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A Bibliometric Analysis of Virtual Reality-Aided Vision Therapy

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Abstract. While Virtual Reality (VR) has gained significant attention in different domains of health care and promises benefits for managing vision disturbances, no bibliometric analysis focuses on its use in vision therapy. This study aims to analyze and visualize the scientific literature indexed in the Web of Science databases by visualizing bibliometric indicators illustrating publication trends from 2001. The findings provide a better understanding of the state-of-the-art of existing vision therapy research utilizing VR.

Keywords. Virtual reality, vision therapy, bibliometric analysis, visualization

1. Introduction

Vision therapy (VT) is a non-surgical, non-medication method of developing, restoring or increasing vision function performance and processing [1]. A wide range of vision and non-vision disorders have been addressed by VT, including oculomotor dysfunction, convergence problems, help for vision training and better focus in sports, dyslexia, and post-concussion vision disorders [2]. The recent advancement of novel technologies has complemented or substituted the conventional VT approaches and minimized some associated challenges such as skin irritation (patching one eye), psychological effects of binocular inhibition, maintaining complete documentation of the treatment [3], or reaching more with challenging training [4, 5].

Virtual Reality (VR) applications can be considered viable tools in health care for non-invasive therapies. The main advantages of using VR applications for VT are providing high imaging for stimuli, customization, and the possibility of using the eyes monocularly and binocularly [6]. The lenses in a Head-Mounted Display (HMD) can display different images to each eye separately, which results in a dichoptic stimulus presentation. The VR technologies' dichoptic and stereoptic characteristics can offer a suitable tool for treating amblyopia and strabismus [3].

The bibliometric method provides quantitative assessments of scientific literature. It can be used to identify the development of a particular field by visualizing, e.g., the distribution patterns of journals, authors, or countries [7]. Currently, only a few bibliometric studies have investigated the impacts of VR-aided therapy. For example, for general health science, Liu et al. [8], but VT was not included. This study aims to analyze

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the role of VR in VT by using a bibliometric analysis to understand the current state-of-the-art in the field.

2. Methods

Web of Science (WoS) Core Collection provides comprehensive results and is a commonly used database in health domains [8]. The flowchart can be seen in Figure 1.

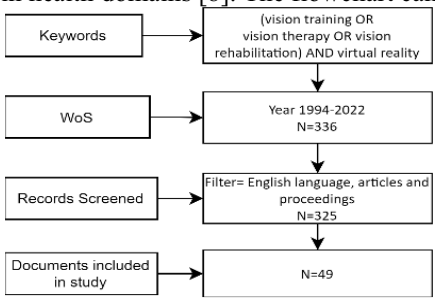

Figure 1. The flow chart of examining the bibliometric data.

The data was analyzed and visualized in the next step using open-source software, including the Bibliometrix [9] R-package and VOSViewer [10]. These software tools provide descriptive analyses, statistical graphs, relationships between authors, keywords, countries, and co-citations. In addition, VOS and Bibliometrix produce clustered data based on the distribution and classification of items. All materials of this study are available on OSF (https://osf.io/m895t).

3. Results

3.1. Publications trends and top sources

Figure 2 shows the number of articles published yearly between 2001 and 2021. Less than 5 articles were published in the early years, but over 9 articles in 2001. This can be explained by the newness of the technology, i.e., the combination of VR, including eye-tracking necessary for VT [5]. The annual publication growth rate since 2001 is 14.01%.

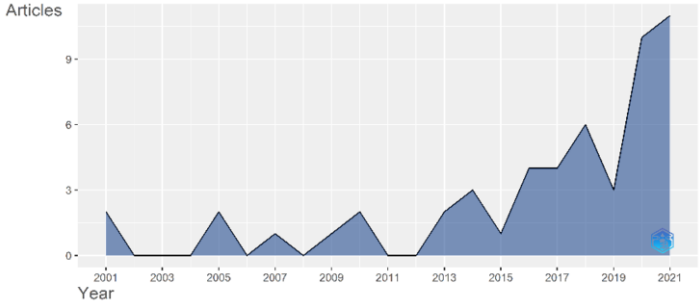

Figure 2. Annual publications since 2021. The earlier papers focus on eye reconstruction, computer vision, or utilizing vision for general training and not on training the eyes to improve human sight.

3.2. Bibliographic coupling analysis (BCA), Co-occurrence of all keywords and most cited countries

Bibliographic coupling analysis (BCA) represents the relationship between articles and their corresponding citation volume. Figure 3 shows 5 clusters identified in BCA. Cluster 1 contains training for amblyopia and strabismus; Cluster 2 examines perception and gaze accuracy in HMD; Cluster 3 focuses on sports training; Cluster 4 investigates VR and mixed reality systems for children with autism disorders blind people; Cluster 5 focuses on rehabilitation of cognitive and functional performance.

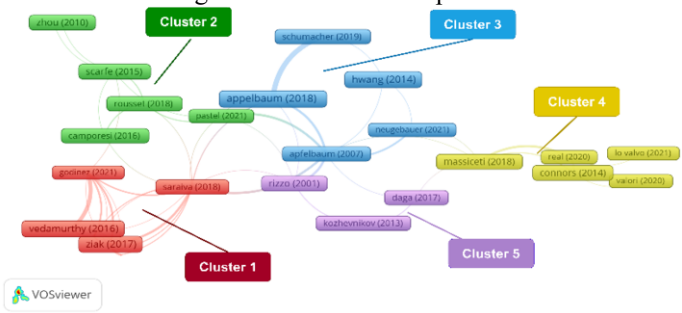

Figure 3. Bibliographic coupling analysis performed by VOSviewer.

Figure 4 shows the co-occurrence of all keywords in documents, including 'Author keywords' and 'KeyWords Plus.' Accordingly, the phrases that frequently appear in the titles of cited articles 'Virtual reality,' 'Vision,' and 'rehabilitation' have a score of 16, 14, 11, respectively. Out of 349 keywords, only 58 met the threshold limit of 2. The co-occurrence shows VR studies are associated with functional vision disorders.

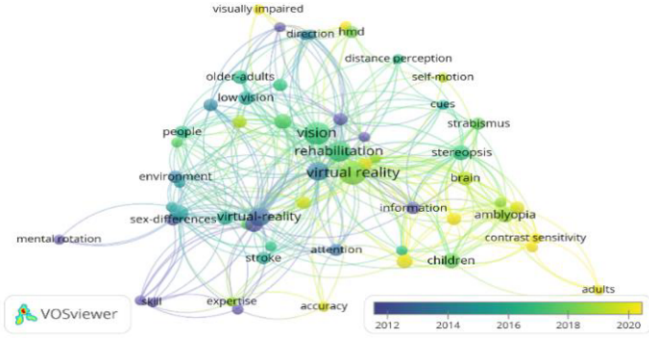

Figure 4. Network visualization of co-occurrences of all keywords.

Figure 5 shows the top 10 countries for citations. USA is leading with 350 citations, whereas Chile received 24. There is a significant gap in citations between countries, e.g., the USA acquired 3 times as many citations as any other country.

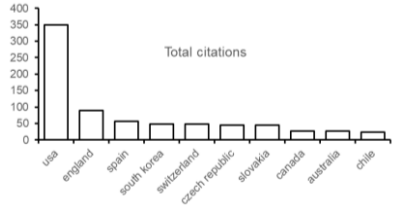

Figure 5. Top 10 countries with highest citations.

4. Discussion and limitations

While VR is not a new technology today, combining VR with eye-tracking is necessary for supporting vision screening and training, and it is new in this millennium. Therefore, identifying the possible departures for this type of research can also be valuable. With this expanding the research fields, we may not observe the strong connection between areas with other methods, e.g., older adults and low vision, or the technical characteristics, such as the importance of considering distances and colors. Collecting only WoS indexed articles, only in English, or choosing the search terms may be incomplete. Other bibliometric indicators can also be investigated, such as institutions' productivity, countries' collaboration rate, etc.

5. Conclusions and future works

To our knowledge, this is the first study providing quantitative insight into VR-aided vision therapy research via bibliometric indicators. VR-aided VT is an emerging field; the scientific production outlined an annual publication growth rate of 14.01%, currently clustering in VR training for 1) amblyopia and strabismus, 2) gaze accuracy, 3) sports, 4) autism disorders (incl. blindness), and 5) cognitive and functional performance.

The results indicate possibilities to complement current VT techniques with VR applications. The affordability and technical potential offered by HMDs combined with eye-tracking technologies for VT tasks point to new needs to be investigated in design, development and use.

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