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Emotional Space Design Research Based on Bibliometric

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ABSTRACT

Environmental psychology research and the emotional design boom have led to a series of theoretical studies and practical activities on emotional design in space. To further research and practice emotional space design, this study uses bibliometric and review methods to visualise and analyse data from the literature on emotional space design to understand its development trends. The literature was sourced entirely from the Web of Science (WoS), and two bibliometric tools, VOSviewer and CiteSpace were used to obtain critical data and visual images on this research topic. According to the results of the analysis, the research in this field is currently at a rapid development stage; the United States, England, China, Australia, and Canada are the major research countries in this field; Cornell University, the University of Leeds, UCL and other institutions with a strong reputation in architecture and design-related disciplines are the leading research institutions in emotional space design; the core journals in the field of environmental science and engineering include most of the literature on emotional space design. The keywords form four clusters named #1 Affective Space Design; #2 Healthcare; #3 Virtual; and #4 Design Evaluation, and in terms of trends, future research in Affective Space Design will focus on Virtual Environment, Healthcare, Differences, Sustainable design, Hot social topics, Interdisciplinary as well as User Spatial Experience and Affective Response. Finally, the analysis of high-frequency co-citations shows that the essential theoretical support for emotional space design comes mainly from environmental psychology, psychology, and colour psychology research. Evidence-based healthcare design is a hotspot for research on emotional space design.

Keywords: Emotional space design, Bibliometric, VOSviewer, CiteSpace

INTRODUCTION

Modern human life is already inseparable from the artificial environment provided by buildings as distinct from nature, and our physical, psychological, and social consciousness is constantly influenced by these architectural spaces (Higuera-Trujillo et al., 2021). When spaces are given emotional elements, users' behaviour and experiences are enriched as a result, and this study of psychological responses related to the environment is known as environmental psychology or architectural psychology (Kaplan and Kaplan, 1989). It has been shown that the environment in a specific space impacts cognitive emotions. For example, open classroom spaces positively affect academic performance for students with self-regulatory skills

(Ahrentzen and Evans, 1984); patients living in hospital wards with no relaxing outdoor green space outside their windows recover relatively poorly (Ulrich, 1984).

Emotion is an affective process that incorporates both physical and conscious feedback, and our subconscious impulses to consume will be influenced by changes in emotion, meaning that in addition to the product's function, users will pay for the emotional experience it conveys (Jensen, 1999). In the past thirty years, designers have been inspired by the connection between emotion, products and users and have gradually shifted the critical entry point for developing new designs from function to emotion (Schmitt, 1999). At the same time, more and more scholars are focusing on the impact of emotion on the user experience and are conducting systematic research. Emotional Design has become a hot topic in the design field (Dazkir and Read, 2011).

Environmental psychology research and the emotional design boom have led to a series of theoretical studies and practical activities on emotional design in space. It includes interior design, architecture design, display design, and other space planning and design work. Under the influence of both industry trends and its characteristics, emotional space design will have far-reaching economic, social, and personal benefits (Li, 2019). Bibliometrics and reviews can effectively learn about the trends in emotional space design, thereby allowing for in-depth research and practice. The current review of research on emotional space design is few and lacks comprehensiveness. The available studies rarely use quantitative analysis and mainly focus on qualitative analysis. Quantitative analysis allows for the inclusion of a significant amount of relevant literature in a particular field to compensate for the incomplete sample that occurs in qualitative research due to the limited effort of the researchers. Therefore, this paper will use VOSviewer and CiteSpace, two bibliometric visualisation data analysis software, as research tools to quantitatively analyse the retrieved data to obtain the status of research and to predict its future research direction, to provide a reference for future research and practice.

DATA SOURCE AND RESEARCH METHODS

Web of Science (WoS) as one of the most authoritative academic databases, it contains various information in different disciplines, including abstracts (Meho and Yang, 2007). Therefore, WoS will be used as the source of all data in this paper.

Select Science Citation Index Expanded (SCI Expanded), Social Science Citation Index (SSCI), and Arts Humanities Citation Index (AHCI) from the WOS core databases as the literature search source and enter TS= ((emotion OR affective) AND (space design OR interior design OR landscape architecture)) in the Advanced Search Formulas Generator and set the search period to the entire year, i.e., 1991 - May 2023, resulting in 1146 documents. After eliminating missing fields, duplicates, and articles irrelevant to the selected topic, 629 valid pieces of literature were obtained.

This study uses VOSviewer (Version 1.6.19) and CiteSpace (Version 5.6.R3), two bibliometric tools are Java-based software for visualising information and have recently been widely used for bibliometric analysis. VOSviewer can extract publication authorship and other critical information and graphically represent this data to clearly show their correlation (Van Eck and Waltman, 2010). CiteSpace is primarily used to learn about trends in citation hotspots in a particular area of research (Chen, 2006).

BIBLIOMETRIC RESULTS AND ANALYSIS

Analysis of Annual Output Trends of Publications

Statistics and analysis of the development of the volume of academic literature over time can provide a valuable assessment of trends in the field of study. Excluding the 29 publications from 2023, the 600 publications related to emotional space design are summarised in Figure 1, which shows a general upward trend in this research area. 1991–2008 was the initial stage of emotional space design research, with a slow growth rate and no more than ten publications/per year. 2009–2016 was the development stage, with a steady increase in literature output. 2017–2022 is the maturity stage of emotional space design. With a rapid rise in literature output, the average annual literature output reached 70 publications/year, and in 2022, the literature publication reached 112 publications. There is no downward trend in the literature publication at this study stage, and it does not show a peak for the time being.

Analysis of Countries and Institutions Contributing to the Publications

By analysing the countries and institutions of academic publications, it is adequate to infer who has an essential status in the field of study (Liang et al., 2018). Table 1 shows the top five countries in terms of the number of publications on emotional space design, i.e., USA (115), England (98), China (89), Australia (47), and Canada (35). From 1991 to 2022, 65 countries

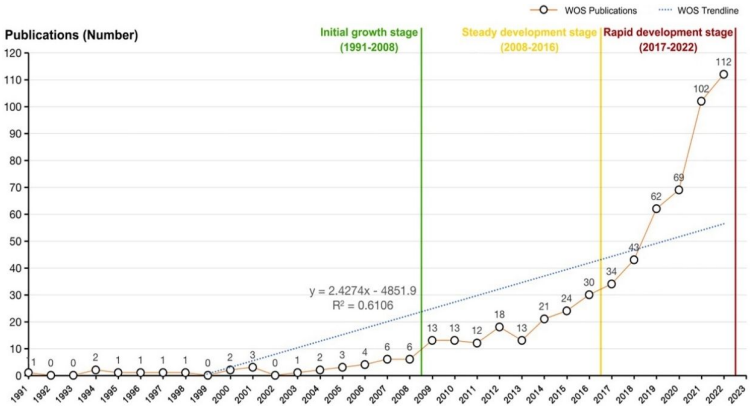

Figure 1: Annual output of publications on emotional space design.

Table 1. Main countries of emotional space design publications.

No.	Country	Publications	Citations
01	USA	115	1676
02	England	98	2405
03	China	89	431
04	Australia	47	922
05	Canada	35	619

Table 2. Main institutions of emotional space design publications.

No.	Institution	Publications	Citations
01	Cornell University (USA)	9	63
01	University of Leeds (England)	9	184
01	Polytechnic University of Valencia (Spain)	9	195
04	UCL (England)	8	355
04	University of British Columbia (Canada)	8	140
06	Eindhoven University of Technology (Netherlands)	7	74
06	Hanyang University (Korea)	7	77
06	University of Melbourne (Australia)	7	50
09	Deakin University (Australia)	6	79
09	Politecnico di Milano (Italy)	6	30
09	University of Sheffield (England)	6	294

published academic papers in this field. A network of national collaborations over the last thirty-one years, with the USA, England, and China at the core.

Table 2 shows the top ten institutions in terms of the number of publications on emotional space design, which are Cornell University (9), University of Leeds (9), Polytechnic University of Valencia (9), UCL (8), University of British Columbia (8), Eindhoven University of Technology (7), Hanyang University (7), University of Melbourne (7), Deakin University (6), Politecnico di Milano (6) and University of Sheffield (6). From 1991 to 2022, 792 organisations published academic papers related to this field. According to the disciplinary distribution, the dominant institutions in architecture and design-related disciplines are the main research contributors.

Analysis of Journals of Publications

The research frontier in a particular field can be reflected by the journals in which it is published (Tan and Hao, 2022). Table 3 shows the top ten publications of journals on emotional space design, its publishers, and their impact factors (IF) over five years. *International Journal of environmental research and public health, Sustainability and Building and Environment* are core journals in the field of environmental science and engineering, with a high number of publications ($\geq$20) and an impact factor (IF) of over 4.00, which shows the importance of emotional space design in this field of research.

Table 3. Main journals of emotional space design publications.

No.	Journal	Publications	Publisher	IF 5-year
01	International journal of environmental research and public health	26	MDPI	4.799
02	Color research and application	22	WILEY	1.606
02	Sustainability	22	WILEY	4.089
04	Building and environment	20	ELSEVIER	7.503
05	Frontiers in psychology	19	FRONTIERS	4.426
06	Herd-health environments research & design journal	15	SAGE	3.233
07	Urban forestry & urban greening	14	ELSEVIER	6.463
08	Buildings	11	MDPI	3.354
09	Landscape and urban planning	10	ELSEVIER	9.409
10	Interiors-design architecture culture	9	TAYLOR & FRANCIS	/

Analysis of Research Hotspots From the Literature

Keywords are usually an overview of the author's research outcomes, so by analysing the keywords that repeatedly appear in the literature, it is helpful to infer and summarise the research hotspots in emotional space design. Running VOSviewer, and importing 629 literature into it, showed that it contained 3181 keywords. The co-occurrence frequency was set to 4 to ensure the quality of the mapping. Finally, 204 keywords were obtained by merging synonyms. As shown in Figure 2, the keywords form four clusters, named #1 Affective Space Design; #2 Healthcare; #3 Virtual; and #4 Design Evaluation, based on the primary keyword information in each cluster.

By analysing the content of each cluster shown in the keyword clustering map: Cluster #1, Affective Space Design, has 52 items with the main keywords: Design, Space, Affect, and Affective Atmospheres. The content of

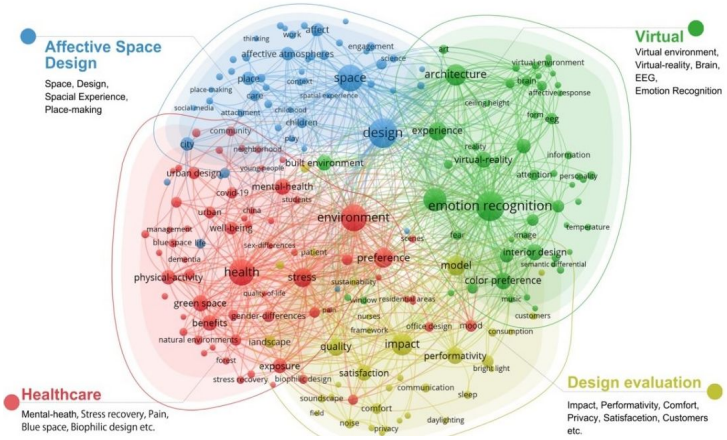

Figure 2: Keyword cluster mapping.

this cluster is directly and explicitly related to the research theme of emotional space design, which analyses the theoretical and practical application of emotional design in architectural spaces and how it contributes to the affective atmosphere and spatial experience in spaces. The co-occurrence of Children and Childhood in the clusters reflects scholars' concern for groups of children in emotional spaces and presents an inclusive perspective. Cluster #2, Healthcare, has 63 items with the main keywords: Health, Benefits, Mental Health, Stress, Well-being, Stress recovery. This cluster was born around the healthcare theme, and environmental psychology research has confirmed that human health can be stimulated and influenced by the surrounding architecture (Evans and McCoy, 1998). More and more healthcare environments are attempting to alleviate patients' psychological stress and anxiety through emotional design to achieve greater patient satisfaction and promote physical recovery (Schweitzer et al., 2004). Cluster #3, Virtual, has 54 items with the main keywords: Virtual Environment, Virtual-reality, Emotion Recognition, Brain, EEG. According to these keywords, scholars no longer limit their definition of environmental space to physical space but have developed research into emotional design and the emotional perception of the user's experience in virtual environments, the emergence of which is inseparable from technological developments. Virtual space design can be used in various contexts depending on its purpose, including exhibition areas (e.g., museums), game scenes, historical event recreations, and animations, etc. (Barab et al., 2007). Cluster #4, Design Evaluation, has 35 items with the main keywords: Impact, Satisfaction, Consumption, Quality, Comfort. This cluster focuses on design evaluation studies of emotive space design. Designers should consider meeting the requirements of future users and other people involved for practicality and satisfaction as a design criterion (Verschuren and Hartog, 2005). The conduct of design evaluation programs is seen as an effective way of moving towards more formal design theory and methods (Chandrasekaran, 1989).

Research Hotspots Evolution and Future Frontier Trends

Statistics and analysis of the average time of occurrence of keywords can provide further insight into the cutting-edge themes of today's emotional space design research and predict its future trends. According to the keyword time mapping in Figure 3, the keywords in 2016–2017 are concentrated in Cluster #1 Affective Space Design and Cluster #4 Design Evaluation, with the main keywords appearing in Affect, interior design, and Bright Light. Daylight, Office Design, the research direction of emotional space design during this period is relatively homogeneous, except for the fundamental theoretical research, which is based on the traditional design direction and essential design elements in interior design. During 2017-2019, the main keywords that emerged were Emotion recognition, quality, Landscape, city, architecture, performative, Space, and Urban Design. Design evaluation is also a popular research theme in this period. In 2019-2021, the main keywords that appeared included Sex-difference, Health, Mental health, Virtual environment, Virtual reality, Covid-19, and Sustainability. In

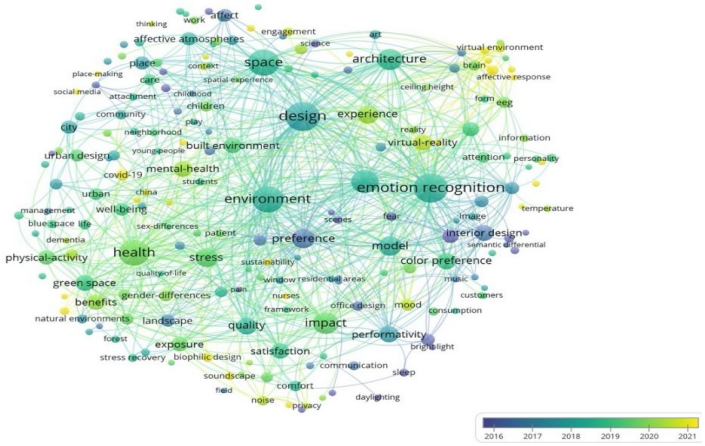

Figure 3: Keyword time mapping.

this phase, emotional space design intersected with other disciplines (VR, psychology, Sex-difference, etc.). Combining theoretical knowledge from different fields will allow designers to generate new, more creative ideas (Chesbrough, 2003).

Figure 4 lists the Top 30 Keywords with the Strongest Citation Bursts generated by Citespace, with the years in which the keywords appear prominently highlighted in red. According to the ranking, the research hotspots can be divided into three stages. In terms of the changing trends of keywords in these three periods: in the first stage, the research content of emotional space design was mainly focused on the fundamental theories derived from environmental psychology; In the second stage, the emergence of the critical words Interior design, Architecture, Park, City, and Green space, shows that practical work has become the focus of research into emotional space design; In the third stage, the content of emotional space design studies is combined with research hotspots such as Education, Attention, Hospital, Recovery, Restoration, and Social Issues (Sex difference, Exposure). Diversity and multi-disciplinarity characterise the content of this phase of research.

A comprehensive analysis of the keyword time mapping and Burst Term shows that the trend of keyword hotspots is consistent in the two graphs. The main keywords in the time mapping with an average occurrence time after 2021 are Virtual Environment, Sustainability, Social media, Biophilic design, Covid19, China, and Affective Response. The keywords that appear with Burst Term in the last three years and continue to appear until 2021 are Hospital, View, Sex difference, China, Exposure, Engagement, and Neuro-architecture. Therefore, future research in emotional space design is predicted will focus on Virtual Environment, Healthcare, Difference, Sustainable design, and the interdisciplinary intersection with topical social issues and research areas. The research content will be more detailed and adapted to the space's purpose and the user group's characteristics while creating a good space experience. Affective Responses for the user will continue to be a trend in future research.

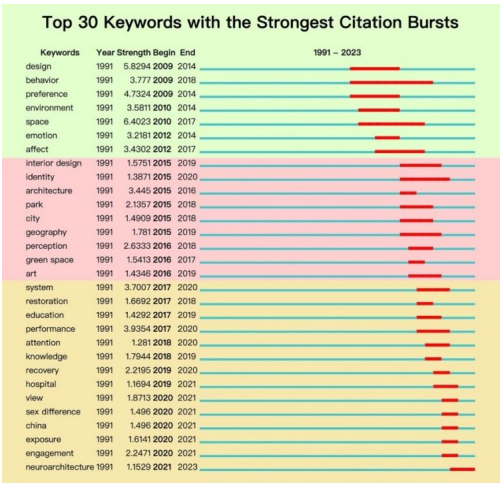

Figure 4: Top 30 keywords with the strongest citation bursts.

Analysis of Reference Co-Citations

VOSviewer showed that 29,862 valid references from 21,698 scholars were cited in the 629 literature in the search. Different studies have cited some references simultaneously and have formed a co-citation relationship. Analysis of the repeatedly co-cited references can effectively infer the underlying theoretical support for studying emotional space design and its evolution.

Table 4 shows the top ten literature in terms of reference co-citations, in which four of them were cited more than 30 times in total: *An approach to environmental psychology* (Mehrabian and Russell, 1974), *Stress recovery during exposure to natural and urban environments* (Ulrich et al., 1991), *The experience of nature: A psychological perspective* (Kaplan and Kaplan, 1989), and *The restorative benefits of nature: Toward an integrative framework* (Kaplan, 1995), they are all classic studies in the field of environmental psychology. The foundational theory of Emotional Space Design is based on environmental psychology. Environmental psychology is the scientific study based on the interaction between human behaviour and its environmental context, and it has contributed significantly to the development of the discipline of environment design and planning (architecture, urban design, landscape architecture, regional planning) (CRAIK, 1973). There is a close link between environmental space and the behavioural and psychological well-being of users, which is the main driving force behind the integration of emotional design into architectural spaces. *Servicescapes: The Impact of Physical Surroundings on Customers and Employee* (Bitner, 1992) is based on environmental psychology and further explores the impact of the physical environment on client and employee behaviour.

The measurement of meaning (Osgood et al., 1957), *core affect, and the psychological construction of emotion* (Russell, 2003) are classic literature in psychological research. Psychology is also the theory underlying the design of

Table 4. High frequency co-citation references.

No.	Literature	Author	Year	Citations
01	An approach to environmental psychology	Mehrabian, Albert Russell, James A.	1974	42
02	Stress recovery during exposure to natural and urban environments	Roger S. Ulrich, Robert F. Simons, etc.	1991	40
03	The experience of nature: A psychological perspective	Rachel Kaplan, Stephen Kaplan	1989	32
03	The restorative benefits of nature: Toward an integrative framework	Stephen Kaplan	1995	32
05	View Through a Window May Influence Recovery from Surgery	Roger S. Ulrich	1984	29
06	Core affect and the psychological construction of emotion	Russell, James A.	1980	20
06	A review of the research literature on evidence-based healthcare design	Roger S. Ulrich, Zimring Craig, Xuemei Zhu, etc.	2008	20
08	Servicescapes: The Impact of Physical Surroundings on Customers and Employee	Mary Jo Bitner	1992	18
09	Tracking restoration in natural and urban field settings	Terry Hartig, Gary W Evans, Larry D Jamner etc.	2003	17
09	The measurement of meaning	CE Osgood, GJ Suci, PH Tannenbaum	1957	17
09	A study of colour emotion and colour preference. Part I: Colour emotions for single colours	Li-Chen Ou, M. Ronnier Luo, etc.	2004	17

emotional spaces, which can provide a basis for understanding user needs and design evaluation. *A study of colour emotion and colour preference. Part I: Colour emotions for single colours* (Ou et al., 2004) systematically studies the link between colour and emotion. Colour is intuitive and emotional, different users will have utterly other colour preferences, and colour also affects the mood of the user, which needs to be considered in any interior design scheme (Haller, 2017). Therefore, the psychology of colour has become one of the foundational theories of emotional space design.

View Through a Window May Influence Recovery from Surgery (Ulrich, 1984), *A review of the research literature on evidence-based healthcare design* (Ulrich et al., 2008), and *Tracking restoration in natural and urban field settings* (Hartig et al., 2003) are classic literature in evidence-based healthcare design. Together they explore the connections between healthcare outcomes and the environment. Roger S. Ulrich is the most cited researcher in evidence-based healthcare design internationally. He has improved patients' health worldwide through the design of hospital construction.

In summary, the theoretical support for the foundations of emotional space design comes mainly from research in environmental psychology, psychology, and colour psychology. Evidence-based healthcare design research repeatedly appears in references to emotional space design and is a current research hotspot.

CONCLUSION

The output of literature on emotional space design has been on a continuous rise, with 112 papers published in 2022, and there is no downward trend in the production of literature at this stage of research, so it is judged that research in this field is in a phase of rapid development. A network of international collaborations in this field has been formed between the USA, England, and China; Cornell University, the University of Leeds, UCL, Politecnico di Milano, and the University of Sheffield are the central institutions for research in architecture and design-related disciplines. The core journals in the field of environmental science and engineering include most of the literature on emotional space design, it shows the importance of emotional space design in this area of research.

The current research themes in emotional space design form four distinct clusters, summarising their characteristics as #1 Affective Space Design; #2 Healthcare; #3 Virtual; and #4 Design Evaluation. Regarding trends, future research in emotional space design will focus on Virtual Environment, Healthcare, Difference, Sustainable design, topical social issues, interdisciplinarity, user experience, and Affective Responses.

The analysis of high-frequency reference co-citations shows that the underlying theoretical support for emotional space design comes mainly from environmental psychology, psychology, and colour psychology research. Evidence-based healthcare design research often appears in the references and is a hot spot for research on emotional space design.

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