

# International Research Developments and Trend Analysis of User Information Behavior in Augmented Reality Environments: Postprint

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## Abstract

[Purpose/Significance] As an emerging information technology, Augmented Reality (AR) technology possesses substantial research and development potential. International research on user information behavior in augmented reality environments holds significant theoretical and practical value for advancing China's augmented reality industry and guiding the library and information science (LIS) discipline in conducting related research.

[Method/Process] Based on bibliometric and knowledge graph methodologies, this study analyzes the origins and developmental trajectories of international research progress on user information behavior in augmented reality environments, performs knowledge graph analysis of research hotspots, and provides insights and analysis on future research trends in the LIS field.

[Results/Conclusion] Research on user information behavior in augmented reality environments is currently in a rapid development phase. The information behaviors encompassed by research hotspots include information adoption behavior, information acceptance behavior, and information interaction behavior. Future research in the LIS field within augmented reality environments can be analyzed from three domains: user interaction experience based on different scenarios, application of augmented reality in library construction, and innovation of augmented reality in book reading methods.

## Full Text

### International Research Trends and Development in User Information Behavior in Augmented Reality Environments

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**Abstract:**

[Purpose/Significance] As an emerging information technology, augmented reality (AR) holds substantial potential for research and development. International research on user information behavior in AR environments is of significant theoretical and practical value for advancing China's AR industry and guiding related studies in library and information science. [Method/Process] Based on bibliometric and knowledge mapping methods, this paper analyzes the origins and developmental trajectory of international research on user information behavior in AR environments, examines research hotspots through knowledge mapping, and provides insights into future trends for the library and information science field. [Result/Conclusion] Research on user information behavior in AR environments is experiencing rapid growth, with hotspots focusing on information adoption behavior, information acceptance behavior, and information interaction behavior. Future research in library and information science can be pursued in three key areas: user interaction experiences across different scenarios, AR applications in library construction, and innovations in reading methods through AR technology.

**Keywords:** augmented reality; user; information behavior; research trends; development trends

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Augmented reality (AR) is a technology that combines computer-generated images with real-world scenes to enable real-time user interaction [1], thereby enhancing users' perception and understanding of reality. Due to its substantial development potential, AR has been designated as a key technology in the smart manufacturing core information equipment sector of China's "Made in China 2025" initiative [2]. Benefiting from rapid advances in related technologies, the number of AR applications has grown significantly in recent years [3], particularly in education [4], entertainment [5], and healthcare [6]. Consequently, research on user information behavior in AR environments has emerged as a new challenge in human-computer interaction development.

Current international reviews of AR user research have primarily focused on statistical analyses of subject characteristics and experimental methods in specific application domains [4], with relatively few studies analyzing the information behaviors involved. In this novel AR context, how do the characteristics and patterns of user information behavior differ from traditional environments? This question holds important research value for improving interactive experiences and fostering industrial innovation in interaction technology. This study addresses three research questions: (1) systematically reviewing and analyzing the origins and development status of user information behavior research in AR environments; (2) summarizing recent research hotspots in this area; and (3) using knowledge mapping tools to analyze future research trends. Based on

a review of relevant international literature, this paper employs CiteSpace to create knowledge maps for visual analysis of research hotspots and trends, providing references for domestic researchers adopting AR technology and pursuing interaction innovation.

## 2. Research Methods and Sample Selection

This study selected the Web of Science's Science Citation Index and Social Science Citation Index databases. Web of Science is a comprehensive international literature retrieval tool, and using both SCI and SSCI databases ensures representative and comprehensive samples. Drawing on relevant literature [3] and consulting domain experts, search terms were determined. Research topics included augmented reality, behavior, interaction, and user study. The final search query was: TS=( "augmented reality" & "user study/ies" ) OR TS=( "augmented reality" & "behavior" ) OR TS=( "augmented reality" & "adoption" ) OR TS=( "augmented reality" & "interaction" ), with publication dates limited from January 1, 1998 to December 30, 2018. This yielded 781 relevant documents across computer science, education, psychology, medicine, and other disciplines, which were subjected to bibliometric analysis.

For content and hotspot analysis, 34 key articles were manually selected from the 781 retrieved documents. The selection process involved: first, refining search criteria to exclude review and conference papers; then ranking results by citation count to prioritize highly-cited works; and finally, researchers individually examined each document to exclude those not closely related to the research theme, such as studies focusing primarily on AR technical design and implementation or non-AR information behavior applications. This process resulted in 34 documents for in-depth analysis of user information behavior in AR environments.

## 3. Origin and Development Analysis

### 3.1 Initial Stage (1998-2002)

During 1998-2002, research on user information behavior in AR environments was in its initial stage, with fewer than 10 publications. Scholar U. Neumann analyzed AR technology's impact on human cognition and behavior, arguing that AR media forms supplement human cognitive processes [7] and prospectively examined AR applications in manufacturing maintenance. Subsequently, L. Nigay extended AR research to mobile collaborative activities [8], while P. Antoniac explored early wearable AR devices [9]. Research in this stage predominantly employed experimental methods to improve AR technologies for tracking user bodies [10] and visual positioning [11].

### 3.2 Development Stage (2003-2012)

From 2003 onward, research entered a development stage, with publications gradually increasing to over 60. Early applications emerged in psychological therapy and education, such as treating acrophobia [12], training automotive service technicians [13], and combining gaming with educational content [14]. These studies found that AR technology could enhance users' information acceptance effectiveness. Later, F. Biocca and colleagues expanded AR applications to environmental and location-based contexts [15]. The 2012 launch of Google Glass accelerated AR commercialization, with increasing applications and research in education, healthcare, tourism, and gaming, along with growing comparative studies on information acceptance between AR and traditional methods.

### 3.3 Rapid Growth Stage (2013-2018)

Entering 2013, research on user information behavior in AR environments began rapid growth, with significantly increased publication volume. In education, AR was applied to collaborative learning [16] and inquiry-based learning [17] to examine its positive effects on student motivation and learning outcomes. In healthcare, AR was used for exposure therapy [18] and training elderly adults' spatial orientation [19]. AR also found applications in exhibitions and tourism [20], demonstrating effective information reception across domains. Over the past three years, development has focused on wearable devices such as handheld mobile AR applications [21], AR glasses, and head-mounted displays. Comparative device studies have increased [22], with deeper investigation into negative effects like cognitive load in AR human-computer interfaces [23], and new hotspots emerging around reducing user dizziness and minimizing attention distraction. AR applications in driving navigation [24] and visual warning systems have also advanced. The 2017 popularity of Pokémon Go sparked numerous related studies [25].

## 4. Research Topic Keywords and Hotspot Analysis

### 4.1 Keyword Analysis

To analyze hotspots in AR user information behavior research, this study used CiteSpace to create keyword knowledge maps for domestic and international literature from 2014-2018. Settings included Time Slicing (2014-2018), Node Types (Keyword), and Selection Criteria (Top 50). The resulting knowledge map is shown in Figure 2 [Figure 2: see original paper], with statistical analysis of high-frequency keywords presented in Table 1 .

Analysis reveals that the most frequently cited keywords are: augmented reality, system, virtual reality, design, environment, education, model, mixed reality, technology, visualization, performance, tracking, behavior, human-computer interaction, etc., reflecting recent international research hotspots. The top 10

keywords by centrality are augmented reality (0.34), system (0.22), virtual environment (0.27), virtual reality (0.31), model (0.11), information (0.17), surgery (0.14), education (0.15), user study (0.13), and vision (0.19), indicating high importance of these nodes.

Most AR research currently focuses on user interface design in human-computer interaction and upgrades to AR image tracking and positioning technologies. Studies on user information behavior in AR environments concentrate on education, healthcare, navigation, and other fields, emphasizing the “perception” theme during interaction. However, most existing studies are not grounded in information behavior theory, focusing instead on comparing user behavior characteristics and effects between AR and traditional environments to optimize AR applications. Consequently, the keyword knowledge map and frequency tables primarily reflect application domains related to information behavior, such as system design, environmental research, tracking, education, and visualization. Based on representative literature, content analysis was conducted to identify research themes in AR user information behavior.

#### **4.2 Impact of AR Environment on User Information Adoption Behavior**

According to behavioral definitions, behavior emerges from human-environment interaction, where the actor’s state can be rational or irrational [26]. Information behavior specifically emphasizes actions based on information needs and motivations [27], encompassing information retrieval, selection, interaction, and utilization behaviors [38]. Information adoption behavior involves purposeful information selection, evaluation, acceptance, and utilization based on personal cognition, influencing subsequent actions. Compared to information acceptance, adoption behavior more strongly emphasizes the actor’s proactive, conscious role [28], making it widely applicable in e-commerce and consumption domains requiring user decision-making.

Research on AR user information adoption behavior primarily focuses on AR’s impact on user decision-making and adoption motivation. In entertainment, players’ purchase and use of AR games represent information adoption behavior. For example, experimental surveys of Pokémon Go players revealed that consumer attitudes toward the game are driven by enjoyment and self-image projection, with nostalgia, immersion, and physical activity positively correlating with adoption attitudes, while injury risk negatively impacts adoption [29].

E-commerce AR studies propose a model of factors influencing user information adoption behavior based on aesthetic, interactive, response time, and information quality features to examine how AR services affect consumer decision-making [30]. In tourism, AR applications generate greater pleasure, influencing users’ behavioral intentions regarding consumption decisions. Research has validated relationships between AR functional attributes, user emotions, and information adoption behavior [31]. User experience studies across different user

groups show that elderly users exhibit superior experience and performance with AR applications compared to younger users, indicating significant potential for AR services among older populations [22].

AR adoption behavior research is crucial for the AR industry. Current studies primarily focus on initial IT service adoption, with relatively less research on continuous use and switching behaviors in AR applications. Most studied AR applications serve entertainment and tool functions, employing theories such as uses and gratifications, immersion, and technology acceptance, typically using mixed methods combining questionnaires and experiments.

### **4.3 Impact of AR Environment on User Information Acceptance Behavior**

Information acceptance behavior differs slightly from adoption behavior, emphasizing passive information reception and encompassing acceptance, selection, and absorption processes without necessarily impacting the actor [38]. While similar in expression, acceptance behavior focuses on user experience, making it prevalent in education, tourism, and other experience-oriented domains.

AR user information acceptance research concentrates on behavioral patterns and effectiveness, often comparing AR environments with traditional settings. In education, AR positively impacts students' construction of abstract concepts, learning outcomes, and emotional motivation [32]. Studies comparing high- and low-achieving students show AR provides better support for low-achieving students, with both student and teacher attitudes significantly affecting application effectiveness [33]. Immersion level during learning serves as an important indicator of information acceptance effectiveness, with AR applications enhancing participants' immersive experiences that positively correlate with cognitive motivation [34]. Educational AR applications span diverse age groups, from early childhood reading to adult skills training, with generally positive student attitudes and improved information acceptance outcomes.

In tourism and museum exhibitions, AR transforms traditional visiting methods, enhancing user experience and satisfaction while improving information acceptance. Tourists exhibit significantly higher immersion levels and satisfaction with AR applications [35]. AR also demonstrates positive effects on multicultural representation, helping reduce prejudice and promote openness [36]. The technology offers substantial potential for tourism by enhancing visitor experiences through scene display and real-time interaction while reducing staffing pressures and risks in exhibiting precious artifacts.

As AR applications increasingly enter the market, research on user information acceptance and experience becomes essential. Future studies should investigate information acceptance effects and influencing factors across different user groups and scenarios, incorporating psychological and behavioral theories. Additionally, more research methods should be employed for in-depth analysis and comparison of immersion levels in AR environments.

#### 4.4 Impact of AR Environment on User Information Interaction Behavior

Information interaction behavior can be categorized as human-computer or human-human (user-user) interaction. Human-computer interaction includes bidirectional processes where users obtain data from and react to information systems [38].

AR user information interaction research focuses on human-computer interaction and user interaction behaviors. Human-computer studies examine AR system operation and interface usability, including icon design and presentation [37], real-world positioning and tracking technologies [10-11], and reducing cognitive load [38]. In psychotherapy, patient-system interaction has been shown to improve treatment outcomes [6]. Driving navigation and surgical navigation represent major human-computer interaction research areas, focusing on driver attention and cognitive load [39]. In e-commerce, businesses use AR for product display and marketing to facilitate user information interaction and enhance shopping experiences.

User-user interaction research in AR is less extensive than human-computer studies. Representative research in education examines how AR environments affect student interaction patterns, promoting collaborative and interactive learning. Interactive learning emphasizes peer cooperation and computer use. Library instruction systems using AR have demonstrated significantly improved teaching and learning outcomes compared to traditional librarian-led instruction [40].

### 5. Future Trends of AR in Library and Information Science User Information Behavior Research

Using CiteSpace to map research from 2014-2018, Figure 3 [Figure 3: see original paper] illustrates the evolution of key nodes, showing a development trajectory from “human-computer interaction, education, user interface design → tracking, perception, visualization → navigation, experience → user acceptance, gaming → decision-making behavior, user profiling, engagement, cognitive load.” Based on these trends, this paper identifies three future research directions for AR technology in library and information science.

#### 5.1 User Information Interaction Behavior in Different AR Scenarios

User information interaction behavior in AR environments represents a current research hotspot. Studies investigating factors affecting user experience during human-computer interaction can improve AR application interfaces [50]. AR's real-time interaction characteristics create novel experiences that can influence user information interaction behaviors, offering substantial research space and industrial application value. Research on user-user interaction has begun exploring integration with location-based social networks, using AR to enrich

social platform interactions and expand application scope [41]. Differences between AR-enhanced social interaction and traditional social interaction have significant implications for platform development and industrial innovation.

While most e-commerce research focuses on AR adoption and user acceptance, fewer studies analyze how AR technology transforms mobile shopping behavior itself. Future research could combine psychology and sociology to explore mobile commerce users' interaction patterns and emotions in AR environments, analyzing how AR-based interaction modes affect mobile shopping. Although mobile AR applications are widespread, wearable AR devices represent the future direction. User experiences with wearable AR differ fundamentally from mobile AR applications [22], making research on user interaction behavior crucial for advancing wearable AR technology.

## 5.2 Application of User Information Behavior Research in Libraries

Both AR and virtual reality can drive innovation in traditional library user experiences, becoming important emerging technologies for building mobile, smart, and virtual libraries, and representing key components of Library 4.0 [42]. Research on library user information behavior in AR environments constitutes a new trend. Analyzing AR-based indoor navigation applications can enhance user experience and library stickiness. AR technology can integrate reading paths, physical locations, real-time dynamics, book introductions, and user reviews [43], improving patron experiences while reducing staff burden. Such integrated AR applications can combine with artificial intelligence to upgrade personalized recommendations.

AR's real-time interactive features enable library applications for book recommendations and reader engagement. Additionally, AR can facilitate facial recognition to simplify borrowing procedures. Public library cultural resources are vital for socially vulnerable groups, and understanding their information behavior characteristics in AR environments is essential for improving library information service models and resource development. Research on vulnerable groups' information behavior in AR environments both expands the scope of such studies and guides AR technology development and application design.

## 5.3 Mobile Reading User Behavior Characteristics Based on AR Technology

AR technology combines virtual images with real scenes, transforming traditional reading experiences into multimedia engagements integrating text, images, video, sound, and action. This turns traditional print media into multimedia carriers enabling interactive reading. Currently, readers can scan QR codes in AR books to see scenes presented in their real environment through AR devices. Research on AR books is gradually increasing in library and education fields [44].

AR technology's innovation in reading methods will drive transformation in

traditional publishing. The “2D+3D” stereoscopic reading experience in AR environments provides immersive interaction [45]. Researchers can analyze information acceptance effects, reading experiences, and user stickiness in AR reading. Comparative studies of information behavior across traditional, AR, and virtual reality reading environments can evaluate AR reading effectiveness and prospects. Additionally, given current technological limitations, analyzing user experience and evaluations can inform improvements. Library and information science researchers can also explore information interaction patterns in AR reading to enhance presentation effects.

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**Author Contributions:**

Wang Xiwei: Conceptualized the research, wrote and revised the manuscript;

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Wang Duo: Assisted with data collection and organization;

Wei Yanan: Translated and processed English content.

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