

A Bibliometric Analysis of Embodied Cognition Based on CNKI from 2005 to 2021

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Abstract: This bibliometric study aims at exploring the publications on embodied cognition in China based on the China Net Knowledge Index (CNKI) database between 2005 and 2021. “Embodied cognition” were keywords used for searching relevant publications in CNKI, November 6th, 2021. There are 1107 articles collected excluding English literature, conference papers, and dissertations. The free software BICOMB 2.0 is applied for data analysis. Results indicated that the number of articles is on the rise yearly since 2005. Most of the articles are seen in the core journals. The leading authors are Hao-sheng Ye, Wei Chen, and Xun-dong Zheng. The 211 level universities in China published more articles than other institutions. There are 5 major clusters representing hotspot issues: embodied cognition in linguistics, the pedagogical application of embodied cognition, cognitive psychology and the study of the embodied mind, the design of teaching environment with embodied cognition, and psychology and cognitive science. The research of embodied cognition in China is still in theoretical discussion, lacking empirical research. Thus, the interdisciplinary applications of embodied cognition in education and the theory of emotional personalization are potential issues in future research. The significance and value of this study tempts to summarize the hotspots and development trends in the field of embodied cognition in China on the basis of literature visualization with the help of scientific knowledge mapping technology, in order to provide some reference for researcher.

Index Terms: Embodied cognition, Bibliometric study, Keyword Co-concurrence, BICOMB 2.0 (Bibliographic Items Co-occurrence Matrix Builder).

1. Introduction

With the rise of the second generation of cognitive science, embodied cognition has attracted the attention of many scholars in philosophy, pedagogy, linguistics, psychology, neuroscience, and computer science and the broad notion of embodied cognition is sweeping the planet. In recent years, Chinese scholars have provided systematic and insightful reviews of this field. Embodied cognition is not just cognition that includes not only mental processes such as thinking, learning, memory, and emotion but also body structure and sensory-motor experience [1]. One decade ago, Hu and Ye reviewed the research work and important achievements of embodied cognition in Chinese psychological circles and comment on the academic significance and research contribution of embodied cognition research to the development of Chinese psychology from the four research levels of concept definition, ideological origin, main content, and theoretical reflection [2]. Recently, Liu and Yu conducted bibliometric statistics with Citespace to explore the co-occurrence of keywords, the number of published articles, the subject distribution of the literature, the leading authors, and the burst themes in the literature co-citation network based on the 198 publications from the CSSCI database from 1998 to 2017[3]. Their research results revealed that embodied cognition in China has become a new research field which becomes more popular with scholars. Therefore, a deeper understanding of embodied cognition is needed through a bibliometric analysis.

2. Literature Review

2.1 Embodied Cognition

The principle of the second generation of cognitive science is that "to understand the mind, we must return to the brain"[4]; "embodiment" in embodied cognition covers different things in different scientific fields; the fundamental theories of embodied cognition are naturalism and body phenomenology, which mainly includes three basic viewpoints: the mind is embodied, metaphor is the core of thinking, and cognition is unconscious [5]. Furthermore, it is worth reiterating that the meaning of embodiment is not just that the body affects cognition; traditional cognitive science regards the body as the base of cognition, the physiological basis of cognition [6], without denying the role of the body. Emerged from the second generation of cognitive science, embodied cognition attributes mental activities to the interaction of brain, body, and physical experience to represent a new orientation, which enriches and deepens its underpinnings that cognitive activities depend on the body itself and individual experience in social culture. In a word, the emerging viewpoint of embodied cognition holds that cognitive processes are deeply rooted in the body's interactions with the world.

2.2 Bibliometric analysis

Bibliometric analysis, also known as bibliometrics, is a technique or an approach for portraying the distributions of publications regarding on specific field of science. The bibliographic characteristics of publications are calculated through algorithm formula [7]. Thus, the results of a bibliometric study can be explained by several indicators such as total citations, total publications, annual distribution, keyword co-occurrence, and bibliographic coupling, etc. The bibliometric approach is more innovative than systematic review and content analysis [3].

Most publications on embodied cognition in the past were literature reviews and few were quantitative studies. Moreover, the bibliometrics in this field was not based on the entire CNKI databases, which contain the CSSCI (China Social Sciences Citation Index), the CSCD (Chinese Science Citation Database), and the CHSSCD (the Chinese Humanities and Social Science Citation Database), etc. The bibliometric analysis, combining quantitative figures and qualitative reviews, is needed for facilitating an objective review and a conversation between readers and researchers in the domain of embodied cognition. With techniques of visualization software, the bibliometric study can profile the development and trends of research on embodied cognition in China and analyze the trajectory growth, distributions of publications, the hotspot themes, and front topics as suggestions for future research.

This bibliometric analysis of the literature included in the CNKI may provide researchers with references for the current status of embodied cognition, as well as for future research and practice by means of visualization techniques to efficiently locate the following questions:

- (1) What is the status of annual publications for 2005–2021?
- (2) What are the top 10 journals that published most embodied cognition research?
- (3) Who are the 10 most frequently published authors?
- (4) Which affiliates are the 10 affiliations with the most publications?
- (5) What are the hot-spot themes on embodied cognition (by high-frequency keywords analysis dendrogram cluster analysis and means of scaling analysis)?
- (6) What are the front themes on embodied cognition currently and in the future?

3. Methods

3.1 Study design

This is a quantitative study of embodied cognition research from the CNKI databases by adopting the bibliometric approach, a data-driven and quantitative method to portray a research field that allows wider coverage. Therefore, the analyses of bibliographic characteristics focus on high-frequency keywords, citations, hot-spot themes, and potential topics from the scholarly literature which concern embodied cognition from 2005~2021 through the BICOMB 2.0. As shown in Fig. 1, the research procedure of data collections and analysis presents that the CNKI is the main database; the BICOMB 2.0 (Bibliographic Items Co-occurrence Matrix Builder) is the bibliometric software for forming high-frequency keywords and lexical matrix; the SPSS is applied to perform hierarchical cluster analysis for dendrogram and multidimensional scaling analysis for Euclidean distance model.

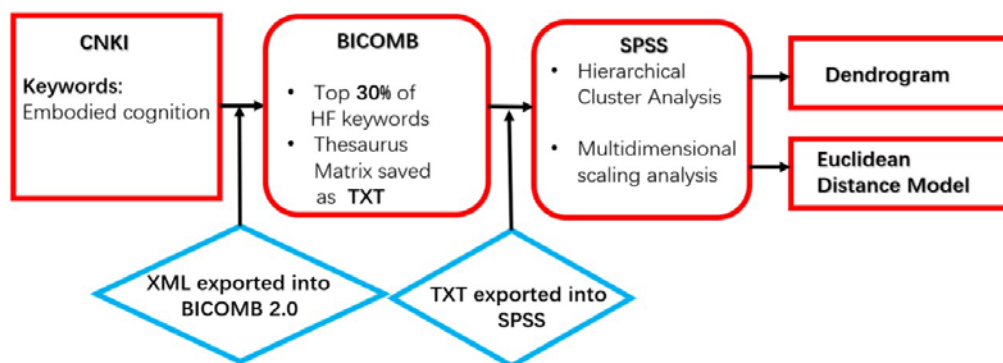


Fig.1. Research procedure of this study.

3.2 Data Collection

Criteria for Inclusion and Exclusion

The keyword “Embodied cognition” was used for retrieving relevant datasets in the CNKI. The data is from CNKI initial time and the document types of the search were not limited, and the searching time was November 6th, 2021. A total of 1,107 journal articles were retrieved after excluding English literature, conference papers, and dissertations. All generated data files were saved in xml format.

3.3 Tools and Data Analysis

The main tools used in this study are the SPSS V.23 and the BICOMB 2.0 software (Bibliographic Items Co-occurrence Matrix Builder), a free bibliometric analysis software, can deal with the high-frequency keywords and annual publication volume statistics. Moreover, it can intuitively show the structure of the research field, hotspot topics, and predict the future trends of the research field by generating a thesaurus matrix or co-occurrence matrix. To find relevant literature on the topics concerned, all xml files were exported to the BICOMB 2.0 software for statistics of 1,107 valid articles as the research sample and resort to journals, authors, affiliations and high-frequency keywords. The co-word analysis is the ample function of the BICOMB 2.0 software to generate thesaurus matrix based on the top 30 % high-frequency keywords. Thesaurus matrix was exported into the SPSSv23 software to for hierarchical cluster analysis and generate dendrogram; meanwhile, multidimensional scaling analysis is performed by the SPSSv23 to generate Euclidean distance model. The datasets were retrieved from CNKI database. The procedure of data retrieval and keyword selections were reported in research method and figure. Thus, the bias was avoided and the content is reliable.

3.4 Ethics statement

Neither institutional review board’s approval nor informed consent is required because it is a study based on the literature database.

4. Results & Discussion

4.1. The Distribution of Yearly Publications

The number of publications represents trajectory growth and developmental trend in the specific field [8]. The past 17 years have witnessed the development of embodied cognition research in China as shown in Table 1 and Fig.2. The first two articles in the CNKI appeared in 2005 and from 2005 to 2017 the number of the articles published was under 100 and showing a slow growth trend. However, since 2018 the articles about embodied cognition were flourished and at the peak of 175(2020). It is estimated that the number of articles on embodied cognition will continue a rise after 2021.

Table 1. Yearly Output of Research on Embodied Cognition

Year	No. of Articles	Year	No. of Articles
2005	2	2014	60
2006	3	2015	80
2007	11	2016	74
2008	3	2017	89

2009	9	2018	155
2010	15	2019	164
2011	21	2020	175
2012	40	2021	154
2013	52	Count	1107

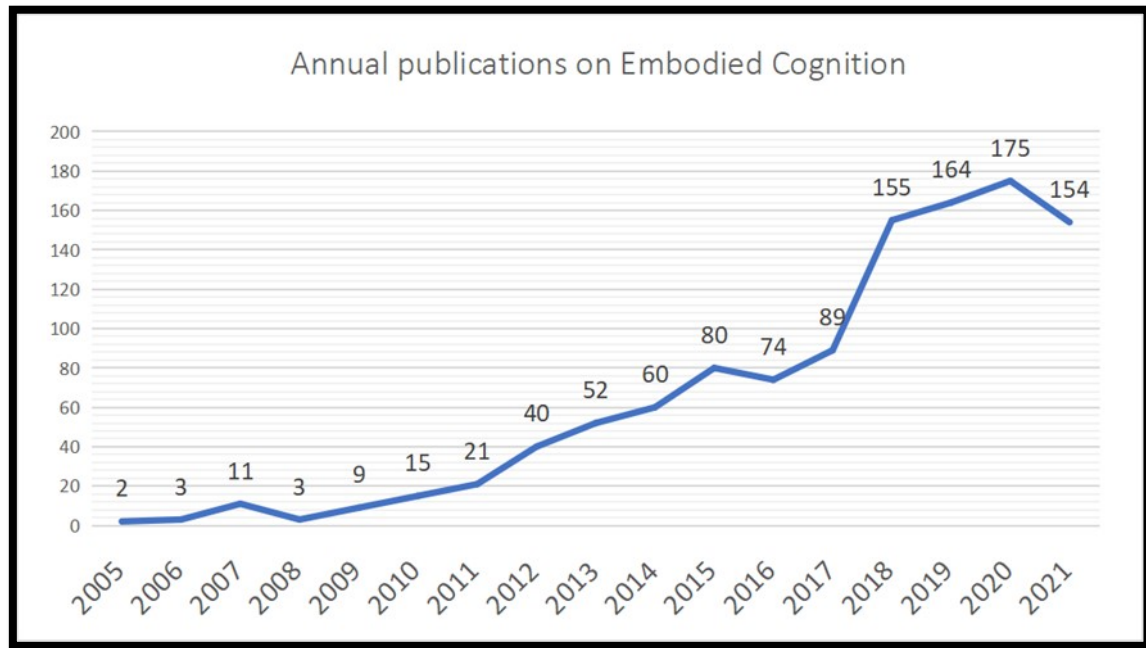


Fig.2. Annual publications on Embodied Cognition Between 2005 and 2021.

4.2. Journals and their article distribution

The core journals produced the most articles in a specific field; the most-cited journals in the field are recognized to represent important sources for influential publications. In a word, researchers can effectively obtain necessary publications in the core and the most-cited journals [9]. According to the statistical analysis of the BICOMB 2.0, there are 486 kinds of Chinese periodicals publishing articles about embodied cognition in China. As shown in Table 2, many journals that pay attention to embodied cognition in China are scattered. The top 10 journals published more than 12 articles, with a contribution rate of 20%. Among the top 10 journals, core journals account for 70%, of which there are four kinds of educational journals: *Journal of Distance Education*, *E-Education Research*, *Modern Distance Education Research*, and *Curriculum Teaching Material and Method*. There are five journals dealing with psychology, namely *Psychological Exploration* (39), *Advances in Psychological Science* (35), *Acta Psychologica Sinica* (28), *Journal of Psychological Science* (25), and *Psychological Research* (19). *Psychological Exploration* (with 39 articles) is the journal with the largest number of articles, followed by *Advanced in Psychological Science* with 35 articles.)

Table 2. Top 10 source journals and their article distribution

Rank	Journal Name	Number of articles	Percentage%	Cumulative percentage%
1	Psychological Exploration*	39	3.4978	3.4978
2	Advances in Psychological Science*	35	3.1390	6.6368
3	Acta Psychologica Sinica*	28	2.5112	9.1480
4	Journal of Psychological Science*	25	2.2422	11.3901
5	Journal of Dialectics of Nature	21	1.8834	13.2735
6	Psychological Research	19	1.7040	14.9776
7	Journal of Distance Education*	16	1.4350	16.4126
8	E-Education Research*	15	1.3453	17.7578

9	Modern Distance Education Research	13	1.1659	18.9238
10	Curriculum Teaching Material and Method*	12	1.0762	20.0000

Note. “*” marks the core academic journals in China.

4.3. Most prolific authors

According to the statistics of 2,119 authors of journal papers (including the second author and the third author, etc.), the top 10 prolific authors are shown in Table 3. The most productive authors are seen as the backbone of discipline development and representative of academic innovation. Mining and analyzing their academic activities can effectively pinpoint the research status and development of different disciplines, which are conducive to grasping the latest trends in the domain [10]. Table3 reports the top 10 most prolific scholars, their affiliations, and the total number of published articles. Eight out of the top 10 authors are from 211 ranking universities in China; they are Ye, Hao-sheng (60) from Guangzhou University, Zheng, Xun-dong (13) and Wang, Mei-Qian (11) both from Central China Normal University, He, Jing (10) from East China Normal University, Yang, Wen-Deng (9) and Li, Xiao-dan (9) from Guangzhou University, Li, Ying (8) from Zhengzhou University, Li, Heng-Wei (8) from Zhejiang University.

Table 3. Top 10 most prolific authors

	Author	Affiliation	No. of Articles
1	Ye, Hao-Sheng	Center of Psychology and Brain Science, Guangzhou University	60
2	Chen, Wei	Shaoxing University	22
3	Zheng, Xun-Dong	Central China Normal University	13
4	Wang, Mei-Qian	Central China Normal University	11
5	He, Jing	East China Normal University	10
6	Lu, Zhong-Yi	Hebei Normal University	10
7	Yang, Wen-Deng	Center of Psychology and Brain Science, Guangzhou University	9
8	Li, Xiao-Dan	Guangzhou University	9
9	Li, Ying	Zhengzhou University	8
10	Li, Heng-Wei	Center for the Study of Language and Cognition, Zhejiang University)	8

4.4. Top 10 affiliations

Revealing the distribution of affiliations by sorting the frequency of publications will provide a whole picture of affiliations, which are focusing on the study of embodied cognition. Table6 shows the top 10 affiliations as references for the scholars to understand the current academic status of this field and seek the opportunity of co-authorship between institutions over the world [10]. Among them, there are six normal universities, accounting for 60%, and comprehensive universities that accounting for 40%. Center of Psychology and Brain Science, Guangzhou University, the maximum number of published articles reached 36. Followed by the School of Education (Teachers College), Guangzhou University (35), School of Psychology, Nanjing Normal University (17), School of Educational Information Technology, Central China Normal University (14), etc.

Table 4. High frequency Published Affiliations

Rank	Affiliations	No. of Articles
1	Center of Psychology and Brain Science, Guangzhou University	36
2	School of Education (Teachers College), Guangzhou University	35
3	School of Psychology, Nanjing Normal University	17
4	School of Educational Information Technology, Central China Normal University	14
5	College of Education, Hebei Normal University	13
6	College of Education Soochow University	12
7	School of Psychology and Cognitive Science, East China Normal University	12
8	Department of Philosophy, East China Normal University	12
9	College of Education Science, Nanjing Normal University	10
10	Jilin University School of Philosophy and Sociology	8

4.5. High-frequency Keywords

The keyword is the key element of a journal paper that can best reflect the themed characteristics and contents, and it is also used for data retrieval. High-frequency keywords can better reflect the development process, characteristics, and trends of research topics. All the 4,751 keywords with the same meanings extracted from the total articles were exported to the BICOMB 2.0 2.0 for analysis after pre-processing; 36 high-frequency keywords about embodied cognition with a threshold greater than 9 were selected, occurring 1470 times and accounting for 30.9% of 4751 times of the total keyword occurrence. As shown in Table 5, Embodied cognition ranked first (869), followed by Body (71), Embodiment (35), Cognition (29), and Allusion (29). The high-frequency keywords gathered to form the hotspot themes in embodied cognition. The higher the quantized value, the more attention the keyword receives from researchers.

Table 5. High frequency keywords of Embodied Cognition

#	Keywords	f	#	Keywords	f	#	Keywords	f
1	Embodied cognition	869	13	Embodied	18	25	Classroom teaching	11
2	Body	71	14	Psychology	17	26	Learning environmental	10
3	Embodiment	35	15	Embodied mind	16	27	Deep learning	10
4	Cognition	29	16	Teaching design	16	28	Enactive cognition	10
5	Cognitive science	29	17	Cognitive psychology	16	29	Embodied emotion	9
6	Allusion	29	18	Disembodied cognition	15	30	Language comprehension	9
7	Embodied Learning	28	19	Conceptual Metaphor	14	31	Moral	9
8	Mirror neuron system	26	20	Conceptual repress	13	32	Education	9
9	Phenomenology	21	21	Key competency	12	33	Experience	9
10	VR	20	22	2 nd generation cognitive	12	34	Teaching	9
11	Embodied cognitive theory	18	23	Extended cognition	11	35	Learning science	9
12	Artificial intelligence	18	24	Emotion	11	36	Environmental	9

4.6. Dendrogram Cluster Analysis

Hierarchical cluster analysis (HCA) was used to perform the cluster analysis of the high-frequency keywords on embodied cognition, which was exported into SPSS 23 as variables to identify the homogeneous groups of keywords by the between-group average linkage method, which starts with each keyword in a separate cluster and then merges clusters until the last single one is left, according to selected characteristics and algorithm. The dendrogram provides a better understanding of the high-frequency keywords in mainstream academic studies on a subject.

From Fig. 3, four keywords related to Embodied Cognition were clustered into category 1, containing Allusion, Moral, Conceptual repress, and Conceptual Metaphor, to reflect the theory of embodied cognition in linguistics. Five keywords constituting Category 2 are VR, Key competency, learning environmental, Deep learning, and Learning science, to describe how embodied cognition is applied to pedagogy. Category 3 includes five keywords: the second generation cognitive, Language comprehension, Mirror neuron system, Embodied mind, and Cognitive psychology, to present the cognitive psychology and the study of the embodied mind. Category 4 is composed of 13 keywords: Embodied, Teaching, Emotion, Extended cognition, Enactive cognition, Embodied learning, Teaching design, Classroom teaching, etc. to present two sub-research: research on the design of teaching environment with embodied cognition, and research on psychology and cognitive science.

4.7. The Multi-Dimensional Scale Analysis

Multidimensional scale analysis, also known as multi-dimensional scale analysis, is a group of individual different data through multi-dimensional scale analysis into spatial composition and retains the relative relationship of the data [11]. The keywords are divided into four quadrants of the Euclidean distance model to map the hotspot research topics, using SPSS v23. Each small circle represents the position of a keyword in the Euclidean distance model, the closer the distance between the circles, the closer the relationship between the keywords, the farther the relationship is more distant [12]. The keywords of the four quadrants are analyzed in the counterclockwise direction to describe the development, evolution, and future tendency of research in a specific field.

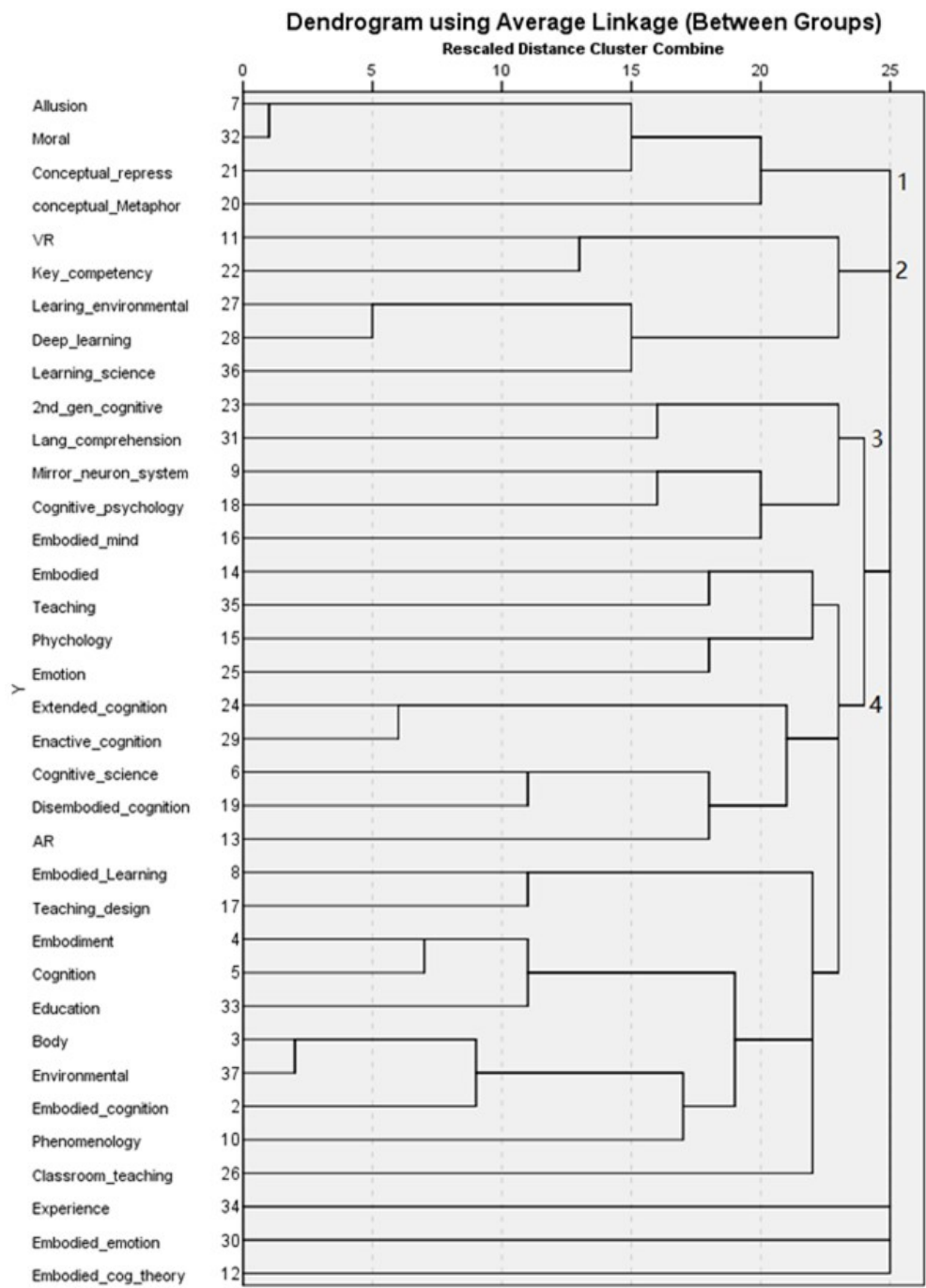


Fig.3. Dendrogram Using Average Linkage (Between Groups) Cluster of Embodied Cognition (2005-2021)

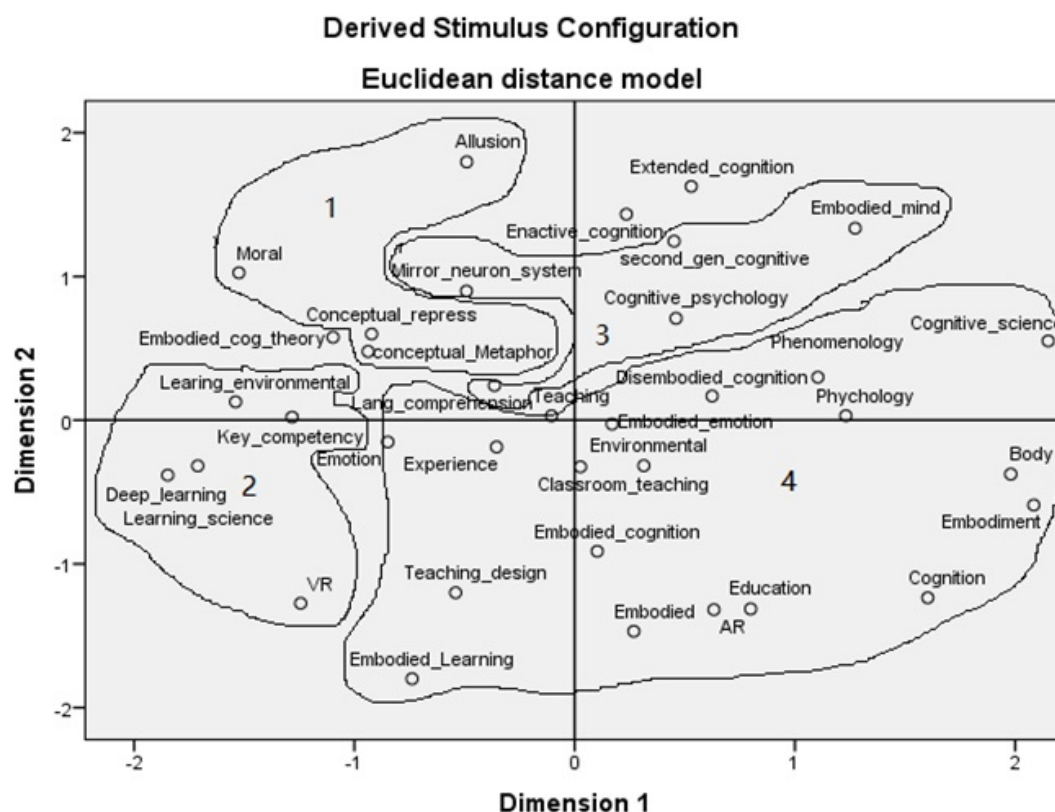


Fig.4. The result of multidimensional scaling analysis of Embodied cognition (2005-2021)

As shown in Fig. 4, Field 1 located in the first quadrant is regarding embodied cognition in linguistics, Conceptual repress and Conceptual Metaphor are more active, but the structure of each keyword is loose. It is a hotspot theme of embodied cognition research at present [13]. The pedagogical application of embodied cognition (Field. 2) is mainly located in the third quadrant to represent the trend of future research. The College of Education of Guangzhou University is the leading affiliation in this field. However, the whole field is far away from the central position and located on the edge of the research map. The keywords of Field 3, including cognitive psychology and the study of the embodied mind, are seen in the first quadrant to explain that this theme with the most attention over the past few years. Keywords of Field 4 focus on the design of a teaching environment with embodied cognition, psychology, and cognitive science, which occupied the largest area, most of them are in the fourth quadrant, and few are in the first and third quadrant respectively [13,14].

The theme of psychology and cognitive science is seen in the first quadrant which means the internal maturity of this theme is sufficient and well developed. Research on the design of teaching environments with embodied cognition is in the third and the fourth quadrant, and most of them are in the fourth quadrant. It is proposed in recent years that it is necessary to increase the research on embodied emotion in the future to contribute more new points to the study of embodied cognition.

5. Conclusion

Based on the BICOMB 2.0, this paper has analyzed articles published in CNKI between 2005 and 2021 From three dimensions: publication, high-frequency keywords, hotspots, and research trends. The main findings are summarized in the following.

Firstly, from 2005 to 2017, there has been a steady increase in the number of articles published on embodied cognition. In 2018, the research in this field reached a climax. The top 10 journals distribution shows that the proportion of core journals in this field is large, which shows that academia attaches great importance to this field. In terms of journal distribution, embodied cognition research mainly focuses on psychology, pedagogy, philosophy, and linguistics. Such information will hopefully facilitate the readers and possible contributors to better target their related studies for the journals. Scholars such as Ye, Hao-sheng, Chen, Wei, and Zheng, Xun-dong are the leading authors of this field. The research affiliations/ institutions in this field are concentrated in 211 ranking universities in China, including the College of Education, the Department of Psychology, and the Department of Philosophy, as well as the

Normal University. Among them, the Psychological and Brain Science Research Center of Guangzhou University, represented by Hao-Sheng Ye, has made great contributions to this field. The Center for the Study of Language and Cognition is leading the study of embodied cognition in linguistics.

Second, the research of embodied cognition in China is still dwelling on the theoretical discussion, lacking empirical research; even the basic principles of embodiment theory are either unacceptably vague or offer nothing new. The results found that the most important research on physical cognition is in the field of psychology, but at present, the research in the field is still about theoretical discussion and concept discrimination; there still exists divergence in theory. The following four claims are (1) cognition is situated; (2) cognition is time-pressured; (3) we off-load cognitive work onto the environment; (4) cognition is for action to be at least partially true. The claims that include the environment as part of the cognitive system are deeply problematic [15]. The claims from authors are representative of stances; some are even more controversial than others. The most important research on physical cognition is in the field of psychology, but at present, the research in the field is still on theoretical discussion, concept discrimination, and divergence in theory. Third, embodied cognition research has continuously been used in the practice of pedagogy, and the design of embodied cognitive educational environments will remain to be the mainstream topic in the future.

The dendrograms show that embodied cognition aggregates four fields on the psychology and cognitive science, research on the design of teaching environments, embodied cognition in linguistics, the pedagogical application of embodied cognition. Embodied cognition research has continuously been used in the practice of pedagogy, and the design of embodied cognitive educational environments will remain to be the mainstream topic in the future. Teachers must be able to create learning environments which are student centric and foster creativity, Meta cognition, meta-literacy, collaboration, and communication in learners.

However, this tendency reveals that educators emphasize the practice and theories of embodied cognition in teaching. The research of embodied cognition in China is in its infancy now, but it is gradually moving into a booming period. There will still be research on the application of embodied cognition in pedagogy and the theory of emotional personalization in the future. It will be more important to have in-depth interdisciplinary research integrating fundamental theories and domestic practice in this field. This study was subject to some limitations. First, Chinese is the main language for publications in the CNKI as the selected databases; therefore, some related papers might not have been collected. Second, the data retrieved in November 2021 might be insufficiently representative for lacking the completeness of year-long data for the whole year of 2021. Based on the above limitations, further Chinese databases, such as Wei-Pu, Wanfang, etc. may be included to expand the system scope to cover as much information as possible.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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