, remains strongly interdisciplinary, and is still more closely aligned with experimental paradigms than with clinically oriented research on early cognitive decline.

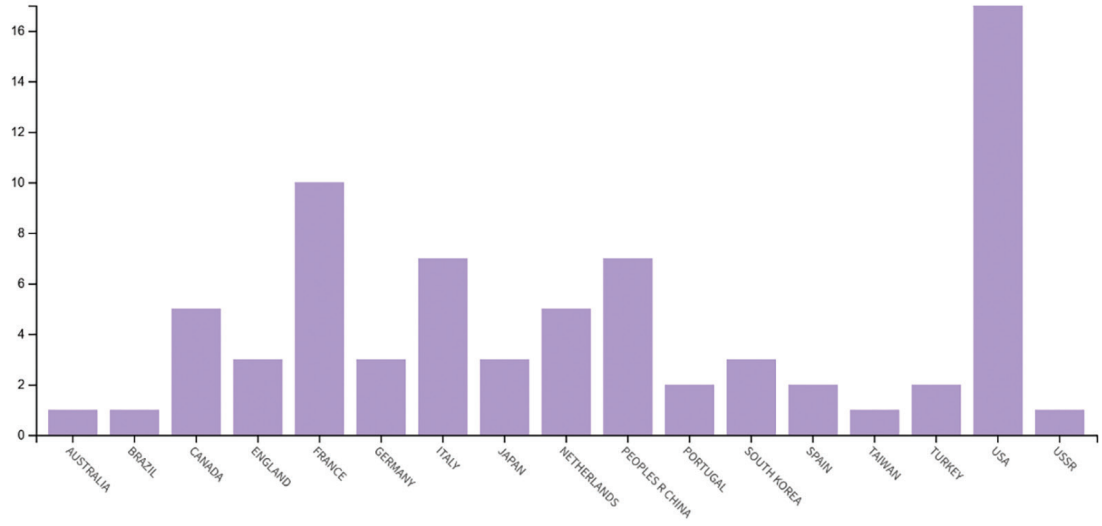

Figure 3. Country-level productivity based on author affiliations. Counts reflect the number of publications assigned to each country from the address/affiliation field; multi-country papers contribute to each represented country according to WoS affiliation parsing.

WoS: Web of Science.

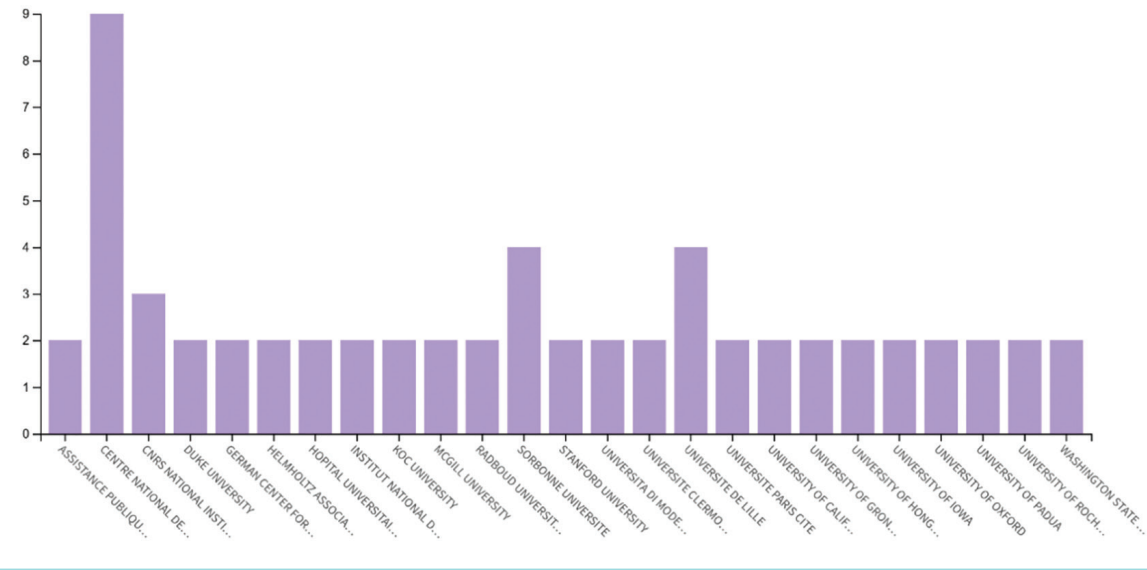

Figure 4. Institutional contributions derived from author affiliations. The figure displays the most productive institutions; values represent the number of records associated with each institution as indexed in WoS.

WoS: Web of Science.

One of the main observations of this study is the delayed integration of time perception research into aging- and dementia-related contexts. Although temporal processing has long been studied in cognitive neuroscience and experimental psychology, its more explicit application to cognitive aging and early cognitive decline appears to have gained momentum more recently.[1-3,7] This pattern may reflect the longstanding emphasis of aging research on memory, language, and executive functions as primary cognitive domains, with temporal processing receiving comparatively less clinical attention.[10]

The disciplinary distribution of the literature further supports this interpretation. The strong representation of neurosciences/neurology and psychology suggests that the field is anchored primarily in cognitive and neurobiological approaches, whereas the relative underrepresentation of geriatrics/gerontology and psychiatry indicates that translation into routine clinical and geriatric settings remains limited. Taken together, these findings suggest that time perception has been studied more often as a methodological or experimental construct than as a clinically integrated domain of investigation.

Figure 5. Treemap visualization of the Web of Science research areas represented in the retrieved literature on time perception in cognitive aging and early cognitive decline. Each rectangle corresponds to a research area assigned by Web of Science, and rectangle size is proportional to the number of records associated with that area. Because Web of Science research area assignments may overlap across records, categories should be interpreted descriptively rather than as mutually exclusive.

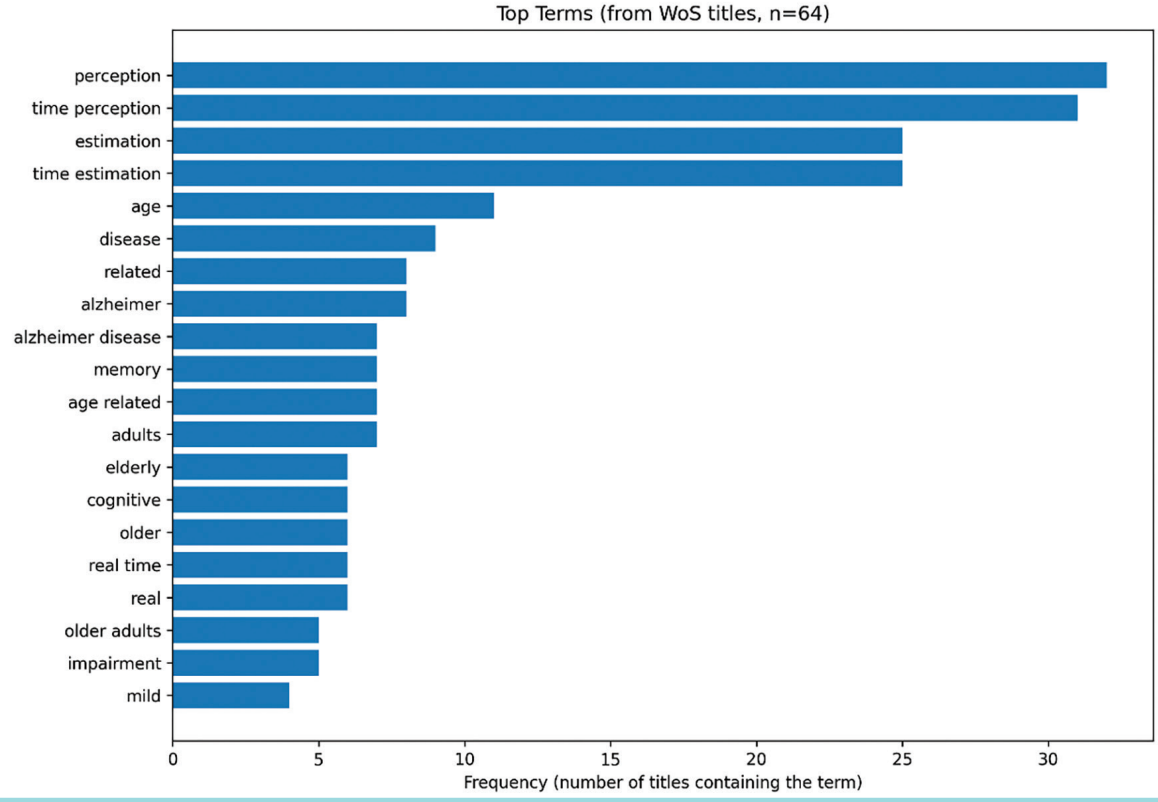

Figure 6. Most frequent title-derived terms in the dataset. Bars indicate the number of records in which each term appears, providing a frequency-based overview of the dominant concepts represented in the literature.

WoS: Web of Science.

The frequency-based analysis of title-derived terms provides additional insight into the thematic structure of the field. The prominence of terms such as time perception, time estimation, and related timing constructs indicates that the literature is organized largely around shared experimental paradigms.[1-3] By contrast, clinically framed concepts such as SCD, MCI, and Alzheimer-related terminology were less prominent at the title level.[4-6] This pattern suggests that early cognitive decline has often served as the clinical context in the literature rather than as its primary conceptual driver.

These findings should be interpreted cautiously. The present study is bibliometric and therefore describes patterns of publication, indexing, and thematic emphasis rather than the diagnostic or clinical utility of temporal processing measures. Nevertheless, the observed trends identify a potentially important area for future empirical research. Because temporal processing tasks engage attention, working memory, and executive control, and rely on neural systems relevant to neurodegenerative disease, they may warrant further investigation in clinically characterized aging populations.[10-12]

Another notable finding is the methodological heterogeneity of the field. Even within central timing paradigms, studies vary substantially in task design, temporal intervals, outcome definitions, and analytic strategies.[1-3,7] While such diversity may support exploratory work, it also limits comparability across studies and complicates synthesis of findings across populations. More harmonized task selection and outcome reporting may therefore improve interpretability in future studies.[5,6,10]

Study Limitations

Several limitations should be acknowledged. First, the analysis was restricted to the WoS Core Collection and may therefore have missed relevant studies indexed elsewhere. Second, the thematic analysis was based on title-derived terms, which capture dominant themes but may not fully reflect concepts emphasized in abstracts or full texts. Third, the relatively small dataset requires cautious interpretation of prominence at the country, institution, and theme levels. Finally, bibliometric methods describe the structure of the literature but do not assess the methodological quality or validity of individual studies.

Overall, the present findings indicate increasing scientific interest in time perception in research on cognitive aging and early cognitive decline. Future work, particularly in SCD and early MCI populations, may help clarify whether temporal processing paradigms have broader relevance in clinically oriented cognitive aging research.

CONCLUSION

This bibliometric analysis provides an overview of the scientific literature linking time perception with cognitive aging and early cognitive decline, including SCD and MCI. The findings show that despite the long-standing experimental tradition of temporal processing research, its integration into aging- and dementia-oriented frameworks has mainly accelerated over the past decade.

The literature is characterized by strong interdisciplinary foundations in neuroscience and psychology, alongside a more limited clinical

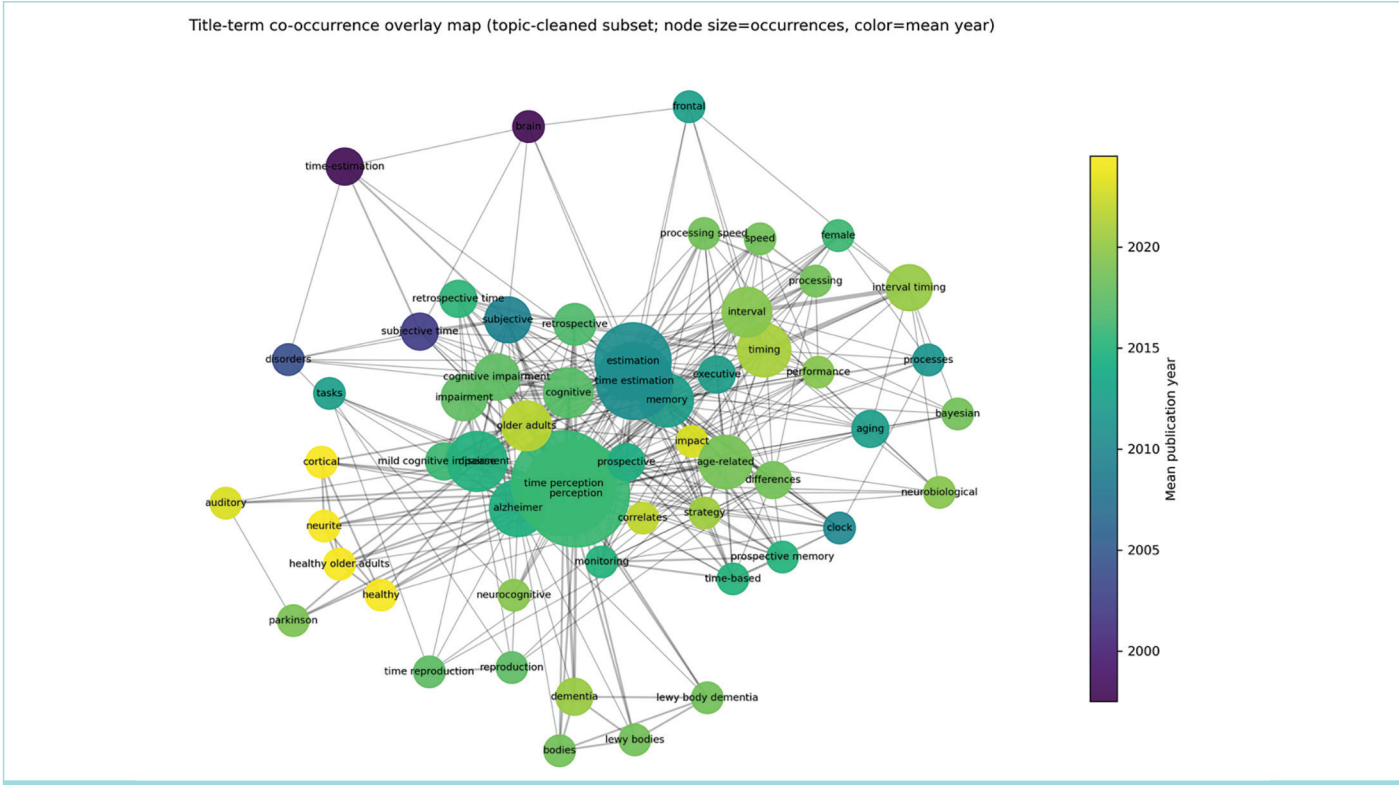

Figure 7. Title-term co-occurrence overlay network for the retrieved literature on time perception in cognitive aging and early cognitive decline. Node size reflects term occurrence frequency, line thickness indicates co-occurrence strength, and node color represents the mean publication year. The figure provides a complementary network-based visualization of thematic relationships among the most prominent title-derived terms.

orientation. Thematic analysis suggests that timing paradigms remain the conceptual core of the field, whereas clinically framed early cognitive decline constructs appear less prominent. This pattern indicates that time perception has been used more often as an experimental framework than as a clinically integrated domain.

Overall, the observed publication trends and thematic structure highlight an opportunity for future research to further connect experimental and clinical approaches. Greater methodological standardization and more systematic study of temporal processing in preclinical and prodromal cognitive states may help clarify its relevance in early cognitive decline research.

MAIN POINTS

- Research on time perception in cognitive aging has expanded markedly over the last decade following a prolonged period of limited output.
- The literature is interdisciplinary but remains centered primarily on timing paradigms rather than clinically framed early cognitive decline constructs.
- Future studies using more standardized temporal processing measures may clarify the relevance of this field to early cognitive decline research.

ETHICS

Ethics Committee Approval: Not applicable. This bibliometric study used publicly available bibliographic data and did not involve human participants, identifiable personal data, or experimental procedures.

Informed Consent: Not applicable. No human participants or identifiable individual-level data were included in this study.

DISCLOSURES

Financial Disclosure: The authors declared that this study received no financial support.

Declaration of Generative AI and AI-assisted Technologies in the Writing Process: During the preparation of this work, the author(s) used ChatGPT to improve “readability” and “language”. After using this tool/service, the author(s) reviewed and edited the content as needed and took full responsibility for the content of the publication.

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