

The Evolution of Hot Topics in the field of Psychology in Virtual Reality Based on the Visualization Analysis of WOS Core Database (2011-2021)

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Abstract—Virtual reality technology has been used far and wide in the field of psychology. However, previous studies have not demonstrated the application status, evolution trend and research hotspots of virtual reality technology in various branches of psychology. Therefore, it is necessary to reveal the current research state of this field objectively and comprehensively, effectively excavate the potential hot research issues from many papers, trace the change path, and carry out visual analysis. A total of 1336 papers with the theme of "virtual reality" and "psychology" included in the core database of WOS from 2011 to 2021 were selected as the research objects. Citespace and other visualization software were employed to draw several maps of author, institution cooperation and keyword co-occurrence. This study explores the research hotspots and mainstream in this field, as well as states explicitly the future development emphasis for virtual reality in psychology research.

Keywords - virtual reality; psychology; visualization; knowledge graph; citespace

1 INTRODUCTION

In the 21st century, On the basis of the fast progress of science and technology, virtual reality has gained widespread attention and investment as soon as it appeared, and a trend of research and application of VR technology emerged. Computer technology is the core of VR technology, and 3D modeling technology is the key technology to establish a digital environment that is similar to the real environment in all aspects^[1]. Immersive VR systems include tools such as sensing headsets and data gloves, with which participants interact with objects in the digital environment to achieve multi-sensory stimulation. As we all know, VR technology possess the advantages, such as immersion, interaction and imagination to promote the experience of participants.

In the area of psychology, domestic and international scholars have been exploring all the time. Nowadays, being widely applied to various psychological disorders, virtual reality technology has achieved significant intervention effects after combining with many psychological therapies. Firstly, in the therapies of psychological barriers, anxiety disorders therapy is the first to introduce virtual reality technology, such as acrophobia, arachnophobia - spiders and

agoraphobia. Difede and Hoffman used virtual realizations to construct the scene of the World Trade Center bombing after 9/11. Patients who had not been cured by conventional exposure therapy were included in the study to re-experience a fictional explosion. With the help of technology, he could actually feel the vivid sound of explosions, people jumping from buildings in flames, thick black smoke and so on. Finally, the patient successfully overcame post-traumatic stress disorder^[2]. In 1997, Riva and his colleagues used VR technology in order to modify patients' body image concept with eating disorders^[3]. After a series of treatments, a woman with anorexia gradually formed a reasonable understanding of her body image, and her bulimic behavior was controlled to a certain extent^[4]. Secondly, applying virtual reality technology for psychological rehabilitation has become increasingly popular. When Jiang Shan et al. applied the projection VR cognitive rehabilitation system to treat the cognitive function of patients with craniocerebral injury, they found that the VR-based training method was more effective than the traditional method for the recovery and improvement of cognitive function and daily life function^[5]. PsyBot, an AI robot based on cognitive behavioral therapy, has a significant intervention effect on moderate and moderate to severe depression compared with the general intervention^[6]. Based on the visualization software: CiteSpace, this study explores the hotspots, trends and evolutionary paths of virtual reality technology in the area of psychology, so as to provide relevant researchers with cutting-edge progress information.

2 VISUAL ANALYSIS OF RESEARCH

2.1 Data source

For data base, employing Web of Science core database, this article selects “virtual reality” as well as “psychology” as subject search headings. The specified time range includes 10-year period from 2011 to 2021, and language is restricted to English and the literature type is Article. The data is download on September 19, 2022. After deletion, this paper totally chose 1336 paper titles, being exported in txt format. Every single one of them contains the following details: title, author, abstract, keywords, years and organization.

2.2 Methods

Bibliometrics and information visualization are used as the primary research means of this research. Citespace ^[7] as a visualization software are used to explore the critical messages including keywords, authors, and organizations of the exported literatures through word frequency statistic, co-occurrence analysis, and cluster research. The social relationship among scholars, countries or institutions in certain a can be found in the collaboration map, which provide a brand-new viewpoint for estimating the academic influence of organizations, scholars or nations or. For us the co-word charts are used to explore hot topics and its evolution. Other important information such as the structural characteristics among highlighting key nodes, clusters as well as significant links can be reflected in the cluster view.

2.3 Annual publication of the amount of literatures

Figure 1 shows the annual publication of the amounts of documents in this area, based on the WOS core database. There was an up-raising trend in the amounts of documents with the theme of virtual reality and psychology from 2011 to 2016, achieving the high point of 96 papers both

in 2013 and 2016. Nonetheless, the amounts of published documents were under 100. By and large it maintained above 110 since 2017, and then in 2019 rose sharply. At last, it remained on the high plane for two consecutive years, but plunged to 117 in 2021.

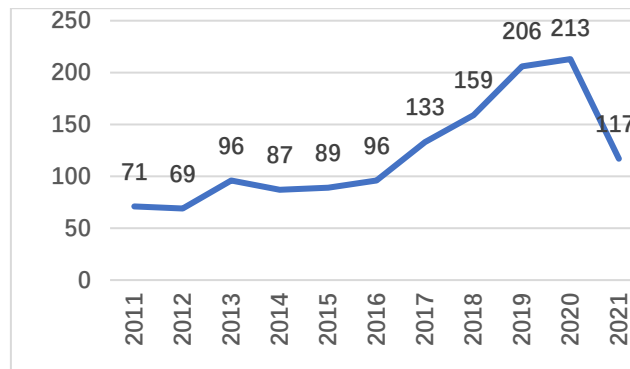


Figure 1 Annual publication of the amount of literatures

2.4 Analysis of Author Collaboration Network

On the strength of Price Law, when 50% or more of the entire amount of articles are taken up by the core authors, it manifests that authors in the area of study have high concentration ratio, and the calculation formula is (1), among which M denotes the smallest amount of articles in demand, and N denotes the amount of articles written by the highest author^[8].

$$M = 0.749 * N^{1/2} \quad (1)$$

Referring to word frequency info in Citespace, the amounts of distribution by the most prolific scholar is 21. Thus, it can be counted that $M=3.43$. On the basis of the principle of rounding, in this area 4 can be considered the lowest amounts of literatures published by high competent authors. By analyzing statistics, the result shows that 35 researchers have published 211 papers in all, taking up 26.7% of the entire published papers, which exceed the standard of 50%. Therefore, the conclusion is that the researchists are considerably scattered on this area.

According to the author's copresence graph making by Citespace, the number of articles published by scholars can be seen by the size of nodes, the link between nodes show that the collaboration relationship of writers has been formed, and the intensity of the authors' collaboration is indicated by the thick rules. According to Table 1 and Figure 2, the results show that KIM J (21), RIVA G (15), SLATER M (14), and KIM S (11) rank in the top four in turn. At the same time, we can find that the first eight authors form four cooperative groups. Among them, the cooperation team of KIM J and KIM S is the largest.

Table 1 Authors With over 8 articles

Author	Related message	
	Number	Frequency
KIM J	1	21
RIVA G	2	15
SLATER M	3	14

KIM S	4	11
GUTIERREZ-MALDONADO J	5	10
FREEMAN D	6	8
CALABRO R	7	7
DE LUCA R	8	7

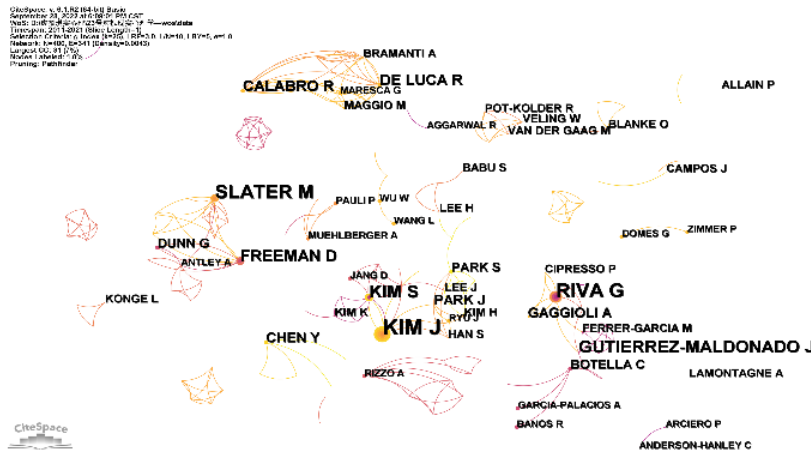


Figure 2 Author collaboration network map

2.5 Analysis of agency collaboration network

Figure 3 shows the organization collaboration map, and Table 2 shows the top 17 institutions on the part of publication volume.

In Table 2, there are 8 organizations, which have published 13 or more articles, and 150 articles, that have been came out in all, taking up 14.55% of the total number of articles published. University College London and Barcelona University take the top two spots with 32 papers and 29 papers respectively. To sum up, universities can be considered as mainly publishing organizations in psychology in virtual reality.

Table 2 High Frequency Organization

Number	Related message		Institution
	Number	Frequency	
1	1	32	University College London
2	2	29	Barcelona University
3	3	18	King's College London
4	4	16	University of Toronto
5	5	15	The University of Sydney

6	14	University of Washington
7	13	University of Oxford
8	13	Università Cattolica del Sacro Cuore

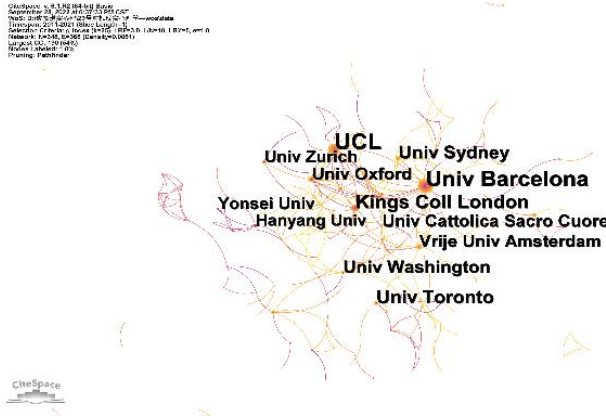


Figure 3 Organization collaboration network map

2.6 Keywords Copresence and Clustering analysis

2.6.1 Keywords Frequency Message

After adjusting some settings, Pathfinder and Pruning sliced networks were selected, Top N was set from the default 50 to 25, and finally Q was 0.4306 (>0.3) and S was 0.7346 (>0.5).

Table 3 Keywords Frequency Messages

Key Words	Related message		
	Number	Frequency	Centrality
Virtual reality	1	712	0.45
Performance	2	223	0.18
Therapy	3	107	0.15
Environment	4	104	0.09
Reality	5	86	0.13
Rehabilitation	6	86	0.22
Perception	7	58	0.10
Model	8	57	0.07
Anxiety	8	45	0.04
experience	10	45	0.08

Using Citespace to count keywords with high-frequency, then unite keywords with high correlation. For instance, “exposure therapy” is merged into “therapy”, “virtual environment” is merged into “virtual reality”, and “response” is merged into “performance”. Table 3 indicates the top-ten keywords with alto frequency after the eventual ranking. Of those, “virtual reality” at the highest frequency, reaches 712 times. The second are “performance” (223 times) and “therapy” (107 times) respectively. “environment” is 104 times. After analyzing the high-frequency keywords from 2011 to 2021, the result can be concluded that “therapy”, “rehabilitation”, “virtual reality”, “performance”, “perception” and other directions can be seen as hot area of research.

2.6.2 Keywords’ Clustering Analysis

On the basis of the network construction as well as the clustering’s precision, two targets are provided in Citespace: module value (Q value) and average contour value (S value). In summary, it is sensible while the Q value change between the interval of [0.1] and $Q > 0.3$, $S > 0.5$ [1]. By contrast, the map construction made by previous settings in Citespace is untidy and unintelligible, therefore this research changed several settings at this stage, for example, selecting Pathfinder and Pruning sliced networks, and last Q value is 0.4306 (> 0.3), and the S value is 0.7346 (> 0.4). At last, Table 4 can show the cluster analysis result that there are 6 cluster labels. " Psychotherapy methods ", " Education ", " psychological disorder ", " cognitive disorder " and so on are known as the cluster labels.

Table 4 Clustering Message

ID	Size	Year	Clustering Terms
0	20	2012	psychotherapy methods
1	15	2013	Education
2	15	2013	psychological disorder
3	15	2014	cognitive disorder
4	14	2012	Augmented Reality Technology
5	14	2014	physical activity
6	9	2016	patient care

The first category focuses on application of virtual reality technology in psychotherapy methods, such as exposure therapy, cognitive-behavioral therapy, mirror therapy and so on. Virtual reality technology as the core technology can make up for the deficiency of psychological intervention, and improve the effect of psychotherapy by giving patients experience close to reality.

The second category focuses on application of virtual reality technology in education, such as gross anatomy education, medical education, undergraduate education, nursing education, teacher education and so on. The influence of virtual reality applying in education should not be underestimated.

The third category is the practical application of virtual reality in psychological disorder. For example, evaluating and treating social anxiety, bipolar disorder, posttraumatic stress disorder, emotional disorder, ASD and so on.

3 TREND OF DEVELOPMENT

At present as one of the primary tools for document's content analysis, Burst detection stood out clearly vibrant or cutting-edge research nodes. In this research 15 burst terms in total, are shown in Table 5. Based on the appearing period and keywords' sort, this article separates the area of virtual reality in psychology into three stages:2014-2015, 2016-2018, and 2019-2021.

Table 5 Burst Terms Message

Key Words	Strength	Begin	End
Brain	6.18	2014	2017
Intervention	8.23	2015	2018
Impact	4.55	2015	2018
Schizophrenia	4.46	2015	2018
People	7.07	2016	2019
Older adult	6.86	2016	2018
Anxiety disorder	4.42	2016	2017
Alzheimers disease	8.14	2017	2018
Adult	6.04	2017	2019
Mild cognitive impairment	5.73	2017	2018
Individual	7.97	2018	2019
Augmented reality	9.77	2019	2021
Technology	7.44	2019	2021
Education	5.99	2019	2021
validity	4.48	2019	2021

The first period ranges from 2014 to 2015. "Intervention" as well as "Brain" had the strongest strength, accounting for 8.23 and 6.18 respectively. The result is showing that the research area of psychology in virtual reality chiefly probes the affect of intervention method and the changes of human brain.

The second phase is between 2016 and 2018. "Alzheimers disease" (8.14) has the highest strength, followed by "Individual" (7.97). The result is indicating that at this phase, scholars mainly pay attention to person's mental-health problem. This is because with the deepening of the understanding of virtual reality technology, researchers have begun to explore how to apply the virtual reality technology for personal problems.

The third period is 2019-2021. The highest is "Augmented reality" (9.77), followed by "Technology" (7.44), "Education" (5.99), "validity" (4.48). As the better understanding of the impact of virtual reality technology, academics pay more attention to a combination of

technologies as well as broaden the field of technology application. These include combining augmented reality technology with virtual reality technology, as well as the exploration of other fields.

In accordance with the progress of the above three stages, we discovered that academics are increasingly exploring virtual reality in psychology, from the initial study of brain, intervention methods, and then to the older adults, mental disorders, AR technology and other fields. The average duration of keywords can last 4 years. Augmented reality and education appearing in 2019, have not yet up to this standard, and are may be the development tendency and research focus in the days to come.

4 CONCLUSION

According to the research means such as knowledge graphs as well as bibliometrics, the paper select 1336 'Virtual Reality' and 'Psychology' papers from WOS database to visually analyze. This investigation discloses core authors' benchmark, as well as discovers that academics containing KIM J, RIVA G, SLATER M, and KIM S are considered as the staple high productivity authors. Moreover, this paper sums up the partnership of research organizations in the study: universities can be known as the main research institution, and the circle of collaboration has been formed around University College London and the University of Barcelona. Third, in this research area the distribution of journals accords to Bradford's law as well as owns definite core effects. Fourth, this research discovers virtual reality's development period in psychology research can be divided into three phases: 2014-2015, 2016-2018, and 2019-2021, as well as concludes the relevant message about keyword mutation. In the end, the paper expounds the focus and development tendency of literatures as well as separates them into three sorts and three phases, that show clearly that in the future research hotspots concentrates upon augmented reality, education, and individual.

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