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URBAN PLANNING AND DESIGN

Effects of vr-based interactive interior design on the emotional and mental health of office worker

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ABSTRACT

From the perspective of the evolution of the concept of health, the purpose of mental health is to achieve better living conditions, higher adaptability and development level, and also the best combination of physical and mental well-being and social well-being. According to the literature, the region and privacy of office interior design, the comfort and convenience of office furniture, the charm of office environment and individuation all have an impact on the mental health of office workers. Interactive interior design based on virtual reality can improve the office environment, thus improving the work efficiency and productivity of employees. A comfortable office environment has a positive impact on physical factors for office workers, which is beneficial for improving their mental health. This paper aimed to study how to analyze and study the impact of interactive interior design based on virtual reality (VR) on the emotional and psychological health of office workers. In this paper, the impact of VR interior design was evaluated by fuzzy comprehensive evaluation method, and the analytic hierarchy process (AHP) was used to quantify the weight. In the experiment part of this paper, through the analysis of the questionnaire of the office workers in Chengdu, Sichuan Province, and the comparison of the experimental data, it can be known that before the experiment, the control group and the experimental group were both very healthy, and after the experiment, the psychological health of the two groups was very healthy, which was 0 and 4 people. It can be seen that the psychological health of the workers in the experimental group has changed significantly. This paper studied the influence of VR interaction design on worker's emotion from the experimental point of view and proved its influence on employee's emotion from the empirical point of view, which had certain reference significance for future research.

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Interior design; virtual reality; fuzzy comprehensive evaluation; mental health; office worker

1. Introduction

Mental health issues have become increasingly prominent social issues. In particular, the pressure of office workers from life, family, and other aspects has greatly aggravated the occurrence of mental health problems of office workers. According to the data released by the National Institute of Mental Health of the United States, about 50% of adults worldwide suffer from mental health problems. Because VR technology can provide a completely immersive space environment to help people overcome tension and anxiety, it has become an effective tool to relieve pressure. However, existing research shows that people have some negative emotions when using VR, and feel bored, anxious, depressed, irritable and helpless in some spaces. If they enter an area of interest or challenge, this emotional change is more obvious. At present, there is not enough research to explore VR interactive interior design in office interior design. Therefore, this study on this aspect can fill the gap in this aspect. To sum up, this paper studies and analyzes the emotional and psychological health of office workers in the interactive interior design of VR.

Nowadays, VR has gradually attracted widespread attention from the academic community. Shouman Bassam aimed to evaluate the participation of users in the construction industry (such as interior design) through mobile augmented reality application, which had been tested with traditional participation technologies through existing facilities, planning and redesign scenarios (Bassam, Ahmed Ezzat Othman, and Marzouk 2022). Juan Yi-Kai stated that a user-oriented interior design and decoration decision support system is developed based on VR. He verified the four-stage decision-making process of the system through a case study of an office building (Yi-Kai, Chi, and Chen 2021). Prabhakaran Abhinesh proposed a new method to develop an interactive and immersive virtual environment for design communication in the furniture, fixture and equipment industry (Abhinesh et al. 2021). Although these research methods are innovative, a large number of experimental data are needed to prove the reliability of the methods.

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At the same time, the research on office worker is also increasing. Riches Simon believed that new solutions were needed to support workers, and VR relaxation could be piloted in more workplaces as a stress management tool (Simon and Smith 2022). Riches Simon stated that a systematic review was conducted on the feasibility, acceptability, and effectiveness of using VR to promote relaxation in the general population. He found that the experience of a pleasant and peaceful virtual environment through a headworn display seemed to promote relaxation (Simon et al. 2021). Kotera Yasuhiro found that although there has been no research on VR relaxation for workers working at home, these research results showed that VR might help to keep workers working at home away from the current work environment, which might reduce the impact of blurred boundaries between work and family, and allow workers to properly recover from work and life stress during the pandemic (Yasuhiro and Correa Vione 2020). Chirissa Innocent believed that the maintenance of social distance measures limited opportunities for leisure and social activities, many people hindered or restricted contact with others, and many workers had limited opportunities to access nature in urban environments. The use of VR in this way could provide another way for all workers to "escape". The "virtual vacation" to the real world destination was even promoted as a "digital substitute" for travel, and was popular during the pandemic (Chirisa 2020). Wang Zhimin pointed out that indoor space was an important space for people's life activities, and people's requirements and expectations for indoor design were getting higher and higher. From the perspective of virtual space, interactive and dynamic design is carried out according to the requirements of indoor design, which makes the whole indoor design scheme more intuitive and flexible in the process of indoor design (Wang 2018). Zhu Dahuang proposed a new interior design based on virtual reality technology, and proved the effectiveness of the proposed interior design method through the interior decoration effect (Zhu 2019). However, according to the literature and relevant information studied so far, the mental health stress of office workers has not been discussed in detail.

In addition, research on mental health is also crucial. Tijani Bashir aimed to analyze 60 papers published between 1989 and 2020 (including years). He used the preferred reporting project of systematic review and meta-analysis to systematically review the existing knowledge system of mental health in the construction project (Bashir, Xiaohua, and Osei-Kyei 2021). Dragano Nico proposed the concept of technical pressure and possible risks and opportunities of digital technology in work and its impact on mental health (Nico and Lunau 2020). Li Yang analyzed the psychological environmental factors in office space interior design from the perspectives of design psychology and environmental behavior. He pointed out that in office space interior design, special attention should be paid to psychological environmental factors such as domain and personal space, distance and seating choice, security and orientation, and privacy and public. Combining specific design examples, he attempted to provide reference and inspiration for office space design, in order to more comprehensively reflect the people-oriented design concept (Yang and Feng 2009). Lu Jing explored three aspects that should be emphasized in the design of an open office based on the psychological feelings of workers: meeting the requirements for domain and privacy in the office space; meeting the requirements for comfort and convenience of office furniture; satisfying the requirements for fun and personalized office environments (Jing and Liang 2002). Starting from the air environment, visual environment, sound environment, electromagnetic radiation, spatial layout, and other aspects of the office, Zhang Xichao elaborated on the impact of these physical factors on workers' mental health, and proposed providing a comfortable workspace for workers to improve job satisfaction and efficiency, as well as contribute to their mental health (Xichao 2006). Therefore, this article has certain research value in elaborating on the mental health issues of office workers.

This paper first analyzed the fuzzy comprehensive evaluation method of interactive interior design based on VR, and introduced the interactive design based on VR and the interactive interior design based on VR. Secondly, the fuzzy comprehensive evaluation method was described in detail, and a fuzzy evaluation matrix was constructed. Then, on this basis, the office workers were selected to conduct a questionnaire survey and comparative experimental analysis. Finally, according to the fuzzy evaluation matrix, the fuzzy comprehensive evaluation results were described.

2. Fuzzy comprehensive evaluation method of interactive interior design based on VR

2.1. Vr-based interaction design

At present, VR technology has been widely used in the industry, among which it has been used in the performance of indoor effects (Saleh and Rong Jeffrey Neo 2020; Yanxing, Li, and Liu 2019). From the development to the present, the expression methods of interior design include manual effect expression, two-dimensional software effect expression, and three-dimensional effect expression (Abeer 2021; Bettaieb Donia, Abeer, and Raif 2022). Through the use of new technology, new interior design has been displayed. VR is a brand new interior design system. Compared with traditional manual rendering technology, its

advantage is the real size of its space (Ji Young and Suh 2019). The designers use the virtual display technology to fully display the design idea, which has the characteristics of design specialization, data science, work efficiency, human-computer interaction and other aspects. Such interior design is more effective, realistic and more intuitive.

Interaction design belongs to the category of design. It allows two or more individuals to interact with each other by defining and designing the behavior of artificial systems, so as to achieve the goal. The basic starting point of interactive design is to establish the relationship among people, things and services. It reflects the core idea of people through technology and information in a complex and changing society.

At present, VR interaction is still in the stage of exploration and research. Combined with various high-tech technologies, it brings infinite possibilities for VR interaction. Figure 1 is a summary of nine VR interaction modes (Srivastava et al. 2019; Wan, Pharmacy, and University 2019).

Industry experts believe that the development of VR in the short term still depends on the dividend of technology, and interactive technology is the key (Liu 2021). At the same time, under the condition that the hardware performance tends to be consistent, interactive technology also forms different competitive advantages. They believe that in the future, the supply of sensors would be partially solved due to the manufacturing of manufacturers. During this period, interactive suppliers with advanced algorithm technology would become increasingly important (Kim et al. 2021).

By using VR interactive technology, designers and users can enter the room at any design stage and view their works from the perspective and angle they set (Liu, Xu, and Guo 2020). Therefore, the size of the internal space can be truly realized, which is convenient for adjusting the scale and proportion in the design, testing the texture of materials, and experiencing the color and atmosphere. Compared with the plane design drawing observed on the screen, it can more intuitively and conveniently imagine the actual space effect or correct the problems in the design. VR technology is introduced into the emotional design of interior space, and a new idea of immersive VR interior design is built.

2.2. VR interactive office interior design

The relationship between interior space design and VR-based office interactive design can be explored from Figure 2.

2.2.1. Identical design objects – human behavior

On the surface, the office interior design space is aimed at human beings. However, to explore at a deeper level, based on human character, in the final analysis, it still depends on human behavior (Khafaji Ibtisam Abdulelah Mohammed and Kamaran 2019; Noorh

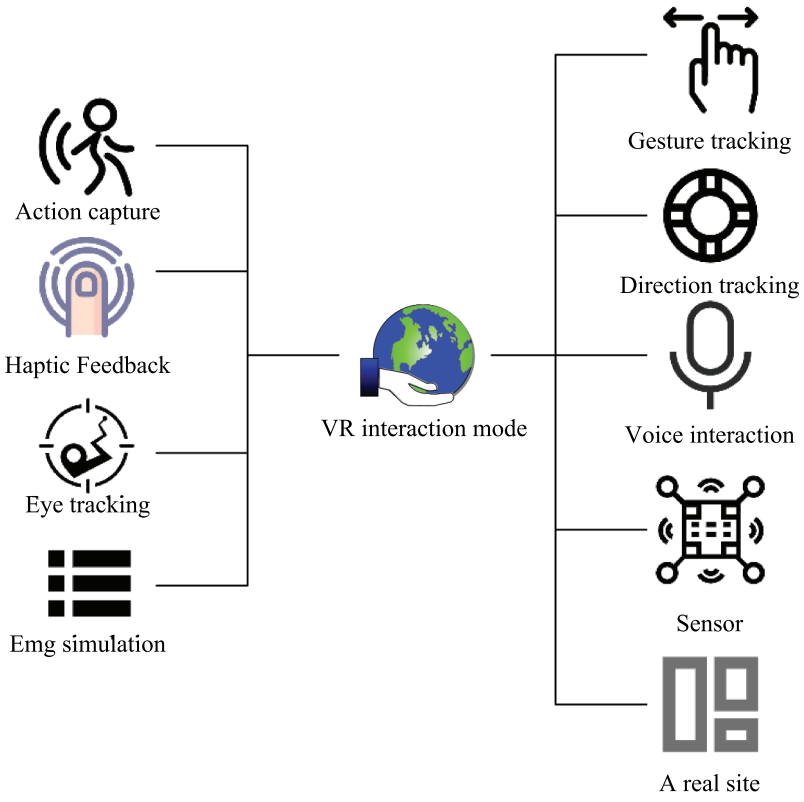

Figure 1. VR interaction mode.

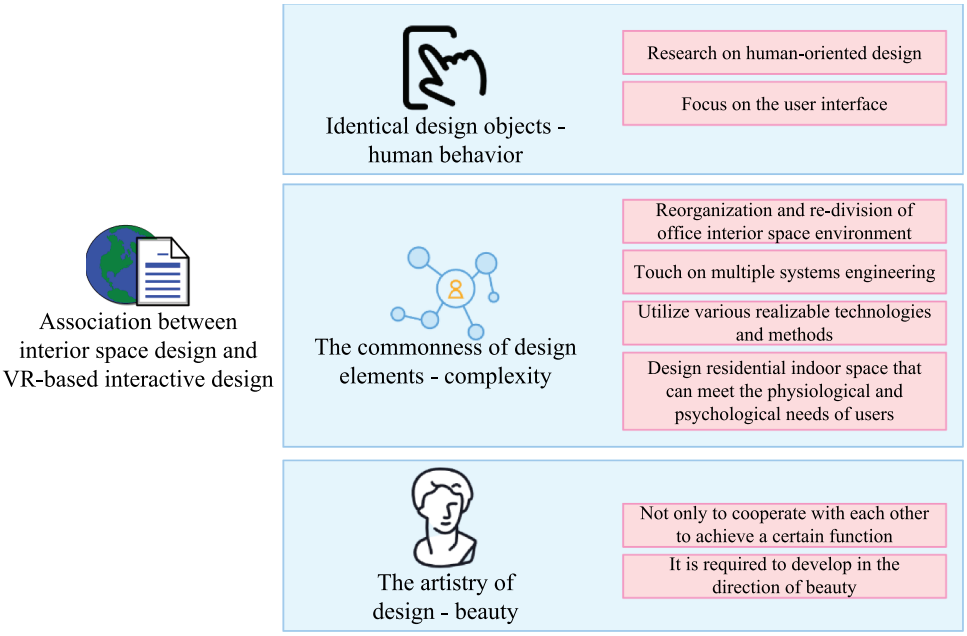

Figure 2. The relationship between interior space design and vr-based interactive design.

and Watson Zollinger 2021). Starting from human behavior, a more reasonable spatial structure can be designed. Therefore, many people began to pay attention to interactive design, that is, the influence of media. At present, both in theory and in practice, interactive design has made great breakthroughs and development. There is no doubt that people define the goal of interactive design as human behavior. Therefore, in terms of design objects, the design of internal space is the same as that of interactive design, both of which take human behavior as the basic starting point and basis, thus serving human beings.

2.2.2. commonness of design elements – complexity

Office interior design is a project involving multiple levels, and it is a project involving multiple factors, which uses a variety of technologies and means (Nathanael, Luthan, and Dwiyanto 2020, O'rmonov 2021). According to the user's living needs and the actual situation of the office, the interior space of the residence that meets the user's physiological and psychological needs is designed. Through the investigation of office space design, the following six aspects can be drawn: function, space, interface, jewelry, economy, and culture. These factors summarize the design of office space from various aspects. These factors are independent and restrict each other, fully reflecting the complexity of the office interior space design.

The designer connects five elements together through a series of means, which is a very complex process. First of all, from the perspective of design elements, the interior space design and interactive design of the office contain many factors (Yu and Ti 2020). Secondly, in the logic of matter and behavior, all factors are similar and different. Finally, these elements must coordinate with each other to meet the user's functional needs and psychological needs, which is a process that needs constant exploration (Wong and Aziz 2021).

2.2.3. Artistry of design – beauty

After the material conditions are met, people often pursue spiritual satisfaction. They cannot be simply combined to form a beauty (Ross 2022). This kind of beauty is a visual feeling that conforms to the user's aesthetics and a form of beauty that conforms to social development. Beauty is a factor considered in design, and the ultimate goal of design is to create valuable products. Its value is not only reflected in aesthetics, but also in its practicality, usability, accessibility, affordability, and sustainability (R. Liu 2020).

VR interactive design is a pursuit of beauty. With mobile phones as the carrier, from the initial appearance design and internal APP design to the current appearance and APP design, the function has been greatly improved (Huiying and Wu 2020).

VR and company culture are inextricably linked. When people work, VR technology can help them better interact with others. Enterprises use VR technology to help workers adapt to the current work environment. It can also make workers stay active, improve their focus, and help them better complete tasks (Chongsan 2019). The company can also use VR technology to communicate with workers and use it as an incentive method to improve performance.

The VR-based office also includes a social space to provide more communication opportunities for workers. For a period of time, it can provide personalized VR experience for every workers (Cordero 2019; Vrgovi et al. 2022). The design is also designed to help

enterprises improve their mental health and improve workers' mood and work efficiency to a new level.

Virtual reality technology has made remarkable breakthroughs in many fields, one of which is interior design. This technology provides a unique way for office workers to improve their indoor environment, which in turn has a positive impact on their emotional and mental health. The application of virtual reality in interior design is realized by VR headset and computer-generated simulation environment. These simulation environments can vividly simulate indoor space, including home, office, leisure space and so on. Users can immerse themselves in exploring and modifying these virtual spaces, including wall colors, furniture placement, lighting and other aspects. This interactive design process allows users to participate in their interior design in an unprecedented way.

The first is to build a virtual reality platform, including hardware and software. Hardware includes VR headset and computer high-performance graphics processing unit. Software includes virtual reality applications and modeling tools.

Designers or interior design teams need to collect data of actual space, including size, structure, furniture, etc. These data can be obtained by 3D scanners or measuring tools. Then, modeling software to transform these data can be used into 3D models in virtual reality environment.

It can also create a virtual indoor environment, including selecting various design elements such as wall color, material, furniture, light, etc., in order to visually present in the virtual environment.

Users can perceive and interact through the sensors built into the headset, and use controllers or gestures to modify elements in the virtual environment, such as adjusting the position of furniture, changing the color or lighting intensity. Virtual reality platform can usually provide real-time feedback, and users can see the effect of their design decisions in the virtual environment. Real-time feedback helps users make more informed design choices.

2.3. Fuzzy comprehensive evaluation method

Due to the complexity, heavy workload, and numerous quality evaluation indicators of interactive interior design evaluation in VR environment, it is difficult to conduct quantitative evaluation. Therefore, in this paper, a variety of commonly used multi-attribute comprehensive evaluation methods are compared in order to select the appropriate method, as shown in Figure 3.

To sum up, this paper makes a scientific and reasonable evaluation of interactive design in VR environment by using fuzzy comprehensive evaluation method (Arpit and Sharma 2020; Li, Wang, and Lei 2020). The main reasons are as follows. The first is the combination of quantitative and qualitative analysis. The expert consultation method is used to classify important data, which is a qualitative assessment. In terms of determining the weight, AHP is used, which is a quantitative evaluation method. The fuzzy comprehensive evaluation method organically combines the two, which is an organic combination of quality and quantity (Lingyan 2022; Zhiying and Lyu 2021). Secondly, the derivation process of the algorithm is both simple and reasonable. This method determines the weight of each index under the comprehensive consideration of various factors.

Thirdly, due to the lack of specific objective criteria, qualitative evaluation indicators are usually defined in

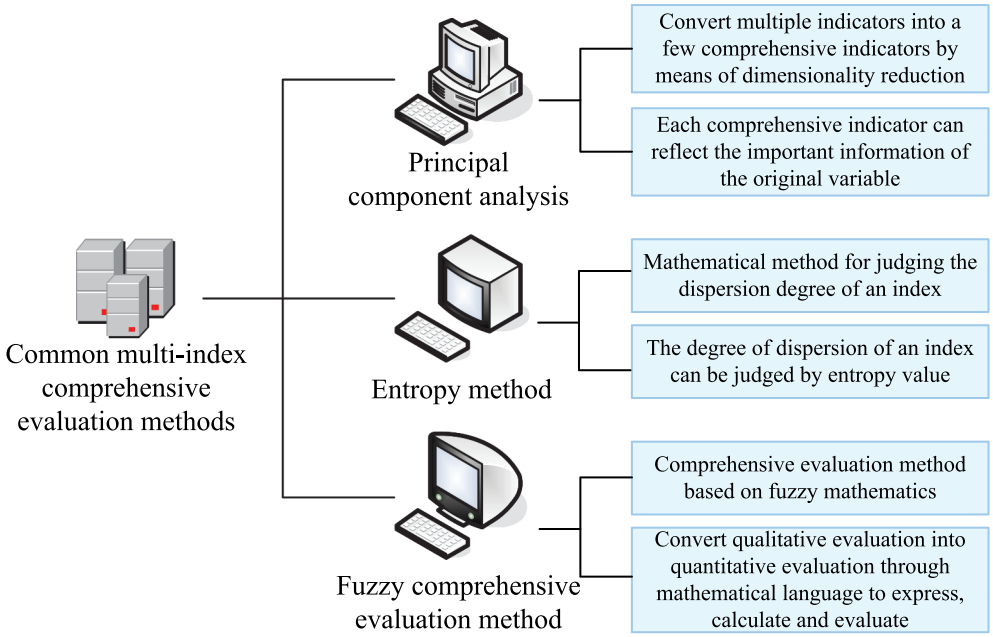

Figure 3. Common multi-indicator comprehensive evaluation methods.

fuzzy language such as "excellent, good, medium, and poor" or "high, medium, and low". Therefore, traditional evaluation methods cannot quantify it. However, it can quantify some uncertain indicators through fuzzy evaluation matrix, thus effectively solving the quantitative problem of qualitative indicators in VR interactive interior design (Min 2021; Yuanyuan, Apel, and Xu 2018).

Therefore, this paper chooses the fuzzy comprehensive evaluation method to establish the comprehensive evaluation system of interior design. In this paper, the application process and ideas of fuzzy comprehensive evaluation are summarized and sorted out, and its application is sorted out. The steps of fuzzy comprehensive evaluation method are divided into seven stages, as shown in Figure 4.

The first step is the evaluation index. The evaluation indicators are divided into the highest level, the middle level and the lowest level (Yonghong, Chen, and Tang 2021). After in-depth analysis of practical problems, the evaluation factors are decomposed layer by layer from top to bottom, without feedback and circulation. The bottom layer is the top layer. The evaluation factors are independent of each other.

The second step is weight set. The weight set reflects the importance of each indicator at its own level (Yixuan, Zhang, and Chen 2018). The data obtained by the expert consultation method is used to construct an evaluation matrix based on AHP. The AHP method is used to determine its weight value, and it is described in detail.

Construction of the judgment matrix method: In the same area, the relative scale is used to compare various elements (Xiaomei and Zuo 2020).

Calculation of weight: According to the constructed judgment matrix, the weight value and maximum characteristic root of each index are calculated. The calculation formula is listed in detail below:

$$\overline{s_{ok}} = s_{ok} \Big/ \sum_{k=1}^{m} s_{ok}(o, k = 1, 2, 3) \tag{1}$$

Secondly, the judgment matrix of Formula (1) is added by row, namely:

$$\overline{W_o} = \sum_{k=1}^{m} \overline{s_{ok}}(o, k = 1, 2, \ldots, m) \tag{2}$$

Formula (2) is sorted out to obtain:

$$\overline{W_o} = \left[\overline{W_1}, \overline{W_2}, \ldots, \overline{W_m}\right]^T \tag{3}$$

Thirdly, Formula (3) is normalized, namely:

$$\overline{s_{ok}} = s_{ok} \Big/ \sum_{k=1}^{m} s_{ok}(o, k = 1, 2, 3) \tag{4}$$

Formula (4) can be sorted out to get the weight value of each evaluation index.

Finally, the maximum characteristic root is calculated:

$$\gamma_{max} = \sum_{o=1}^{m} \frac{(SW)_o}{m * W_o}(o = 1, 2, \ldots, m) \tag{5}$$

Consistency check: The calculation formulas of indicators are:

$$\mathrm{CI} = \frac{\gamma_{\max} - \mathrm{m}}{\mathrm{m} - 1} \tag{6}$$

$$\mathrm{CR} = \mathrm{CI} \Big/ \mathrm{RI} \tag{7}$$

When CR < 0.1, the consistency of the representation decision matrix is verified.

The third step is element set. The element set is composed of the selected evaluation indicators, that is, the evaluation indicators at each level, reflecting the various levels of evaluation.

The fourth step is comment collection. Comment collection refers to the evaluation results made by the evaluator on the evaluated object, which is used to reflect the quality of the evaluated object.

The fifth step is the evaluation scale. The evaluation scale is the measure of each indicator. For the convenience of calculation, the evaluation results are digitally processed.

The sixth step is the fuzzy evaluation matrix. The fuzzy evaluation matrix R is used to express the fuzzy

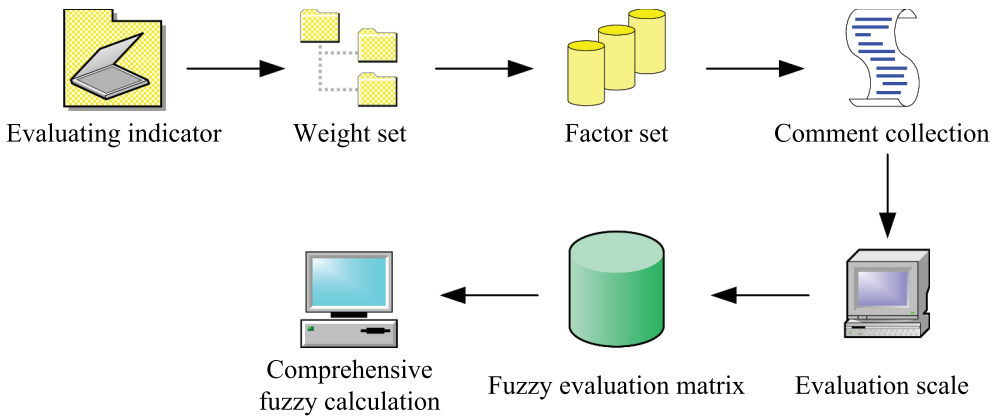

Figure 4. Steps of fuzzy comprehensive evaluation method.

relationship between the evaluation level and the evaluation factor, and it is a fuzzy mapping. By means of expert consultation and questionnaire survey, the fuzzy evaluation matrix can be obtained.

$$R = \begin{bmatrix} r_{11} & \cdots & r_{1n} \\ \vdots & \ddots & \vdots \\ r_{m1} & \cdots & r_{mn} \end{bmatrix}_{m\times n} \tag{8}$$

The seventh step is comprehensive fuzzy calculation.

$$Z = W \cdot R \cdot E^{T} = (W_1, W_2, \ldots, W_m) = \begin{bmatrix} r_{11} & \cdots & r_{1n} \\ \vdots & \ddots & \vdots \\ r_{m1} & \cdots & r_{mn} \end{bmatrix}_{m\times n} \cdot (e_1, e_2, \ldots, e_m)^{T} \tag{9}$$

According to the above formula, the comprehensive score of interactive interior design based on VR is obtained. The higher the score, the better the effect of interactive design on interior design in VR environment. On the contrary, it means that the evaluation effect is poor.

3. Experiment on the influence of interactive interior design on workers' emotional and mental health

3.1. Questionnaire

The primary component of a building is its space, which must fulfill the material needs of its occupants. Consequently, interior design significantly influences material culture and quality of life, making "space" a critical element in interior design (Patil 2018; Yin 2018). Space serves both material and spiritual functions. Technological advancements have transformed building usage, emphasizing the importance and complexity of physical functions. Meanwhile, spiritual functions stem from material needs, as well as cultural and psychological requirements. Individuals' hobbies, desires, wills, aesthetic tastes, national culture, symbols, and customs profoundly impact space utilization and image formation, thereby providing spiritual satisfaction and pleasure (Mcandrew 2018; Yarmolitska and Moskalchuk 2020). However, due to diverse and evolving aesthetic perceptions, achieving consensus on the aesthetic appeal of architectural space remains challenging, complicating the establishment of a unified standard.

This study explores the integration of VR-based interactive interior design and its effects on the mental health of office workers in Chengdu, Sichuan Province. A novel questionnaire, distinct from previous research, was administered to 80 randomly selected participants, all of whom provided valid responses. The questionnaire covered aspects such as privacy, furniture comfort and convenience, office environment appeal, and personalization, along with participants' basic information, opinions on VR, and perceptions of interior design. Using a fuzzy evaluation matrix, the study aimed to comprehensively understand participants' perspectives on virtual interior design and its impact on their mental health.

The basic information of the sample is shown in Table 1.

Table 1 shows that the gender distribution of participants was relatively balanced, with most office workers aged between 26 and 35 years. The majority held a bachelor's degree, and the largest income group had an average monthly income of 4501–6000 yuan.

Table 2 shows the relevant data for questions 1 and 2.

Table 2 indicates that 47 office workers reported poor privacy, 44 reported a poor sense of domain, and 35 noted a spatial monotonicity. Additionally, over the past 12 months, 78 office workers experienced work-related physical or mental health problems, highlighting serious mental health issues in the office environment. These findings align with existing literature on the adverse effects of inadequate workplace design on mental health (S. Y. Lee and Brand 2005).

Table 3 shows the relevant data for questions 3, 4, and 5.

Table 3 presents that most office workers consider control over their physical environment important, with only 2 respondents stating it was not critical.

Table 1. Basic information.

Essential information	Concrete content	Number of people
Gender	Male	41
	Female	39
Age	Age 25 and under	18
	26-35 years old	32
	36-50 years old	19
	Over 50 years old	11
Education level	Junior high school and below	0
	Senior high school	0
	Junior college	28
	Undergraduate course	40
	Postgraduate or above	12
Average monthly income	Below 3000 yuan	0
	3001–4500 yuan	15
	4501–6000 yuan	42
	6001–10,000 yuan	18
	More than 10,000 yuan	5

Table 2. Questions 1 and questions 2.

Problem	Option	Number of people
What elements in the room do you feel stressed? (Multiple choices are allowed)	Spatial monotonicity	35
	Poor sense of domain	44
	Poor privacy	47
	Poor air environment	25
Weak lighting environment		31
Have you experienced work-related physical or mental health problems in the past 12 months?	Yes	78
	No	2

Table 3. Questions 3, questions 4, and questions 5.

Problem	Option	Number of people
How important is it for you to control the physical environment in the work environment (such as lighting, temperature, personalization of the work space)?	Very critical	31
	More critical	29
	General critical	18
	Not critical	2
How much do you value visual stimulation and dynamic working environment?	Very meaningful	27
	Relatively meaningful	33
	Generally meaningful	17
	Not too meaningful	3
How important are sensory elements such as smell, sound and touch to your overall experience in the workplace?	Very critical	40
	Relatively critical	24
	Generally critical	16
	Nothing	0

Specifically, 31 workers found it very critical, 29 more critical, and 18 generally critical. Regarding visual stimulation and a dynamic working environment, 27 and 33 office workers found these elements very meaningful and relative meaningful, respectively. In response to the question about the importance of sensory elements such as smell, sound, and touch, 40 said these were very critical, with none saying they didn't matter.

This highlights the significant impact of controlling the physical environment, visual stimulation, a dynamic working environment, and sensory elements on most office workers. These preferences are supported by research on environmental psychology, which indicates that well-designed physical and sensory environments can significantly boost employee well-being and productivity (Vischer 2007).

Table 4 shows the relevant data for questions 6 and 7.

According to Table 4, 29 office workers reported that music, whether loud or soothing, influenced their happiness levels. 21 indicated that dull or bright images influenced their mood. Additionally, 37 felt relaxed and happy in interactive environments, while 18 preferred a quiet environment. However, 10 office workers chose a lively environment instead."These preferences highlight the diverse needs of office workers and the importance of personalized workspaces, aligning with studies on stimulating office environments (Cummings and Oldham 1997).

Table 5 shows the relevant data for questions 8 and 9.

Table 5 highlights the responses familiarity and usage of VR technology among office workers. Out of the respondents, 11 office workers frequently use VR, 37 have used it in other contexts, and 32 have never used it. When asked about preferred areas for VR application in daily life, the top choices were the office (46 responses), social contact (41), gaming (34), shopping (27), traffic (20), and study (18). This indicates

Table 4. Questions 6 and questions 7.

Problem	Option	Number of people
What sound/smell/touch/vision/taste make you happy or unhappy in the office?	Loud or soothing music	29
	A pungent or fragrant smell	16
	A dull or bright image	21
	Bitter or sweet taste	14
What kind of things or circumstances will make you feel relaxed and happy?	Space with appropriate temperature	15
	Quiet environment	18
	A lively environment	10
	Interactive environment	37

Table 5. Questions 8 and questions 9.

Problem	Option	Number of people
Have you used VR before?	Frequent use	11
	Used elsewhere	37
	Never used	32
What areas do you want VR to be applied in daily life? (Multiple choices are allowed)	Game	34
	Shopping	27
	Social Contact	41
	Study	18
	Traffic	20
	Office	46

Table 6. Questions 10 and questions 11.

Problem	Option	Number of people
Do you know the combination of office interior design and VR interactive design?	Quite understanding	18
	Know Of	40
	Not very clear	22
What do you think are the functional defects of the existing interior design VR interactive design products? (Multiple choices are allowed)	Few interactive function options	31
	Smaller optional area	44
	Difficult technical operation	25
	Poor performance	39
	Other	10

a strong interest in integrating VR into daily office environments, suggesting potential for VR to enhance productivity and satisfaction (Jerald 2015).

Table 6 shows the relevant data for questions 10 and 11.

Table 6 assesses the office workers understanding of the combination of office interior design and VR interactive design, as well as perceived functional defects of current VR products, were assessed. 18 respondents reported a comprehensive understanding, 40 were aware of it, and 22 had limited knowledge. Regarding functional defects, the main concerns were smaller optional areas (44 responses), poor performance (39), few interactive function options (31), and difficult technical operations (25). These findings indicate that office workers have varying levels of familiarity with VR interior design, influenced by their daily experiences and cultural backgrounds. This range of opinions provides valuable insights for the study.

Overall, the survey data reveal that many office workers have experienced work-related physical or mental health issues, highlighting the significant impact of the physical and sensory environment on their satisfaction and well-being. The findings demonstrate a strong interest in using virtual reality (VR) technology to improve office environments. However, current VR products have notable limitations, including smaller optional areas, poor performance, limited interactive functions, and technical difficulties, which raise concerns and suggest areas for improvement. Despite these challenges, the potential benefits of incorporating VR into office design, such as enhanced employee well-being and work efficiency, are evident. While VR design may not meet every individual's preferences, this study aims to address the needs of the majority, emphasizing the importance of well-designed workspaces and the role of advanced technologies in creating better work environments.

3.2. Comparative experiment

Based on the results of the questionnaire, this study aimed to assess the impact of VR glasses on facilitating an interactive office experience for office workers. The experimental group consisted of 10 office workers who had previously experienced work-related physical or mental health issues and used VR glasses for the interactive office experience. The control group, comprising another 10 office workers, did not use VR glasses and maintained their normal work conditions. All 20 participants had substantial office experience, with more than three years in their roles, and had encountered various mental health challenges due to their work. This selection ensured a representative sample and reliable experimental data. The participants were randomly chosen from a pool of 80 office workers who had completed the initial questionnaire.

Emotional stability was assessed on a 10-point scale: scores of 9–10 indicated very stable, 6–8 generally stable, 4–7 not very stable, and 0–3 very unstable. During the VR experience, participants received 1 point for each factor encountered that caused stress or happiness, and 1 point for each factor causing stress or fatigue. The total score was then calculated and categorized into the corresponding stability grades.

Figure 5 surveys the emotional stability of the two groups before and after the experiment.

In Figure 5(a), the control group saw a decrease in the number of participants categorized as "very stable", and a slight decline in those categorized as "general stability". Conversely, the number of participants classified as "not very stable" increased, suggesting a shift towards less stable emotional states. The number of participants categorized as "very unstable" decreased to 0, indicating a positive impact.

In Figure 5(b), the experimental group exhibited a notable improvement in emotional stability. The number of participants categorized as "very stable" increased significantly, and those categorized as "general stability" also rose. Additionally, the number of participants classified as "not very stable" and "very unstable" decreased to 0, highlighting a strong positive effect of the experimental condition on participants' emotional stability.

The results indicate that the experiment was more successful in improving the emotional stability of participants in the experimental group compared to the control group, highlighting the effectiveness of the intervention used in the experimental setting.

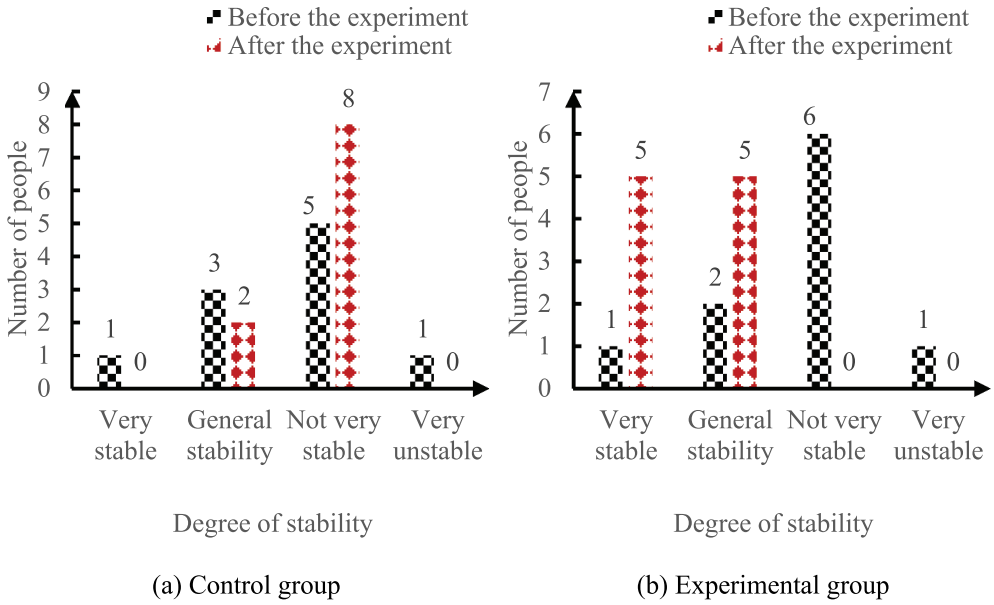

Figure 5. Changes in emotional stability of the two groups at work before and after the experiment. (a) Control group, (b) experimental group.

Figure 6 surveys the changes of mental health data before and after the experiment.

Figure 6(a) shows that, in the control group, none of the participants were very healthy before or after the experiment, and there was a slight decrease in those with general health. However, there was a modest improvement in the number of relatively healthy participants, suggesting some positive impact of the control condition on mental health.

Figure 6(b) illustrates that, in the experimental group, There was a significant reduction in the number of unhealthy participants, with none remaining unhealthy after the experiment. Additionally, there was a substantial increase in the number of relatively healthy and very healthy participants, coupled with a significant decrease in those with general health. This indicates a strong positive impact of the experimental condition on mental health, with many participants moving from unhealthy and general health categories to relatively healthy and very healthy categories.

The experiment was notably more effective in enhancing the mental health of participants in the experimental group than those in the control group, illustrating the success of the intervention implemented under the experimental conditions.

Table 7 presents the satisfaction degree of office workers in the experimental group with the VR indoor environment in this experiment.

Table 7 indicates that in the experimental group, A significant portion of office workers, 19 out of 40 (47.50%), reported being very satisfied with the VR indoor environment. This indicates a high level of approval among nearly half of the participants, 15

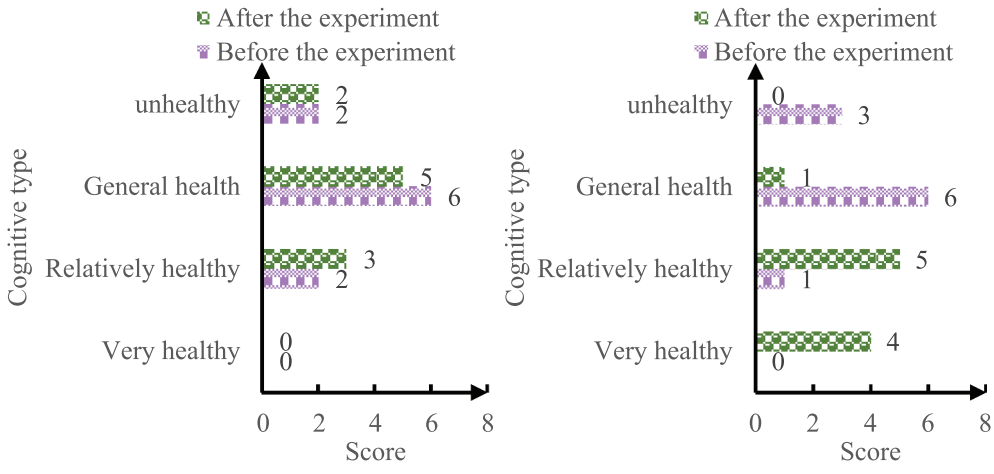

Figure 6. Changes of mental health data before and after the experiment. (a) Control group data, (b) experimental group data.

Table 7. Workers' satisfaction.

Satisfaction	Number of people	Percentage
Very satisfied	19	47.50%
Relatively satisfied	15	37.50%
Generally satisfied	5	12.50%
Not very satisfied	1	2.50%
Very dissatisfied	0	0.00%

Table 8. Fuzzy comprehensive evaluation results.

Index	Score
Mental health	81.94
Emotional cognition	83.18
Perceptual cognition	84.75
Somatic cognition	86.86

workers (37.50%) were relatively satisfied, 5 workers (12.50%) expressed generally satisfied. Only 1 workers (2.50%) expressed that they were not very satisfied, suggesting minimal dissatisfaction within the group. There were no workers who reported being very dissatisfied (0%), indicating that the VR indoor environment did not evoke strong negative reactions.

The data from Table 7 reveals that the majority of office workers in the experimental group were satisfied with the VR indoor environment. Specifically, 85% of participants reported being either very satisfied or relatively satisfied. This high level of satisfaction suggests that the VR indoor environment was well-received by most participants. The absence of any very dissatisfied responses further supports the positive reception of the VR environment. Therefore, the VR indoor environment can be considered effective in enhancing the satisfaction of office workers in the experimental group.

Table 8 shows the results of fuzzy comprehensive evaluation.

The fuzzy comprehensive evaluation results in Table 8 indicate that the participants scored highly across all measured indices. Mental health, emotional cognition, perceptual cognition, and somatic cognition all received scores above 80, with somatic cognition scoring the highest at 86.86. These results suggest that the intervention was effective in enhancing various aspects of cognitive and emotional functioning. The high scores across all indices imply a comprehensive improvement in the participants' mental and cognitive health, demonstrating the overall efficacy of the intervention.

In summary, the experimental group demonstrated superior effectiveness in enhancing emotional stability and mental health compared to the control group. The positive reception of the VR environment among participants and the high evaluation scores across various indices collectively highlight the success of the intervention in improving both cognitive and emotional well-being.

4. Discussion

In contemporary society, the rapid pace of work and life has significantly impacted the emotional and mental well-being of office workers (Jones and Roberts 2021; Smith, Johnson, and Lee 2020). The work environment plays a crucial role in shaping mental health, as poor conditions can exacerbate stress and anxiety [56]. This study analyzes the impact of interactive interior design based on virtual reality on the emotional and mental health of office workers, and explores its potential benefits and application prospects.

The study employed a comparative experimental design, utilizing questionnaire data to assess the impact of VR-based interactive environments. Participants in the experimental group used VR glasses to experience an interactive office setting, resulting in notable improvements in emotional stability and mental health, as compared to the control group. The experimental group reported positive feedback on their VR experience, with the final fuzzy comprehensive evaluation reflecting a satisfactory outcome. These findings suggest that VR technology can enhance workplace conditions, alleviate stress and anxiety, and contribute to a safer and more engaging work environment. This underscores the value of integrating advanced technologies like VR to foster emotionally supportive office spaces (S. Lee, Kim, and Park 2022; Zhang and Wang 2023).

5. Conclusions

This paper examined the impact of VR-based interactive interior design on the emotions and mental health of office workers. The results demonstrate that this technology significantly improves emotions, reduces stress, enhances work efficiency and creativity, and boosts mental health and happiness. VR technology allows office workers to personalize their work environment, increasing their sense of control and satisfaction, which in turn improves their emotions and reduces work pressure. This immersive virtual environment effectively minimizes external distractions, promotes creative thinking, and enhances work efficiency. Moreover, the inclusion of natural elements and leisure spaces in virtual environments helps alleviate anxiety, depression, and other negative emotions, improving mental health and quality of life. Interactive design in virtual environments benefits not only personal development but also social interaction and teamwork, enhancing team cohesion and collaboration.

Moreover, the findings have broader implications for achieving United Nations Sustainable Development Goal 3 (UN SDG 3), which aims to ensure healthy lives and promote well-being for all at all ages. UN SDG 3 targets include reducing mortality rates, combating diseases,

and improving mental health through innovative and inclusive solutions. By enhancing workplace environments, VR technology can contribute to these global health goals, supporting overall well-being and productivity.

These results underscore the significance of incorporating VR in office design to foster a healthier and more productive work environment, thereby contributing to the broader objectives of global health and well-being.However, this study has limitations, as it does not explore the integration of interactive interior design with practical work environments. Future research should investigate the feasibility and long-term effects of VR in work environment design to further optimize modern workspaces.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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