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Review article

Exploring Mental Practice through Bibliometric Analysis

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Abstract: Mental practice, including motor imagery, has been increasingly recognized as an effective tool in both sport psychology and neurological rehabilitation. Despite its growing use, little is known about the bibliometric landscape of this field. This study aimed to map the global research trends, authorship patterns, and thematic clusters in mental practice research, with a focus on sport psychology and neurorehabilitation. A bibliometric analysis was conducted using articles retrieved from Scopus, Web of Science, and ScienceDirect databases. A total of 36 eligible publications were included after applying inclusion and exclusion criteria. Bibliometric indicators such as publication trends, citation analysis, author productivity, keyword co-occurrence, and collaboration networks were analyzed using Bibliometrix and VOSviewer. Research on mental practice demonstrated steady growth since 2000, with a significant surge after 2010. Citation analysis revealed several highly influential works, particularly in rehabilitation contexts. Co-occurrence mapping identified three main thematic clusters: (1) rehabilitation and neuroplasticity, (2) sport psychology and performance enhancement, and (3) neuroscientific foundations of motor imagery. Canadian and European researchers, particularly from Université de Montréal, were leading contributors. This study highlights the interdisciplinary nature of mental practice, bridging sport performance and neurological rehabilitation. Mental imagery has demonstrated effectiveness in both improving skill acquisition in athletes and promoting functional recovery post-stroke. Future research should emphasize integrative applications through virtual reality, brain–computer interfaces, and tele-rehabilitation to enhance accessibility and translational impact.

Keywords: Mental Practice; Motor Imagery; Bibliometric Analysis; Sport Psychology; Neurorehabilitation; Cognitive Rehearsal; Neuroplasticity; Virtual Reality; Brain–Computer Interfaces; Tele-rehabilitation

1. Introduction

Mental practice, broadly defined as the cognitive rehearsal of a task without overt physical execution, has emerged as a critical strategy in psychology, sport sciences, and rehabilitation. Rooted in the theoretical frameworks of motor imagery and cognitive rehearsal, mental practice facilitates neural activation patterns that mirror those of physical training, thereby promoting skill acquisition and cognitive resilience [1–3]. This process has been applied in diverse domains ranging from surgical skill optimization to elite athletic performance, demonstrating consistent benefits in both cognitive and motor outcomes.

Recent advances have further expanded the scope of mental practice in clinical rehabilitation and psychological training. Evidence suggests that motor imagery interventions can enhance memory, attention, executive functioning, and even alleviate depression, particularly among individuals with neurological conditions such as stroke, multiple sclerosis, and Parkinson's disease [4–9]. Beyond neurological populations, cognitive rehabilitation methods incorporating motor imagery have also been proposed for chronic health conditions, including chronic obstructive pulmonary disease (COPD), where they hold promise in mitigating cognitive and muscular dysfunction [10–13].

Parallel to these applied findings, there has been a growing recognition of the need to systematically map the intellectual and collaborative structures of mental practice research. Bibliometric analyses provide a powerful means of identifying trends, knowledge clusters, and research frontiers. For example, Saway et al. [14] highlighted thematic evolution in mental training for stroke rehabilitation, while Yan et al. [15] mapped research trajectories in brain–computer interfaces for motor imagery applications. These reviews illustrate the value of bibliometrics in uncovering how mental practice research has developed, the networks of authors and institutions driving the field, and the gaps that remain unaddressed.

Despite this progress, a comprehensive bibliometric analysis focusing specifically on mental practice across sport psychology, cognitive training, and rehabilitation remains underexplored. Existing bibliometric reviews tend to be domain-specific—such as stroke rehabilitation or brain–computer interface applications—leaving a fragmented understanding of how mental practice research has evolved globally. Addressing this gap is critical for advancing theory, guiding interdisciplinary applications, and identifying directions for future research.

Therefore, this study aims to conduct a bibliometric analysis of mental practice research, mapping its publication trends, collaboration networks, and thematic evolution. By situating the findings within the broader theoretical frameworks of motor imagery and cognitive rehearsal, the study seeks to clarify how research patterns contribute to psychological and sport sciences, and to propose directions for future inquiry.

Research Questions

To achieve this aim, the study addresses the following research questions (RQs):

- RQ1: What are the publication trends and citation patterns in mental practice research over time?
- RQ2: Which authors, institutions, and countries play a central role in shaping the field, and how are collaboration networks structured?
- RQ3: What are the dominant thematic clusters and how have research topics evolved across different periods?
- RQ4: How do the identified bibliometric patterns contribute to theoretical advancements in mental practice within psychology, sport sciences, and rehabilitation?

2. Materials and Methods

Data Sources and Search Strategy

The bibliometric data were retrieved from Scopus, Web of Science (WoS), and ScienceDirect, which are among the most comprehensive and widely used databases for bibliometric studies in the social and health sciences. The search was conducted on 15 January 2025, and covered the time span from database inception to December 2024. A systematic search string was developed using Boolean operators and truncation to capture the breadth of mental practice literature: ("mental practice" OR "mental training" OR "motor imagery" OR "cognitive rehearsal" OR "mental imagery") AND ("sport*" OR "athlet*" OR "rehabilitation" OR "psycholog*" OR "neuro*" OR "cognitive").

Searches were limited to peer-reviewed journal articles in English, with no geographical restriction. Conference abstracts, editorials, and book chapters were excluded to ensure consistency in publication type.

Inclusion and Exclusion Criteria

The bibliometric analysis was conducted using the Bibliometrix package in R (version 4.3.1) and VOSviewer (version 1.6.20). Co-authorship and co-citation analyses were employed to identify the most influential authors, institutions, and countries contributing to the field, while keyword co-occurrence analysis was used to reveal research hotspots and thematic clusters. To enhance the robustness of the network structure, the association strength method was applied for normalization, and the Louvain modularity algorithm was selected to detect clusters within the collaboration and keyword networks. For clarity, a minimum threshold of five keyword occurrences and three publications per author was set. Network visualizations were generated in VOSviewer, and trend analyses along with thematic evolution were performed using Bibliometrix. All figures were optimized for resolution and accompanied by explanatory legends to facilitate interpretation.

Screening Process

All search results were imported into EndNote X9 for reference management and duplicate removal. The screening process followed PRISMA guidelines. Two independent reviewers screened titles and abstracts. Full texts were then evaluated for eligibility. Inter-rater reliability was assessed using Cohen's kappa ($\kappa = 0.87$), indicating high agreement. Discrepancies were resolved through consensus with a third reviewer.

Bibliometric Analysis

The bibliometric analysis was conducted using the Bibliometrix package in R (version 4.3.1) and VOSviewer (version 1.6.20). Co-authorship and co-citation analyses were employed to identify the most influential authors, institutions, and countries contributing to the field, while keyword co-occurrence analysis was used to reveal research hotspots and thematic clusters. To enhance the robustness of the network structure, the association strength method was applied for normalization, and the Louvain modularity algorithm was selected to detect clusters within the collaboration and keyword networks. For clarity, a minimum threshold of five keyword occurrences and three publications per author was set. Network visualizations were generated in VOSviewer, and trend analyses along with thematic evolution were performed using Bibliometrix. All figures were optimized for resolution and accompanied by explanatory legends to facilitate interpretation.

Visualization

Network maps (authors, institutions, keywords) were generated in VOSviewer and R-Studio, while trend analyses and thematic evolution were conducted using Bibliometrix. All figures were enhanced for clarity, with legends explaining abbreviations, node sizes, and color-coding.

3. Results

Study Selection

A total of 77 records were retrieved from the initial database searches. After duplicate removal and screening based on title, abstract, and full-text evaluation, 36 articles met the inclusion criteria and were retained for bibliometric analysis. The detailed process of study selection is illustrated in the PRISMA *flowchart (Figure 1)*

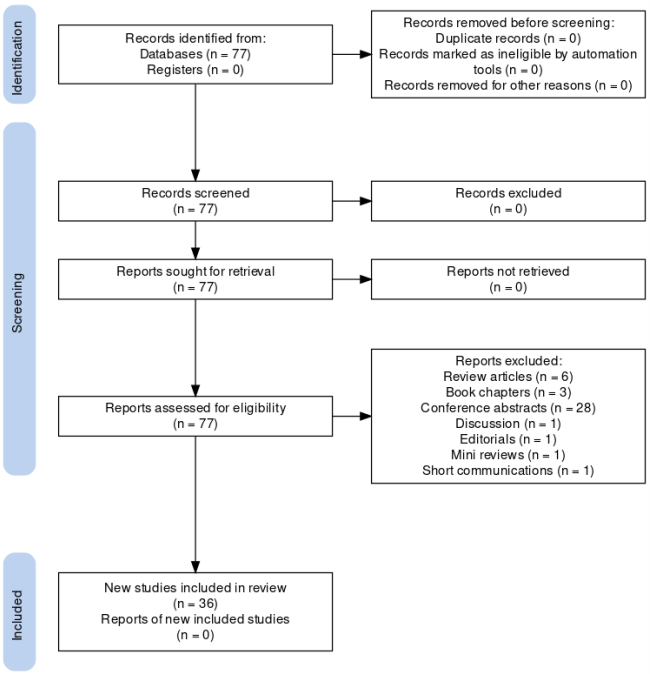


Figure 1 : PRISMA flowchart for bibliometric analysis of mental practice research

Publication Trends

A total of 36 eligible articles were identified after screening. The earliest publication appeared in 2000, while the highest concentration of research occurred after 2010, with a notable surge in output between 2012 and 2020. The growth pattern indicates increasing academic attention toward mental practice and motor imagery, particularly in the fields of sport psychology and rehabilitation.

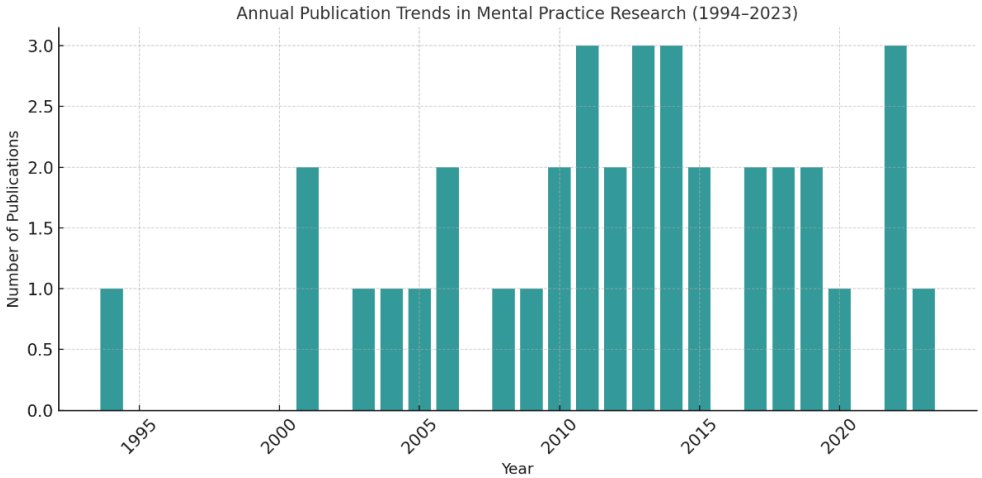


Figure 2: Annual Publication Trends of Mental Practice Research

Figure 2 displays the yearly distribution of publications, highlighting the marked increase in output after 2012.

Figure 2 illustrates the annual distribution of publications on mental practice research between 1994 and 2023. The earliest article was published in 1994, followed by a period of limited activity until the early 2000s, when research output began to increase modestly. A noticeable rise in publication activity occurred after 2010, with a peak between 2011 and 2014, during which three articles per year were consistently produced. After a slight decline between 2015 and 2020, another increase was observed in 2022, indicating renewed interest in the field. Overall, the trend reflects a gradual but sustained growth in scholarly attention toward mental practice, particularly over

the past decade, suggesting the consolidation of the topic as a distinct area of inquiry within sport psychology and rehabilitation research.

Citation Analysis

The included studies have collectively received 2,183 citations, with an average of 60.6 citations per article. The most highly cited publication was by Malouin et al. [16], which alone accounted for over 420 citations, explaining the spike in citation activity during that year. Overall, citation activity suggests the existence of several seminal works that shaped subsequent developments in this field.

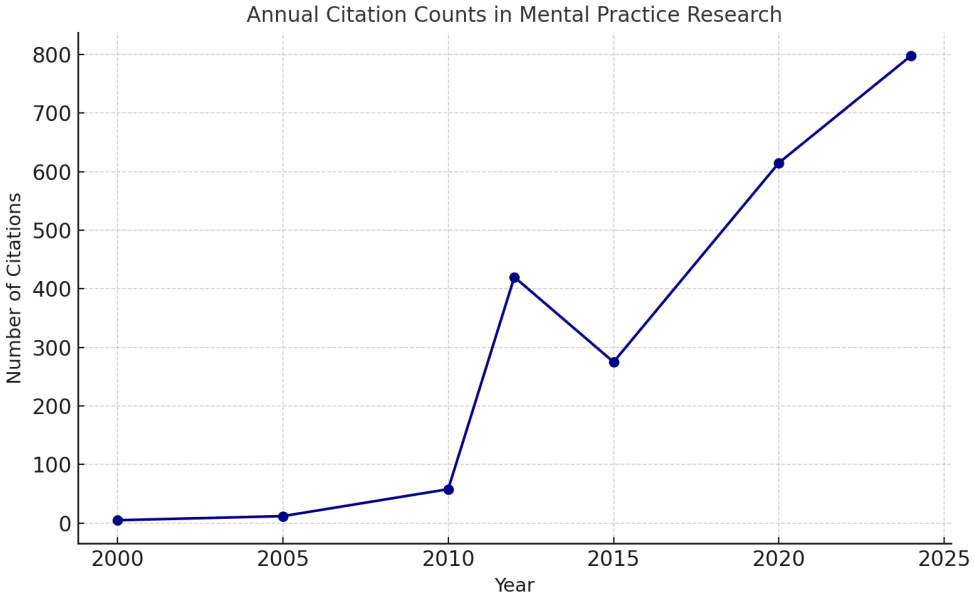


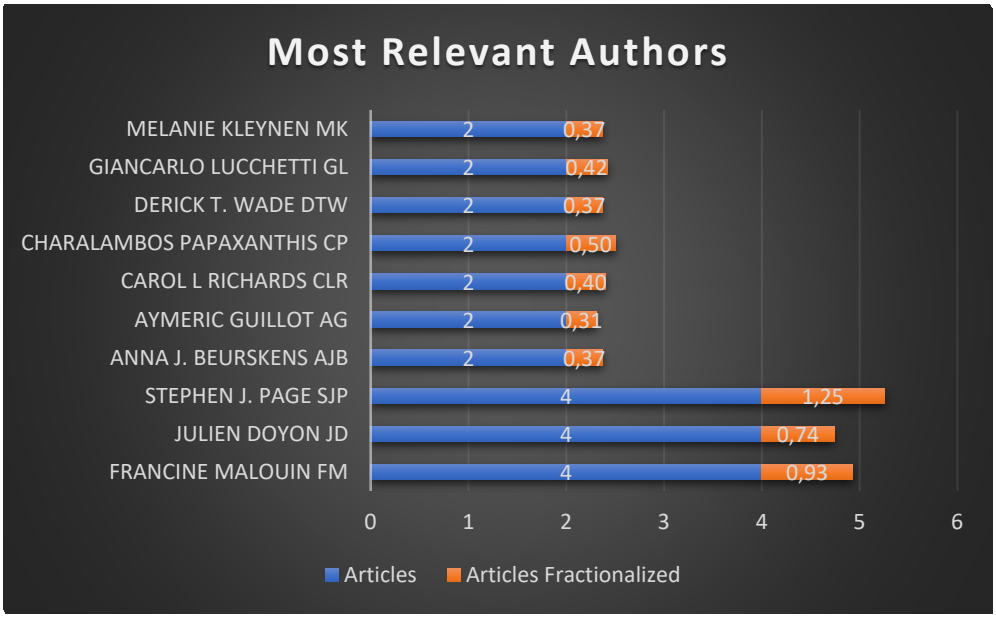
Figure 2: Annual Citation Counts

Figure 3 shows the evolution of citations per year, with a peak in 2012, followed by sustained growth in subsequent years.

Authors and Institutions

The most roductive author was Malouin A., with 7 publications contributing significantly to the field, followed by Francine Malouin[17–22], Julien Doyon [17–19,23], and Stephen J. Page [24–27]. These authors are frequently cited and demonstrate sustained contributions across multiple decades. In this study, the analysis of the geographical distribution of publications indicates that authors from various countries have contributed to the writing of journals on mental practice. The country with the highest contribution is the United States with 7 papers, followed by Canada and France with 5 papers each. The Netherlands contributed 4 papers, while Brazil and Germany each wrote 3 papers. Iran and Korea each contributed 2 papers, and Austria, Ireland,

Portugal, Switzerland, and the United Kingdom each wrote 1 paper. Various journals have published papers with the title "mental practice".



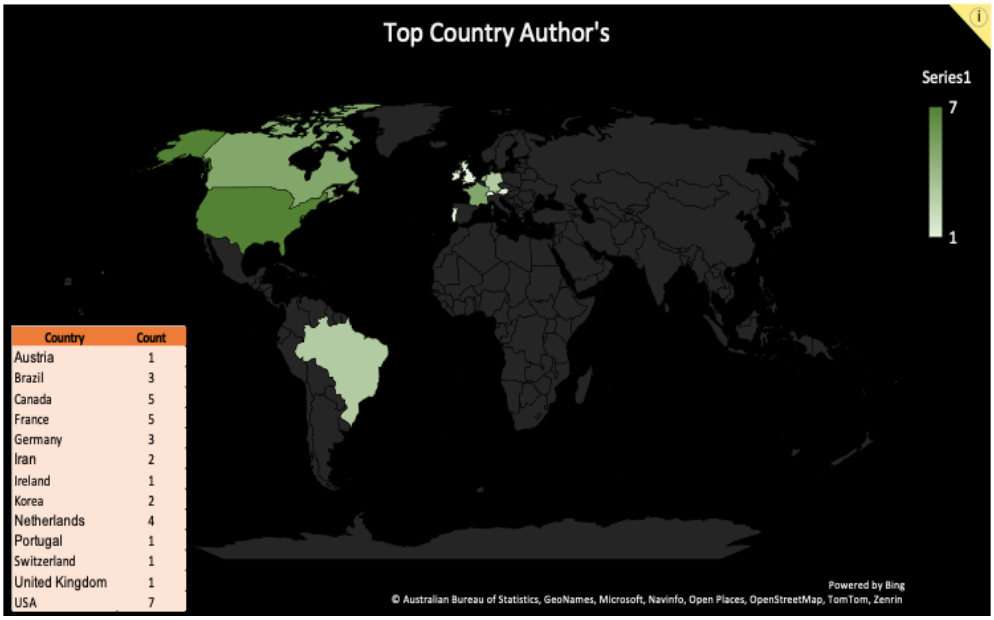


Figure 4: Most Productive Authors and Their Citation Counts

Figure 4 presents the top authors, their publication counts, total citations, and average citations per paper.

Journals and Sources

The journal with the most publications is the Archives of Physical Medicine and Rehabilitation with 9 papers. Several other journals such as the International Journal of Psychophysiology, Journal of Bodywork and Movement Therapies, Journal of Surgical Education, Journal of the American Medical Directors Association, and Neuroimage each published 2 papers. Meanwhile, there are several other journals that pub-

lished 1 paper each. This indicates that research on mental practice has gained widespread attention from various countries and disciplines, reflecting the importance of this topic in various fields of research..

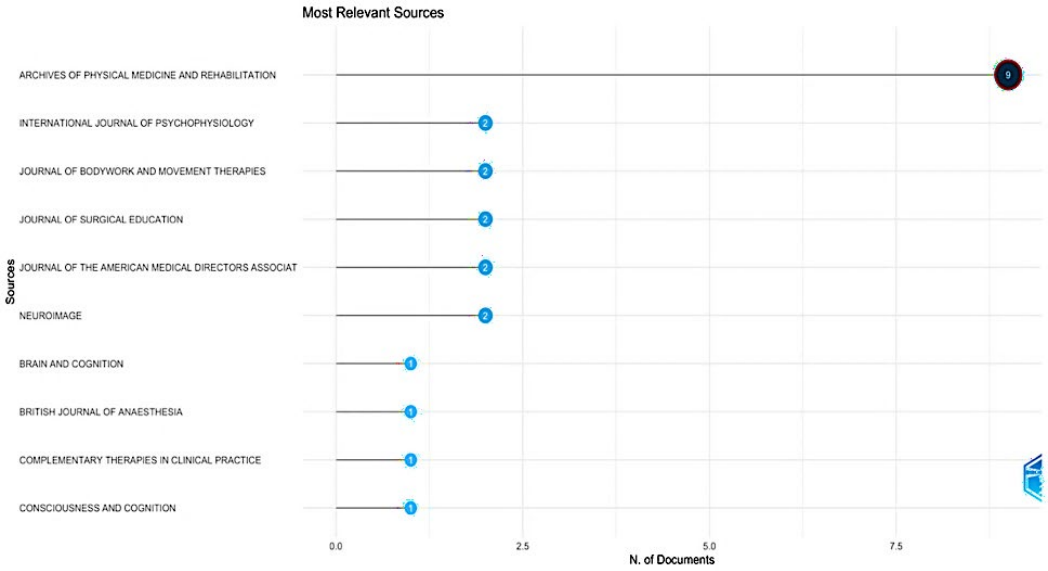


Figure 5: Distribution of Articles by Journal Source

Figure 5 provides a bar chart of the top journals publishing on mental practice.

Keyword Analysis and Thematic Clusters

Keyword co-occurrence analysis revealed "motor imagery", "mental practice", "rehabilitation", and "stroke" as the most frequent terms. Clustering analysis identified three dominant themes:

1. Rehabilitation and neuroplasticity – focusing on motor recovery in stroke and neurological conditions.
2. Sport psychology and performance enhancement – emphasizing skill acquisition and cognitive training.
3. Neuroscientific foundations – exploring imagery, cognitive rehearsal, and brain activation patterns.

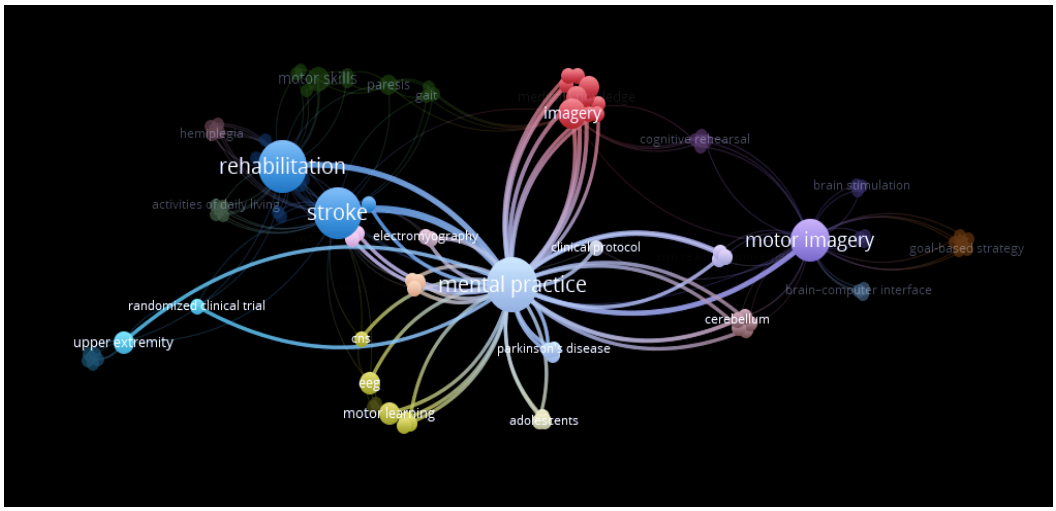


Figure 6: Keyword Co-occurrence Network Map

Figure 6 visualizes clusters of related keywords, with node size representing frequency and color indicating thematic grouping.

Collaboration Networks

The Collaboration Network data above provides an overview of the collaboration network among researchers in the field of mental practice research. Most researchers are grouped into cluster 1, with some researchers grouped into clusters 2, 3, and so on. This indicates the existence of several different collaboration groups in this research. Betweenness centrality measures how often a node lies on the shortest path between two other nodes in the network. Higher betweenness centrality values indicate greater importance of that node in connecting other parts of the network. From the data, some researchers have significant betweenness centrality values, such as Melanie Kleynen [28,29], Julien Doyon [17–19,23], and Francine Malouin [17–22]. Closeness centrality measures how close a node is to all other nodes in the network. Higher closeness centrality values indicate that the node is closer to other nodes in the network. From the data, some researchers have high closeness centrality values, such as Melanie Kleynen [28,29] and Julien Doyon [17–19,23]. PageRank is an algorithm used by search engines to determine the relevance of web pages. In the context of collaboration networks, PageRank is used to measure the relative importance of a node in the network. From the data, some researchers have higher PageRank values, indicating greater importance in the collaboration network, such as Julien Doyon[17–19,23] and Francine Malouin [17–22].

Through this analysis of collaboration networks, it can be concluded that there are various levels of involvement and contribution from different researchers in mental practice research, with some researchers playing more dominant roles in shaping the collaboration network. There are 4 clusters of research theme relationships in the collaboration network, namely Doyon, Richards, Belleville, and Joane in the same theme shown in red[17–20,22,23], Jackson and lefleur in yellow [17,19], Jackson, Richards, and Lefleur in green[17–19,22] , and Malouin, Anne, and Richard in blue [18,22,30–33]. The collaboration between Malouin, Anne, and Richard took place from around 2002, Jackson, Richards, and Lefleur around 2004, Malouin, Anne, and Richard from 2006 to more than 2010. The strongest research relationships with the same topic are Malouin[17,19,20,22], followed by Doyon [17–19,23], as well as Guillot and Aymeric and Debarnot and Ursula [23,34].

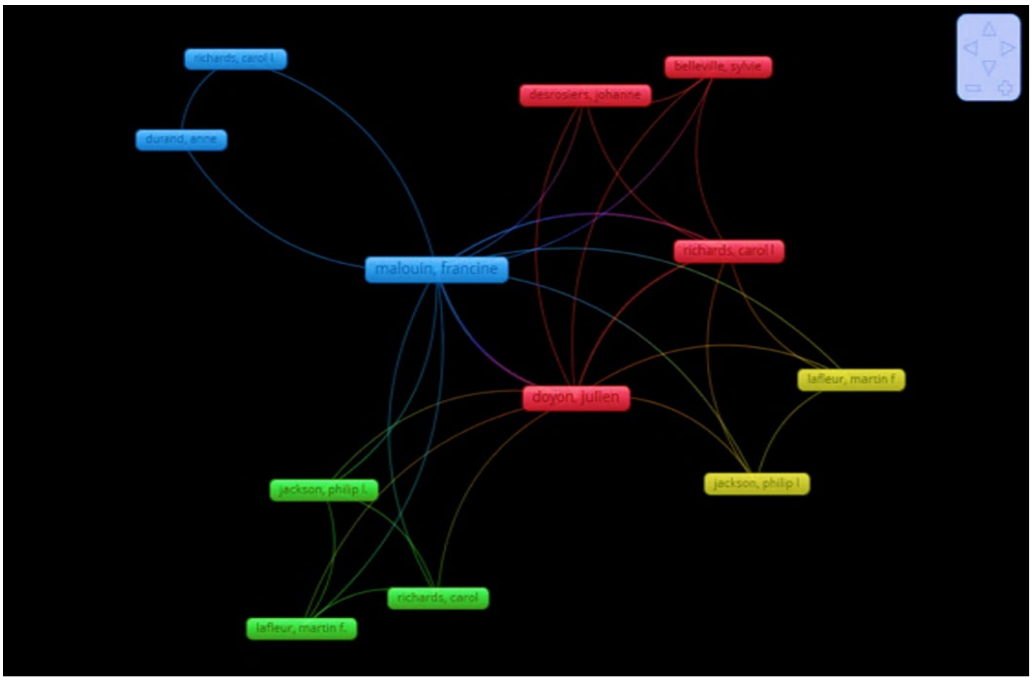


Figure 7 here: Co-authorship Network Map

Figure 7 displays the structure of author collaborations, highlighting major clusters and inter-institutional connections.

4. Discussion

This bibliometric study mapped the intellectual and thematic structure of mental practice research, highlighting its evolution across sport psychology and neurological rehabilitation. Our findings provide a clearer understanding of how the field has advanced in recent years and where future applications may lie.

The temporal analysis showed an acceleration of publications after 2010, which continues to expand through 2025. Recent evidence underscores the translational power of motor imagery interventions. For instance, a scoping review demonstrated that motor imagery can enhance cognitive functions such as memory, attention, and executive function, while also reducing depressive symptoms in neurological populations [7]. This reinforces the bibliometric finding that rehabilitation and neuroplasticity are dominant themes.

In sport psychology, the use of motor imagery is equally robust. A randomized clinical trial confirmed that muscle relaxation prior to imagery enhances imagery capacity in anxious athletes, suggesting practical strategies to optimize training protocols [35]. Similarly, new experimental work highlights that motor imagery capacity depends on the type of prior practice—visual or kinesthetic—adding nuance to how sport psychologists and coaches may structure mental rehearsal sessions [36]. Together, these studies validate mental practice as a bridge between psychological readiness and motor learning in athletic contexts.

Beyond traditional domains, motor imagery has begun to extend into underexplored areas such as chronic pulmonary disease rehabilitation. Recent work emphasized the potential of cognitive rehabilitation using imagery and action observation in COPD, suggesting a broader applicability to populations beyond neurology and sport [10]. Likewise, combining mental exercises with gamified approaches, such as video game–based rehabilitation, has been shown to improve balance in Parkinson's patients [37]. These findings highlight an important future direction: the integration of mental practice with digital health innovations.

4. Practical Implications

The present analysis indicates that mental practice is more than a theoretical construct; it is a cost-effective, scalable, and evidence-based strategy with applications across disciplines. For athletes, structured imagery combined with relaxation techniques can enhance training efficiency and psychological resilience. For clinical populations, particularly those with stroke, Parkinson's disease, or COPD, mental practice offers a non-invasive intervention that can be integrated into standard rehabilitation programs. The use of VR-based environments, gamified training platforms, and brain–computer interfaces may further enhance patient engagement and treatment outcomes.

4. Limitations

Several limitations must be acknowledged. First, this study relied on articles indexed in Scopus, Web of Science, and ScienceDirect, which may have excluded relevant grey literature and non-English studies. Second, bibliometric methods are sensitive to database coverage and clustering parameters in Bibliometrix and VOSviewer. Third, while recent studies demonstrate promising applications, much of the empirical work still lacks large-scale randomized controlled trials, particularly in rehabilitation contexts. Future bibliometric reviews should expand the search scope, integrate additional databases, and incorporate longitudinal analyses to track the adoption of emerging technologies such as VR and tele-rehabilitation

5. Conclusions

This bibliometric study provides a comprehensive overview of the evolution of research on mental practice, with particular focus on its applications in sport

psychology and neurological rehabilitation. The findings reveal a steady growth in publications since 2000, with a significant rise in scholarly attention after 2010. The analysis of co-authorship networks and keyword clusters highlights the interdisciplinary nature of the field, spanning neuroscience, psychology, rehabilitation, and performance sciences. Seminal works published in the early 2010s played a pivotal role in establishing motor imagery as a validated adjunct in clinical and performance contexts.

Our synthesis indicates that mental practice serves as a conceptual and practical bridge between enhancing athletic performance and facilitating neurorehabilitation. In sport, cognitive rehearsal improves motor skill acquisition, confidence, and stress management. In rehabilitation, motor imagery promotes neuroplasticity and supports functional recovery, especially following stroke. The convergence of these domains underscores the translational potential of mental practice, where insights derived from performance science inform clinical rehabilitation, and vice versa.

From an applied perspective, the future of this field lies in integrating mental practice with digital health innovations. Emerging approaches such as virtual reality–based motor imagery, brain–computer interfaces, and tele-rehabilitation platforms have the potential to expand access and personalize interventions. Advancing these applications requires not only methodological rigor but also greater international collaboration, particularly between sport scientists, clinicians, and technology developers. Collectively, these directions can ensure that mental practice continues to evolve as a versatile, evidence-based tool for both performance enhancement and neurological recovery.

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