

Original Article



China Pilot Psychological Training Research - A visual Analysis using CiteSpace

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Abstract:

Objective To perform a visual analysis of the research on psychological training for pilots in China, providing a theoretical foundation and practical evidence for future studies.

Methods Selecting relevant literature from the China National Knowledge Infrastructure (CNKI) database as the data source, this study utilized bibliometric methods for retrieval, screening, and quality assessment to determine the research sample. Software like VoSviewer, Pajek was employed to analyze the knowledge structure, core authors, primary research institutions, and keyword co-occurrence networks, revealing the main trends and hot issues in this field.

Results Research on pilot psychological training in China can be divided into four stages: nascent formation, stagnation and fluctuation, steady development, and surging growth phases. The volume of publications has shown a fluctuating development trend, with research hotspots focusing on psychological quality cultivation, flight stress response, and cognitive skills enhancement. The research groups have relatively close internal connections.

Conclusion The research on pilot psychological training in China presents characteristics that are driven by demand and led by application. Areas such as the assessment of psychological training effects and innovation in psychological intervention techniques still require further exploration and improvement. Future research should delve deeper into the key issues of pilot psychological training, promote the integration of psychological training theory and practice, enhance pilots' psychological qualities, and further ensure flight safety.

Keywords: Pilot; Psychological Training; Bibliometrics; Situation Analysis; Topic Evolution

1. Introduction

With the continuous evolution of aerospace concepts, the rapid development of advanced technologies centered on artificial intelligence and information networks, and their extensive application in the military domain, the psychological quality and cognitive ability requirements for pilots are increasingly heightened. This has led to a historic transformation in the field of pilot psychological training^[1, 2]. Psychological training is a method by which individuals consciously control and adjust psychological processes (such as perception, emotions, thinking, and behavior) to enhance psychological adaptation, decision-making

efficiency, and stress management, which is of significant importance for improving flight safety^[3-5]. China places a high degree of importance on the field of pilot psychological training, including the introduction of supportive policies, the establishment of professional institutions, and the application of scientific training methods^[6].

First, at the national level, there is a strong emphasis on pilots' mental health issues, requiring airlines and related institutions to strengthen pilots' psychological training and mental health management. Second, to conduct pilot psychological training in a more systematic

manner, institutions such as the Chinese Society of Aviation Psychology have developed and implemented pilot psychological training programs^[7]. Third, China has adopted diverse training methods, including simulation training, situational training, team-building activities, and stress management courses, to help pilots maintain psychological stability when dealing with high-pressure and unexpected situations^[8]. Fourth, technologies such as virtual reality (VR), biofeedback, and big data analysis have been introduced into pilot psychological training in China, making the training more aligned with actual flight environments^[9, 10]. Fifth, psychology courses have become a mandatory part of pilot training. Pilots receive systematic psychological education during their training phase, learning the importance of mental health and how to conduct self-regulation. Although there are many studies in the field of pilot psychological training in China, the dispersion and complexity of the research make the integration and understanding of the findings challenging^[11, 12]. Using CiteSpace software for visual analysis to systematically integrate research in this field reveals research hotspots, trends, and key nodes, providing a macro perspective and in-depth understanding of pilot psychological training, and offering references and insights for related research and practice^[13].

2 Materials and Methods

2.1 Source of Data

To ensure the authority and representativeness of the research data, this paper selects research papers related to pilot psychological training from core journals (Peking University Core, CSSCI, CSCD, AMI) included in the China National Knowledge Infrastructure (CNKI) database. The retrieval strategy of the CNKI database is: SU = ('pilot' OR 'aviation personnel' OR 'air force personnel' OR 'aircrew' OR 'aircraft pilot' OR 'aviation pilot' OR 'civil aviation pilot' OR 'fighter pilot' OR 'flight instructor' OR 'test pilot') AND ('psychological training' OR 'psychological guidance' OR 'psychological adjustment' OR 'psychological adaptation' OR 'psychological regulation' OR 'psychological endurance' OR 'psychological training' OR 'psychological selection' OR 'psychological health' OR 'psychological quality' OR

'psychological literacy' OR 'psychological testing' OR 'psychological support' OR 'emotional regulation' OR 'cognitive ability' OR 'situational awareness' OR 'mental rotation' OR 'decision-making ability' OR 'stress management' OR 'self-adjustment' OR 'emergency handling' OR 'logical thinking' OR 'teamwork'). The document type is set as journal papers included in the Peking University Core, CSSCI, CSCD, and AMI databases, and the subject categories are set as aerospace science and engineering, special medicine, military medicine and health, safety science and disaster prevention, transportation economics, psychology, computer software and computer technology, automation technology, weapon industry and military technology, and clinical medicine. After manually reviewing and removing less relevant papers, a total of 492 sample papers were finally collected. The literature retrieval time is January 10, 2024.

2.2 Analytical Methods and Data Processing

Using bibliometric methods, main path analysis, and content analysis, this paper examines the characteristics of literature, knowledge diffusion paths, and key research content related to psychological training for pilots in China from four perspectives: publication characteristics, research strengths, research hotspots, and knowledge diffusion paths (technical route see Figure 1). First, the Derwent Data Analyzer and COOC software are utilized to clean information such as institutions, journals, authors, and keywords from the pure text format bibliographic records exported from the CNKI database of China National Knowledge Infrastructure. Next, statistical analysis software SPSS 29.0 and Excel, bibliographic information statistical analysis tool SATI, literature retrieval and management system Note Express, knowledge mapping software CiteSpace, and co-occurrence network analysis and visualization tool VOSviewer are employed to explore the development trends of psychological training research for pilots in China. Finally, citation analysis software HistCite, social network analysis software Pajek, and the JVM-based complex network analysis software Gephi are used to deeply reveal the field's hotspot research themes and to sort out the knowledge diffusion context.

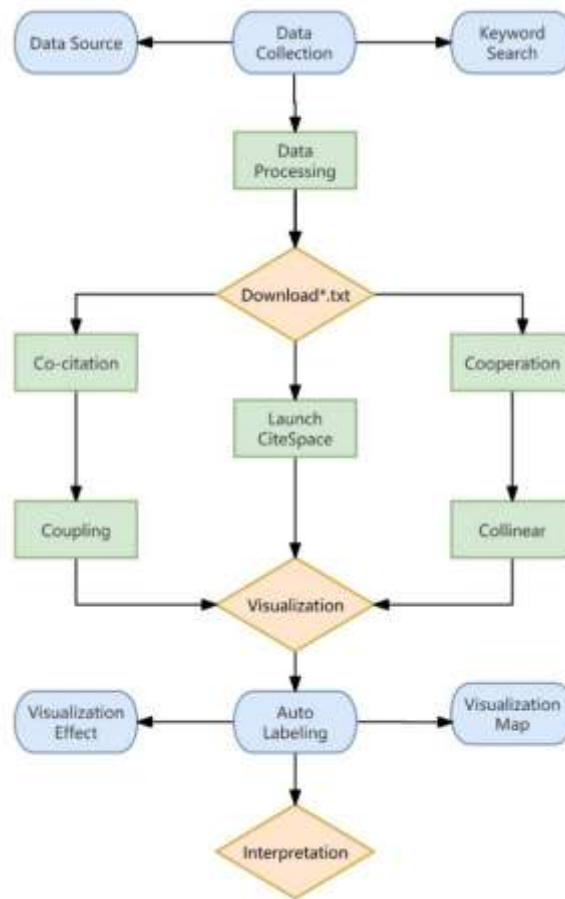


Figure 1 Research Technology Roadmap for Psychological Training of Pilots in China

3 Results

3.1 Trend Analysis of Published Articles

Based on the publication years of sample literature, we obtained the annual publication distribution trend in the field of psychological training for pilots in China. By analyzing the publication trends, we can infer the general development characteristics of this field (see

Figure 2). According to the aforementioned statistical data, from 1992 to the present, the cumulative research achievements in the field of psychological training for pilots in China have reached 492 articles, exhibiting a fluctuating development trend. This section will analyze from three dimensions: time series analysis, exploration of hotspot events, and identification of key years.

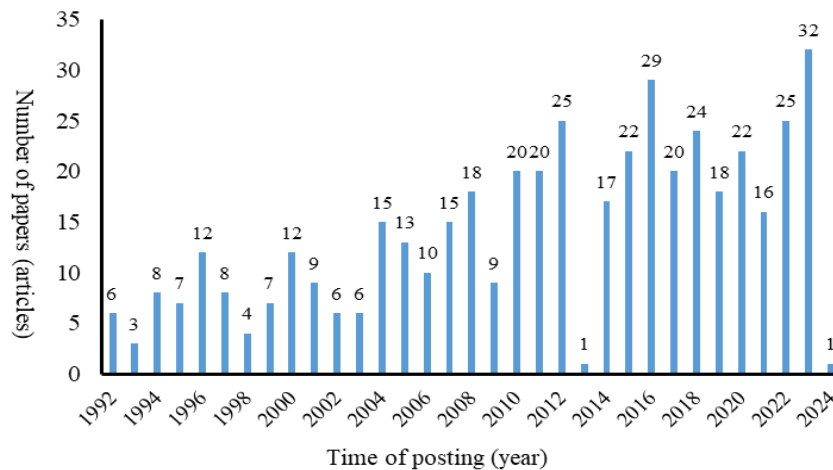


Figure 2 Annual Publication Trends in Psychological Training Research for Pilots in China

Based on Figure 2, the development of psychological training research for pilots in China can be divided into four stages: the Germination and Formation Period (1992-2004); the number of research papers on psychological training for pilots in China showed an increasing trend, reflecting that the emphasis on flight safety promoted by the development of the aviation industry has led to an increase in related research^[14]. The Stagnation and Fluctuation Period (2004-2009); the decline during this period was due to the rotation and adjustment in the field of aviation psychology research. The subsequent recovery in the number of papers indicates that this fluctuation was not a long-term trend^[15, 16]. The Steady Development Period (2010-2019); during this period, the field of psychological training for pilots formed a systematic and standardized structure, with a focus on the assessment and improvement of psychological qualities, safety culture and accident prevention, and the integration of Crew Resource Management (CRM)^[17, 18]. The Surge and Rise Period (2020-present); the number of papers peaked in 2020, possibly related to the emergence of the novel coronavirus disease (COVID-19).

During the pandemic, pilots faced unprecedented work pressure and psychological challenges, which promoted the development of psychological training for pilots. The number of papers peaked again in 2023, possibly related to several recent flight accidents. The occurrence of special situations has increased the attention in the field of aviation psychology on aspects such as pilots' psychological state, human-machine interaction, flight training, team collaboration, and safety culture, leading to an explosive growth in the number of papers in the field of psychological training for pilots^[19-21].

3.2 Keywords Analysis

The research topic is a highly concise and refined summary of scholars' core research achievements and also serves as a guiding indicator for the scientific research development of national governments, research institutions, and researchers. First, eliminate keywords that lack substantive meaning, such as policies, methods, and models. Next, through manual interpretation and standardized organization, merge the keywords. Finally, obtain the top 10 main research topics in the field of psychological training for pilots in China (Table 1).

Table 1 Research on pilot Psychological Training in China High-frequency Keywords TOP 10

Rank	Keywords	Count
1	Pilot	206
2	Civil Aviation Pilot	26
3	Air Safety	19
4	Risk Factor	13
5	Morbidity	11
6	Pilot Model	11
7	Safety Performance	9
8	Military Personnel	9
9	Air Safety	8
10	Mental Workload	8

As the core research subject in this field, the keyword "pilot" highlights the central role of the human factor in ensuring flight safety and enhancing performance. The specific subclass keyword "commercial pilot" reflects the unique training methods and psychological health challenges inherent in the commercial aviation industry^[22]. "Flight safety," as an enduring core issue in aviation, emphasizes the central position of safety in the study of pilots' psychological

training. The emergence of keywords such as "risk factors" and "safety performance" reveals that aviation psychology researchers are dedicated to identifying and quantifying risk factors, and enhancing pilots' safety operation skills through psychological training strategies^[23, 24]. The term "prevalence" highlights the importance of mental health issues and the need for such research. The keyword "pilot model" was mentioned 11 times, indicating the importance of constructing theoretical models for psychological training^[25].

The keywords "military personnel" and "aviation safety" indicate that the scope of psychological training research covers types of pilots ranging from civilian to military^[26]. As a key cognitive psychology parameter, "mental workload" is related to the cognitive demands in flight operations and their potential impact on pilot performance.

3.3 High frequency keyword clustering analysis

Using the VOSviewer literature visualization tool,

we performed a co-occurrence clustering of the psychological training themes of pilots in China (see Figure 3). Each node represents a keyword or research theme, with larger nodes indicating a higher importance of the theme. The lines represent the co-occurrence frequency between themes, with thicker lines indicating a closer relationship between two themes. Different colored clusters represent related thematic groups and the different subdomain focus areas within the field.

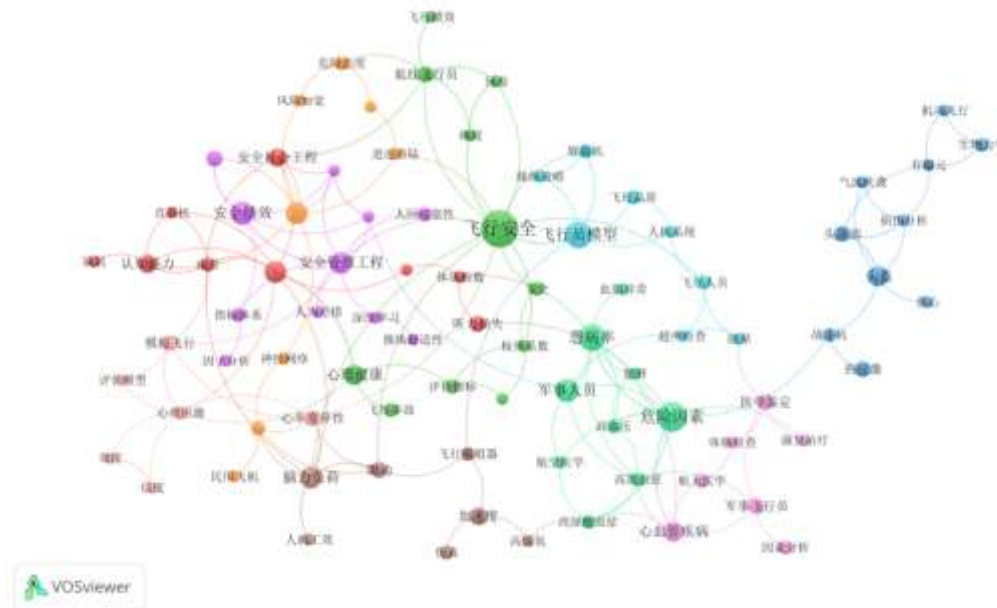


Figure 3 Co-occurrence Cluster Map of Research Topics in the Field of Psychological Training for Pilots in China

Analyze different nodes and clusters from four dimensions. First, key topics and research focuses. "Flight safety" is the core node, and the closely related sub-themes "mental health" and "flight performance" are critical research directions in pilot psychological training. Second, the degree of association between topics. The thickness and color of the lines represent the degree of association or co-occurrence frequency between different topics. The themes "flight accidents" and "mental health" are closely connected, showing strong logical relevance. This is because a good level of mental health and a calm psychological quality are key driving factors in ensuring flight safety, while abnormal psychological states are risk factors leading to flight accidents^[27, 28]. Third, research clusters and subfields. Clusters of different colors show different subfields of research, with each color cluster representing a

unique research direction, such as the development of psychological assessment tools, analysis of training methods' effectiveness, and the correlation between flight performance and psychological state^[29]. Through cluster analysis, one can deeply identify and explore research trends in the field of pilot psychological training. Fourth, potential research space. Smaller or marginal nodes like "human-machine ergonomics," "risk perception," and "factor analysis" represent emerging trends in the field of pilot psychological training. Further exploration of these nodes can lead research in new directions and fill current research gaps^[30].

3.4 Journal Analysis

Conduct a quantitative study on journal citations to analyze the extent to which various journals in the field of pilot psychological training focus on

research topics. Based on publication frequency, the top 15 leading journals are selected (see Table

2).

Table 2 Top 15 Journals in China for Pilot Psychological Training Research

Rank	Journal title	Count	Research direction
1	Space Medicine & Medical Engineering	52	Aerospace science and engineering; medical aspects of specific environments
2	Journal of Beijing University of Aeronautics and Astronautics	25	Aerospace science
3	Medical Journal of Chinese People's Liberation Army	23	Medical and health science and technology
4	Journal of Preventive Medicine of Chinese People's Liberation Army	22	Military medicine and health; medical aspects of specific environments
5	China Safety Science Journal	20	Safety science and disaster prevention
6	Journal of Safety and Environment	18	Safety science and disaster prevention
7	Journal of the Fourth Military Medical University	15	Medical and health science and technology
8	China Safety Production Science and Technology	12	Safety science and disaster prevention
9	Science of Psychology	11	Psychology
10	Flight Mechanics	10	Aerospace science and engineering
11	Science Technology and Engineering	10	Engineering science and technology
12	International Air	10	Aerospace science and engineering
13	Journal of Medical Biomechanics	9	Biomedical engineering
14	Journal of System Simulation	8	Computer software and computer application
15	Journal of PLA Medical College	8	Medical and health science and technology

Analyzing from three dimensions: the number of articles published in journals, the distribution of research directions, and the association of journal research directions. The core journals in the field of pilot psychological training research in China mainly focus on aerospace science and engineering, psychology, and military medicine and health. Among them, "Space Medicine & Medical Engineering" and "Journal of Beihang University (Beijing University of Aeronautics and Astronautics)" have made significant contributions to the field of pilot psychological training research. The average number of published articles is 16.87, with a standard deviation of 11.33, indicating a significant difference in the number of articles published in various journals. 25% of the journals have a publication volume of ≤ 10 articles, and 50% have a publication volume of ≤ 12 articles. "Space Medicine & Medical Engineering" has the highest publication volume, making it more authoritative in this field, and it is strongly associated with aerospace science and engineering and special

medicine. Although the journal "Psychological Science" ranks 9th in publication volume, it is more relevant to the theme of pilot psychological training in terms of professional research direction. Statistics on the publication volume of research directions show that the field of aerospace science and engineering is the most focused research direction, while medical and health technology and special medicine have also received high attention. The research direction of safety science and disaster prevention is also highly popular, reflecting the importance of safety issues in pilot training.

3.5 Analysis of issuing institutions

Based on the research publications on psychological training for pilots in our country, we have organized the TOP10 publishing institutions and conducted statistics and analysis on the total citation frequency, total download frequency, average citation frequency per article, and average download frequency per article (see Table 3).

Table 3 Main research institutions for pilot psychological training in China

Rank	Institution	Publications (paper)	Total cited Frequency	Total downloads Frequency	Citations per paper Frequency	Downloads per paper Frequency
1	Civil Aviation University of China	72	710	35521	9.86	493.35
2	Beihang University	47	542	19670	11.53	418.51
3	PLA Air Force General Hospital	41	512	5137	12.49	125.29
4	PLA Air Force Institute of Aviation Medicine	37	316	7924	8.54	214.16
5	Civil Aviation Flight University of China	26	214	8182	8.23	314.69
6	Hangzhou Sanatorium of Nanjing Military Region	16	168	2596	10.50	162.25
7	Air Force Medical University	15	179	4660	11.93	310.67
8	Shaanxi Normal University	14	155	11079	11.07	791.36
9	PLA Navy General Hospital	14	74	2543	5.29	181.64
10	Shanghai Jiao Tong University	13	100	3916	7.69	301.23
10	Nanjing University of Aeronautics and Astronautics	13	69	3174	5.31	244.15

Collect collaboration data from various institutions in relevant research papers, remove duplicate records, correct erroneous information, unify institution names, and fill in missing data.

Adjust the layout algorithm as needed to display the network structure and important nodes. The results are shown in Figure 4.

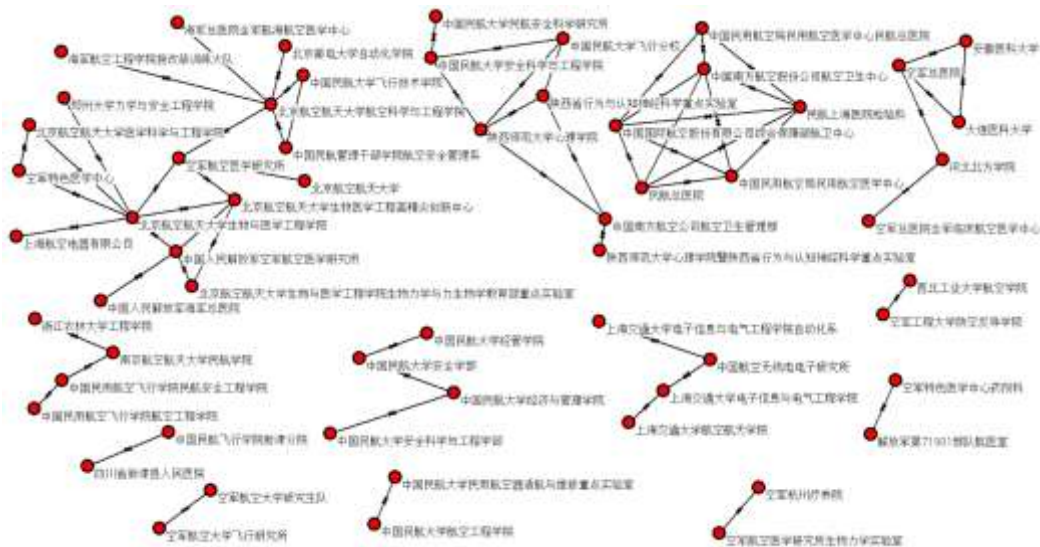


Figure 4 Cooperation network of pilot psychological training institutions in China

Figure 4 displays the collaborative relationships among various institutions within the field, highlighting the most influential institutions and their frequency of collaboration within the network. Each red dot represents an institution, and the lines indicate the collaborative relationships between these institutions, excluding isolated nodes in the social network structure analysis.

Firstly, the main collaborative institutions; Beihang University has more connections, indicating its role as a core institution with collaborations with more universities and research institutions, having numerous collaborative partners. Additionally, this institution serves as a bridge in the network topology, connecting different clusters, promoting interdisciplinary collaboration, and facilitating the dissemination and application of new methods and technologies. Secondly, the collaboration density and clusters; dense lines indicate close cooperation among these institutions. The lines from the upper left to the central part of the figure are denser, indicating more joint research among institutions such as the Aerospace Medical Research Institute of the Air

Force and Civil Aviation University of China. The figure shows multiple collaborative clusters, reflecting some research hotspots or the main collaborative institutions for specific topics within the field. Lastly, research collaboration in this field is mainly concentrated among a few core institutions, which radiate and drive other institutions to participate. The existence of collaborative clusters promotes in-depth research and technological innovation in specific areas. The bridging role of central institutions accelerates the sharing of knowledge and resources, promoting the development of the field of pilot psychological training.

3.6 Analysis of Core Scholars

The total citation frequency, total download frequency, average citation frequency per article, and average download frequency per article of domestic pilot psychological training research authors were statistically analyzed (see Table 3), identifying the drivers of research hotspots and trends in this field, which is of significant importance for understanding the future development and potential research hotspots of pilot psychological training research.

Table 3 Core scholars in pilot mental training research in China

Rank	Author	Publications	Total cited	Total downloads	Citations per paper	Downloads per paper	Institution
		(paper)	Frequency	Frequency	Frequency	Frequency	
1	Xu Xianrong	13	215	2137	16.54	164.38	Air Force Characteristic Medical Center
2	Wang Yonggan	12	170	6820	14.17	568.33	Civil Aviation University of China
3	Wang Lei	12	42	5332	3.50	444.33	Civil Aviation University of China
4	Lou Zhenshan	11	111	1920	10.09	174.55	Air Force Hangzhou Sanatorium
5	You Xuqun	11	138	9577	12.55	870.64	Shaanxi Normal University
6	Liu Songyang	10	94	2302	9.40	230.20	China Aerospace Life-Support Industries Ltd
7	Wu Qi	10	77	2890	7.70	289.00	Shanghai Jiao Tong University
8	Yuan Xiugan	10	245	5480	24.50	548.00	Beihang University
9	Zheng Jun	8	142	994	17.75	124.25	Air Force Characteristic Medical Center

10	Liu Hongjin	8	53	662	6.63	82.75	Air Force Characteristic Medical Center
10	Li Minggao	8	52	1921	6.50	240.13	The Sixth Medical Center of PLA General Hospital

Analyzing from three dimensions: the number of publications, citation frequency, and average citations per paper. Xu Xianrong from the Air Force Special Medical Center is the top scholar in terms of number of publications, and is relatively active in pilot psychological training field. 8 core scholars have published ≥ 10 papers, with a median of 10 papers, indicating variations in activity among researchers in the field. The average total number of citations for core scholars' articles is 121.73, with 75% of authors having at least 65 citations. There is a significant difference in the total number of citations between scholars, but most scholars' citations are concentrated between 65 and 156 times, reflecting the stable academic influence of the majority of scholars in

the field. There are no significant outliers, indicating a consistent academic citation level among core scholars in the field. By conducting a correlation analysis, the strength of the linear relationship between average citations per paper and average downloads per paper is quantified. The Pearson correlation coefficient is 0.2174, indicating a positive correlation between average citations per paper and average downloads per paper, suggesting a connection between article quality and audience breadth.

Using VOSviewer software to construct a co-authorship network, identifying key nodes in the network, and using network graphs to display the collaboration relationships and citation patterns among core scholars (see Figure 5).

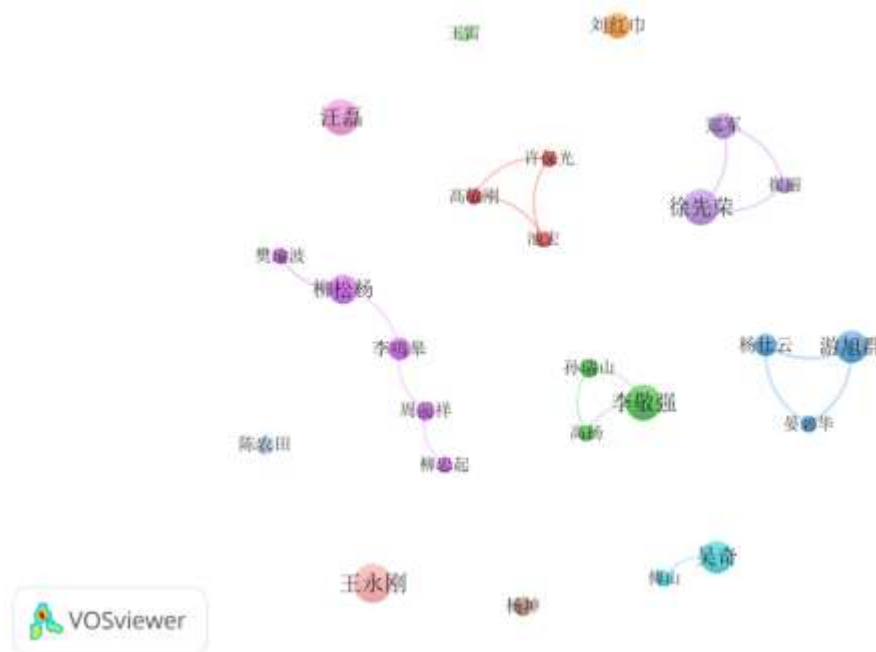


Figure 5 Network co-authored by the core scholar of pilot psychological training in China

The largest circle in different clusters represents scholars with the most collaborations, each node represents a researcher in the field; the size of the node indicates the importance in the network, the larger the node, the higher the importance. Li Jingqiang, Xu Xianrong, and You Xuqun are key researchers in various subfields. The connections

represent relationships between nodes, and the thickness of the connections indicates the frequency of collaboration. The purple cluster lines in the graph are both numerous and dense, indicating more frequent collaboration among scholars in that cluster. Different colors represent different clusters, nodes of the same color belong to the same research group, with more

collaboration and intersections. Except for the small part of overlap and connection between the collaboration networks represented by Li Jingqiang, Xu Xianrong, You Xuqun, and Chi Hong, the rest of the core clusters are relatively isolated. Researchers mostly choose to collaborate within the boundaries of their own professional fields. In the future, researchers can actively seek communication and collaboration between different institutions, using research results in different directions to drive the continuous

progress of China's pilot mental training practice and development.

3.7 Knowledge diffusion paths and analysis of key research content

Using text analysis techniques, identify high-frequency co-occurring vocabulary, use word clouds to represent the structure and paths of knowledge diffusion, and analyze the six-stage temporal trends in the frequency of appearance of research topics and keywords (see Figure 6).



Figure 6 Word Cloud of Hot Research Topics in the field of pilot psychological training research in China

Based on Figure 6, pilot psychological training ranges from basic selection and assessment to personalized interventions, integration of technology, and the correlation between safety and individual characteristics in various research areas. This indicates that psychological training not only focuses on enhancing the personal capabilities of pilots, but also integrates technological innovations into the pilot training process, emphasizing the critical role of psychological factors in air safety. In the first phase from 1992 to 1999, a series of physiological concepts were key words for this period. Selection and assessment played a central role in pilot psychological training during this phase, focusing on selecting suitable pilots and evaluating whether they possess the physical and mental conditions necessary for flying^[31]. The academic community primarily focused on the quantitative assessment of pilot psychological characteristics and the application of neurophysiological research findings in the selection process^[32]. In the second phase from 2000 to 2004, researchers began to emphasize the most important subject, "human," and the emergence of the keyword "situation awareness" indicated that flight training was no

longer limited to physiological and technical aspects, but deepened into the internal integration of military and psychological education^[33]. In the military field, psychological training is gradually becoming a systematic framework that spans a pilot's career. In the third phase from 2005 to 2009, the focus was mainly on pilots' stress responses and pathological issues. The main task of this phase was the management of individual physical and mental health, emphasizing the cultivation of pilots' psychological resilience and the ability to maintain psychological stability in stressful and high-pressure environments^[34]. In the fourth phase from 2010 to 2014, the keywords "Pilot model" and "error causes" represented the emergence of a more autonomous training concept. Pilot psychological training became more refined, considering individual differences in each pilot and providing targeted interventions, also marking the gradual maturity of personalized psychological training concepts^[35]. In the fifth phase from 2015 to 2019, keywords such as "Risk factor" and "influencing factors" received high attention in the field. With the emergence of technologies like brain-machine interfaces and virtual reality, psychological training entered a

new era driven by technology, focusing on the application of technology in specialized scenario training and exploring the combination of cutting-edge technology to ensure air safety^[36, 37]. In the sixth phase from 2020 to 2024, the research focus shifted towards safety social engineering. Researchers in this phase paid attention to the development of technology and the implementation of personalized training, while also analyzing in depth the impact of individual Mental workload and cognitive models on air safety^[38].

4 Research conclusions and recommendations

4.1 Research Conclusion

This study used bibliometrics method, with China National Knowledge Infrastructure (CNKI) as the data source, to collect academic papers on pilot psychological training in China from 1992 to 2024. After data cleaning and discernment with CiteSpace software, keyword co-occurrence maps, literature co-citation maps, and author collaboration network maps were generated based on the information in the literature^[39, 40]. Firstly, pilot psychological training in China has strong practicality, with research results closely integrated with demands. Secondly, the research hotspots and development trends of pilot psychological training in China are clearly defined and staged. Finally, there is a close internal integration among research institutions and personnel in pilot psychological training in China, with loose connections between groups.

4.2 Research Recommendations

In recent years, with the gradual expansion of the field of aviation psychology research, pilot psychology training research in China has shown a rapid growth trend^[41]. The application of new methods and technologies such as virtual reality, electrical stimulation, and near-infrared spectroscopy has been emphasized^[42, 43]. The theoretical and practical aspects of pilot psychology training are continuously integrated, forming a pattern of interdisciplinary research^[44, 45].

The Chinese military originally conducted simple psychological assessment and training for pilots to select suitable candidates and improve mission execution efficiency, focusing mainly on coping with psychological pressure in combat^[46]. With the development of civil aviation industry,

researchers began to explore the impact of different psychological factors on civil aviation safety. Psychological training gradually introduced into the field of civil aviation and became part of the training system^[47]. With the advancement of psychology and aviation technology, the psychological training for pilots in the 21st century has introduced modern methods such as simulated flight training and virtual reality technology, becoming a comprehensive training system including stress management, emotional management, team cooperation, and other contents^[48, 49]. With the development of artificial intelligence and big data technology, the future psychological training for pilots will be more personalized and efficient. By monitoring the real-time psychological state of pilots and analyzing data, training programs can more accurately match the specific needs of each pilot^[50].

Currently, there are four research hotspots in the study of pilot psychological training in China.

The first research hotspot is stress management; as the complexity of flight tasks continues to increase, the cognitive psychological burden of pilots also continues to grow. Methods such as cognitive behavioral intervention, mindfulness therapy, and breathing relaxation are emphasized to provide technical support for effectively managing and relieving psychological pressure^[51]. The second research hotspot is emotional regulation; when performing tasks, pilots need to quickly and accurately deal with various emergencies. How to improve the emotional regulation and recovery capabilities of pilots, enabling them to remain calm in the face of stress and challenges, has become a current research focus^[52]. The third research hotspot is psychological adaptability training; adaptability training can enhance individual psychological resilience, improve problem-solving abilities, and make optimal decisions, helping pilots better adapt to the ever-changing flight environment and task requirements^[53, 54]. The fourth research hotspot is virtual reality and simulation training; through VR technology simulating various flight environments and emergencies, pilots can enhance their psychological coping abilities and decision-making methods in a risk-free environment, improving their emergency response capabilities^[55]. Pilot psychological training is a highly specialized and technologically intensive

field, requiring information flow and knowledge sharing among research institutions internally^[56, 57]. Due to national security and air safety considerations, the psychological training of pilots requires high confidentiality. Therefore, information sharing and communication among research institutions and personnel may be limited due to confidentiality requirements. Resources for pilot psychological training (such as simulators, professional equipment, and funds) are often concentrated in specific research institutions, and the uneven allocation of these resources can lead to the formation of relatively tight groups by the resource holders in the industry, with relatively loose connections to other groups.

Based on the above analysis results, the pilot psychological training research in China presents a diverse and in-depth characteristic. However, there are also some problems and challenges: firstly, the integration of theory and practice; in the existing research of pilot psychological training, there is still a certain gap between theoretical research and practical application, and the effective transformation of research results into practical operations is a key direction that future research needs to focus on. Secondly, the development of personalized training methods; each pilot's psychological characteristics and needs are different, and future research should pay more attention to the development and application of personalized training methods^[58, 59]. Finally, the promotion of interdisciplinary research; pilot psychological training involves multiple fields such as psychology, aviation, human-computer interaction, etc. Establishing an interdisciplinary cooperation platform and strengthening the information and resource sharing mechanism will be the key targets to improve the quality of research in this field.

Data Availability Statement: The datasets generated and analyzed in the present study are available from the corresponding author on reasonable request.

Ethics Statement: The studies involving human participants were reviewed and approved by the Ethics Committee of the Air Force Military Medical University. The patients/participants provided their written informed consent to participate in this study and to comply with the Declaration of Helsinki.

Clinical Trial Number: N/A.

Author Contributions: Study concept and design: YG, RQ, and XZ. Data collection, analysis and interpretation: BC, and SC. Writing—original draft: YG, MX and RQ. Writing—revision and edit: XZ, YG, and RQ. All of the authors have approved the publication of this manuscript.

Funding: No Funding

Acknowledgments: The authors would like to thank all the individuals who participated in the study. The authors also thank MogoEdit (<https://www.mogoedit.com>) for its English editing during the preparation of this manuscript.

Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Competing Interests

The authors declare no competing interests.

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