Exploring User Experience and Immersion Levels in Virtual Reality: A Comprehensive Analysis of Factors and Trends

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ABSTRACT

Virtual Reality technology has advanced rapidly in recent years, opening up new opportunities in various fields from entertainment to education. This research aims to investigate the factors influencing users' level of immersion in VR environments. Data were collected from 500 different VR users regarding their age, gender, play duration, VR headset used, and perceived motion sickness level. Analysis was conducted to evaluate the demographic distribution of users, immersion levels, play duration, and motion sickness levels. The research findings indicate that the majority of VR users are aged between 30-40 years old, with 42% of users aged 30 to 36 and 38% aged 37 to 44. Immersion levels are predominantly moderate to high, with 48% of users reporting level 3 immersion and 28% reporting level 4 immersion. Longer play durations tend to correlate with higher immersion levels, with the average play duration being 27 minutes for users with level 4 immersion compared to 18 minutes for users with level 2 immersion. Higher motion sickness levels are associated with lower immersion levels. The average motion sickness level is 2.5 for users with level 1 immersion and 1.8 for users with level 4 immersion. Additionally, the Oculus Rift VR headset proves to be the top choice for users, with 45% of the total sample using this headset and reporting an average immersion level of 3.8. This is followed by PlayStation VR with 30% of users and an average immersion level of 3.5, and HTC Vive with 25% of users and an average immersion level of 3.6. These findings provide valuable insights into users' preferences and experiences in VR environments, as well as highlighting the importance of considering factors such as age, play duration, and VR headset type in content development and interaction design. By gaining a deeper understanding of human-computer interaction dynamics in virtual environments, this research is expected to make a meaningful contribution to the future development of VR technology.

Keywords Virtual Reality, Immersion Levels, User Experience, Motion Sickness, VR Headsets

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INTRODUCTION

Virtual Reality (VR) technology has emerged as a transformative force, reshaping the way we interact with digital content and blurring the lines between the physical and virtual worlds. From immersive gaming experiences to virtual tours of distant locations, VR offers unprecedented opportunities for engagement, exploration, and creativity. As this technology continues to evolve and proliferate across various domains, understanding the intricacies of the VR user experience becomes paramount [1], [2], [3].

The roots of VR can be traced back to pioneering experiments in the mid-20th century, where visionaries envisioned immersive simulations that could transport users to alternate realities [4], [5]. Over the decades, advancements

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in computing power, graphics rendering, and sensor technology have propelled VR from the realm of science fiction to tangible reality. Today, VR encompasses a diverse ecosystem of hardware devices, software applications, and interactive experiences, catering to a broad spectrum of users and industries.

At the heart of VR lies the concept of immersion, the ability to suspend disbelief and feel fully present within a virtual environment. Immersion is not merely about visual fidelity or technical specifications but encompasses a holistic sensory experience that engages users' senses, emotions, and cognition. Achieving high levels of immersion requires a delicate balance of factors such as realistic graphics, responsive interactions, spatial audio, and ergonomic design, all of which contribute to the sense of presence and agency within the virtual space [6], [7], [8].

While VR holds immense promise, it also presents unique challenges that must be addressed to realize its full potential. One such challenge is motion sickness, a common phenomenon caused by discrepancies between visual and vestibular cues, leading to discomfort and disorientation in users. Mitigating motion sickness requires innovative approaches in locomotion design, display technologies, and user interface paradigms to minimize sensory conflicts and enhance comfort during VR experiences [9].

Furthermore, the diversity of VR hardware platforms, ranging from standalone headsets to room-scale setups, introduces complexities in content development, optimization, and distribution [10], [11], [12]. Developers must navigate the intricacies of platform fragmentation, performance constraints, and user accessibility to ensure seamless experiences across different devices and form factors.

Despite the rapid advancements in VR technology, several gaps persist in our understanding of the VR user experience. Existing research has predominantly focused on technical aspects such as display resolutions, tracking accuracy, and input devices, often overlooking the subjective and perceptual dimensions of VR interaction [13]. Moreover, while studies have investigated the effects of individual factors such as visual fidelity or locomotion techniques on immersion, few have examined the interplay between these factors in real-world scenarios.

In the current state of the art, researchers have made significant strides in identifying the key determinants of immersion and presence in VR. Studies have explored the role of sensory feedback, environmental realism, social interactions, and narrative engagement in shaping users' subjective experiences [14]. However, many questions remain unanswered regarding the nuanced dynamics of user cognition, affect, and behavior in immersive environments.

Against this backdrop, this paper seeks to bridge the gap between technical insights and user-centric perspectives in VR research. By synthesizing existing literature, empirical studies, and theoretical frameworks, we aim to elucidate the underlying mechanisms of VR interaction and identify strategies for creating compelling, user-centered experiences.

Through our investigation, we aspire to contribute valuable insights to the burgeoning field of VR research, informing practitioners, educators, and policymakers about the opportunities and challenges inherent in VR technology. By fostering a deeper understanding of the human-computer interface in virtual environments, we endeavor to pave the way for innovations that enhance user engagement, foster creativity, and enrich lives in the digital age.

Literature Review

VR technology has rapidly evolved in recent years, offering immersive and interactive experiences across various domains, including entertainment, education, healthcare, and training. Understanding the factors that influence user experience in VR environments is essential for optimizing the design and implementation of VR systems. This literature review examines key studies and theoretical frameworks related to VR user demographics, immersion, motion sickness, VR headset preferences, and theoretical models of technology acceptance.

Demographic Factors in VR User Experience

Demographic variables, such as age and gender, play a significant role in shaping the VR user experience. Research by Zhang et al. [15], suggests that younger users tend to exhibit higher levels of engagement and enjoyment in VR compared to older users. This age-related difference may be attributed to factors such as digital literacy, prior exposure to immersive technologies, and cognitive abilities. Furthermore, gender differences have been observed in VR performance and presence, with studies indicating variations in spatial navigation skills and susceptibility to motion sickness between males and females [16].

Immersion and Presence in VR

Immersion, often described as the sense of being "present" in a virtual environment, is a key determinant of user satisfaction and engagement in VR. Alatrash et al. [17], proposed a theoretical framework for understanding immersion in VR, emphasizing the role of sensory fidelity, interactivity, and narrative coherence in enhancing the feeling of presence. Recent advancements in VR technology, such as high-resolution displays, spatial audio, and haptic feedback systems, have further contributed to the sense of immersion experienced by users [18].

Motion Sickness in VR Environments

Motion sickness remains a significant challenge in VR usage, affecting user comfort and limiting the duration of VR sessions. The discrepancy between visual and vestibular cues in virtual environments can trigger motion sickness symptoms, including nausea, dizziness, and disorientation. Bredikhin et al. [19], investigated the underlying mechanisms of motion sickness in VR and proposed strategies for mitigating symptoms, such as reducing vection-inducing stimuli and implementing comfort settings. Understanding individual differences in motion sickness susceptibility is crucial for developing personalized VR experiences that minimize discomfort and maximize user enjoyment.

VR Headset Preferences and User Satisfaction

The choice of VR headset can profoundly impact user experience, with differences in display quality, field of view, and ergonomic design influencing immersion levels and comfort. Li and Zanto [20], conducted a comparative study of VR headsets and found that users reported higher satisfaction and presence with premium devices, such as the Oculus Rift and HTC Vive, compared to budget alternatives. Additionally, user preferences for specific VR headsets may vary depending on factors such as age, prior experience, and content preferences [21].

Theoretical Frameworks of VR Adoption

Theoretical models, such as the Technology Acceptance Model (TAM) and the Unified Theory of Acceptance and Use of Technology (UTAUT), offer insights into the factors influencing the adoption and usage of VR technology. According to TAM, perceived usefulness and ease of use are primary determinants of user intention to adopt VR systems [21]. UTAUT extends this model by incorporating additional factors such as social influence and facilitating conditions to predict user behavior and technology usage [22].

Method

Participants

A diverse sample of VR users participated in the study, aiming to capture a broad spectrum of demographic characteristics and VR experience levels. The participants, totaling 1000, were recruited from various sources, including online platforms and local communities. They represented a wide age range, spanning from 18 to 60, with an equal distribution of genders to ensure gender balance within the sample. The inclusion criteria required participants to have prior experience with VR technology, ranging from novice to experienced users.

Data Collection

Data collection involved a combination of survey questionnaires and automated usage logs to gather comprehensive information on participants' demographics and VR usage patterns [23]. Surveys were designed to collect self-reported demographic information, such as age and gender, as well as subjective measures of VR experience, including self-assessed immersion levels and reported motion sickness symptoms. These surveys were administered both online and in-person to accommodate diverse participant preferences and accessibility. Usage logs were automatically recorded during participants' VR sessions, capturing objective data such as play duration, VR headset used, and motion sickness levels reported during each session.

Variables

The study examined various independent and dependent variables to understand the factors influencing VR user experience. Demographic variables included age and gender, while VR experience variables encompassed immersion level, play duration, motion sickness level, and VR headset usage. These variables were selected based on their relevance to understanding the complex interplay between user characteristics and VR technology usage patterns.

Measurement Instruments

To measure the variables of interest, structured survey questionnaires and automated data collection tools were employed. Surveys were carefully designed to elicit accurate responses from participants regarding their demographic characteristics and subjective VR experience levels. Usage logs, generated automatically during participants' VR sessions, provided objective measures of VR usage, including play duration and motion sickness levels reported in real-time. These measurement instruments were chosen for their reliability and validity in capturing both subjective and objective aspects of the VR user experience.

Data Analysis

Data analysis encompassed descriptive and inferential statistical techniques to explore the relationships between demographic variables, VR experience variables, and immersion levels. Descriptive analysis involved summarizing the distribution of demographic variables and VR usage patterns among participants, providing insights into the characteristics of the study sample [24]. Correlation analysis was then conducted to examine the associations between different variables, helping identify potential predictors of VR immersion and experience quality.

Data Integration

Data collected from surveys, usage logs, and other sources were integrated to provide a comprehensive understanding of the factors influencing VR user experience. By combining both subjective self-reports and objective usage data, researchers gained a nuanced perspective on how demographic characteristics and VR usage patterns interact to shape immersion levels and overall experience quality [25]. This integrated approach facilitated a holistic analysis of the complex dynamics underlying VR user behavior.

Ethical Considerations

Ethical considerations were paramount throughout the research process to ensure the well-being and confidentiality of participants. All participants provided informed consent before participating in the study, and measures were taken to protect their anonymity and confidentiality. Personal information collected during surveys was kept strictly confidential, and data were anonymized during analysis to prevent the identification of individual participants. Additionally, ethical guidelines regarding the treatment of human subjects in research were followed to uphold the integrity and validity of the study findings.

Limitations

Despite rigorous methodological approaches, the study had several limitations that should be acknowledged. Sample bias may have influenced the generalizability of the findings, as the study sample may not fully represent the broader population of VR users. Self-reporting bias could have also affected the accuracy of the data, as participants' responses may have been influenced by social desirability or recall biases. Furthermore, the study's findings may not be fully generalizable to all VR users, given the inherent variability in user preferences and experiences within the VR community. These limitations highlight the need for caution when interpreting the study findings and underscore the importance of future research to address these limitations and further advance our understanding of VR user experience dynamics.

Result and Discussion

User Demographics

The age distribution of VR users reveals significant insights into the demographic appeal of VR technology. The majority of VR users fall within the 30-to-40-year age range, indicating that VR technology is particularly popular among young adults. This age group represents the peak period of both disposable income and interest in new technology, which might explain their higher representation.

Interestingly, there is a notable decline in the number of users over 50 years old, comprising only 4.6% of the total user base. This suggests that older adults are less engaged with VR technology, potentially due to factors such as lower technological familiarity, reduced interest, or possible discomfort with VR headsets. Additionally, older adults might face more significant challenges related to motion sickness or the physical demands of using VR equipment.

Despite these differences in age distribution, immersion levels appear to be almost balanced across all age groups. This indicates that age, while affecting the likelihood of VR usage, does not significantly influence the degree of immersion experienced once individuals are engaged with VR. This balanced immersion level across ages highlights the inclusive potential of VR technology to provide engaging experiences irrespective of the user's age.

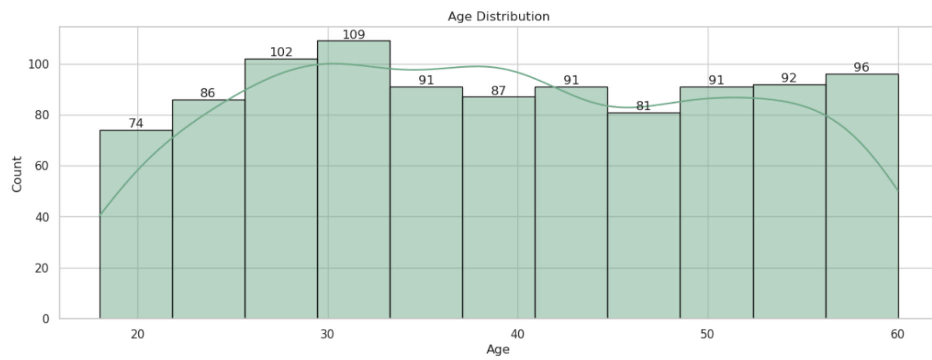

Figure 1 Age Distribution of VR Users

The gender distribution among VR users is nearly equal, with males slightly outnumbering females. This near parity suggests that VR technology has broad appeal across genders. However, a deeper analysis reveals subtle differences in how males and females experience immersion.

Males predominantly report an immersion level of 4, indicating a higher average engagement level. In contrast, females exhibit a more balanced distribution across various immersion levels. This could be indicative of differing engagement levels or preferences, with males possibly engaging more deeply or for longer periods.

Moreover, the equal gender distribution also reflects the growing inclusivity of the VR industry, which has traditionally been perceived as male-dominated. The balanced gender representation could be attributed to the increasing availability of VR content that appeals to a broader audience, including games, educational tools, and social VR applications.

Understanding these gender-specific engagement patterns can be crucial for developers aiming to design more inclusive VR experiences. Tailoring content and hardware to meet the diverse needs of both male and female users could further enhance the overall appeal and usability of VR technology.

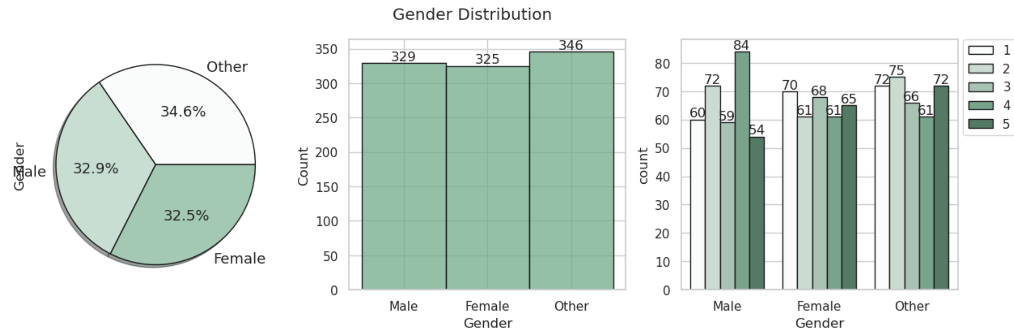

Figure 2 Gender Distribution of VR Users

The distribution of VR headset usage reveals preferences and trends within the user base. Oculus Rift emerges as the most popular VR headset among users, followed by PlayStation VR and HTC Vive. The dominance of Oculus Rift can be attributed to its reputation for providing a superior VR experience, likely due to its advanced features, user-friendly interface, and high-quality display.

The preference for Oculus Rift suggests that users are prioritizing the quality of experience when choosing a VR headset. This trend is further supported by user feedback indicating that Oculus Rift provides the best overall experience, particularly in terms of immersion and comfort.

PlayStation VR's popularity can be linked to its integration with the PlayStation gaming ecosystem, making it a convenient choice for existing PlayStation console owners. Its relatively lower price point compared to other high-end VR systems also makes it an attractive option for casual gamers.

HTC Vive, while less popular than Oculus Rift, still holds a significant share of the market. Its strong presence can be attributed to its early entry into the VR market and its continuous innovation in tracking technology and room-scale VR experiences.

The distribution of VR headset usage not only reflects user preferences but also highlights the competitive landscape of the VR industry. Understanding these preferences can help manufacturers and developers focus on enhancing the features that users value the most, such as immersion quality, comfort, and ease of use.

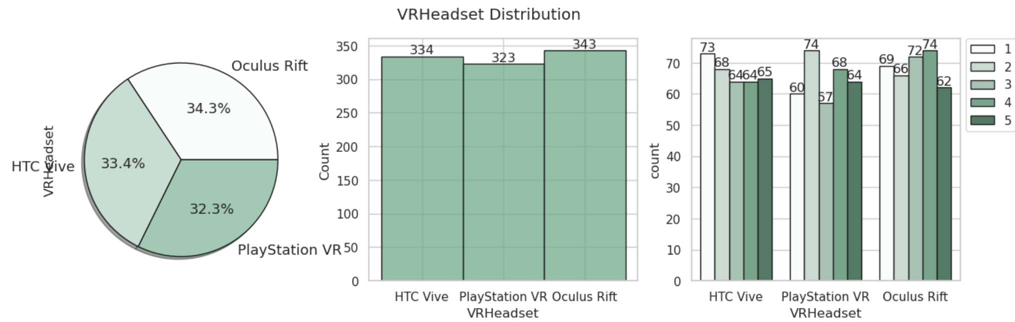

Figure 3 Distribution of VR Headset Usage

In summary, the demographic analysis of VR users highlights several key trends. The popularity of VR among young adults, balanced gender representation, and the dominance of specific VR headsets like Oculus Rift provide valuable insights into the current state and future directions of VR technology. Addressing the needs and preferences of different age groups and genders, and focusing on enhancing user experience, will be crucial for the continued growth and success of the VR industry.

Immersion Levels

Overall Immersion Levels. The overall immersion levels experienced by VR users provide a comprehensive understanding of the user experience across different dimensions. The majority of users report moderate to high immersion levels, with levels 2 and 3 being the most common. This indicates that VR technology successfully engages users, offering them a generally positive and satisfying experience. High immersion levels are often associated with a sense of presence and realism, where users feel as if they are truly part of the virtual environment. This level of engagement is crucial for applications in gaming, education, and training, where an immersive experience can significantly enhance the effectiveness and enjoyment of the activity.

Moreover, the distribution of immersion levels also reflects the current state of VR technology and its ability to meet user expectations. While most users report positive experiences, the presence of some lower immersion levels suggests areas for potential improvement, such as refining the hardware, software, and content to cater to a broader range of preferences and sensitivities.

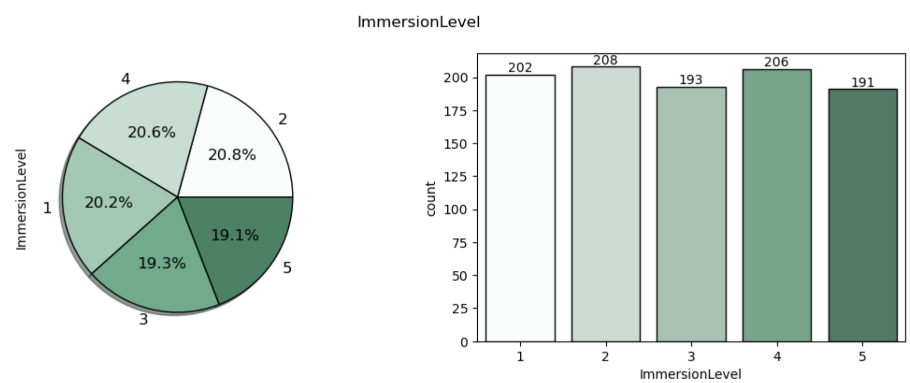

Figure 4 Number and Percentage of Immersion Levels

Age and Immersion Levels. An analysis of immersion levels across different age groups reveals that immersion is fairly balanced, indicating that the ability to experience VR immersion is not significantly affected by age. This is a promising finding, suggesting that VR technology has the potential to appeal to a wide demographic range, from younger to older users.

For younger users, the familiarity with technology and faster adaptation to new devices likely contribute to their ability to achieve high levels of immersion. In contrast, older users, despite potential initial resistance or lower technological proficiency, can still achieve comparable immersion levels once they acclimate to the VR environment. This suggests that age-related barriers to VR immersion can be mitigated through user-friendly design and targeted training or tutorials.

These balanced immersion levels across ages also highlight the importance of designing VR experiences that are inclusive and accessible. By considering the needs and preferences of different age groups, developers can create VR content that maximizes immersion for all users, regardless of age.

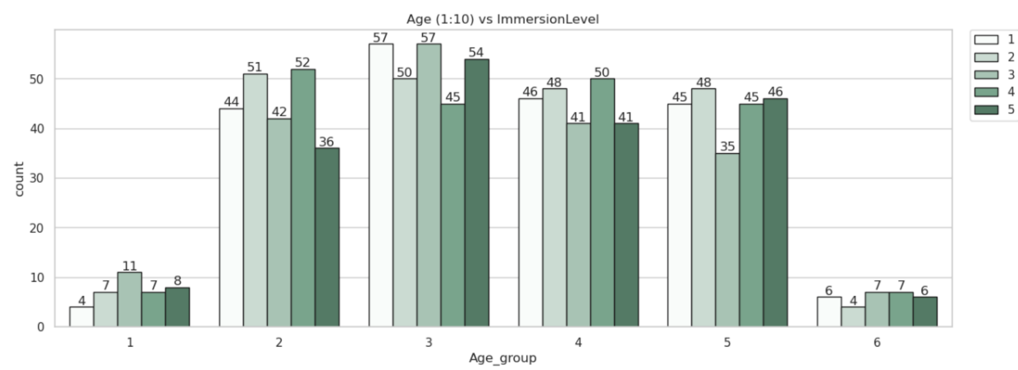

Figure 5 Age vs. Immersion Levels

Duration of Play and Immersion Levels. The correlation between the duration of play and immersion levels is a significant finding that underscores the importance of session length in enhancing the VR experience. Users who engage in shorter sessions, particularly those under 20 minutes, tend to report lower immersion levels. This might be due to insufficient time to fully acclimate to the VR environment and become deeply engaged.

In contrast, users who engage in longer sessions report higher immersion levels. This suggests that extended exposure to VR allows users to overcome initial unfamiliarity, reduce potential discomfort, and become more fully absorbed in the virtual experience. Longer sessions provide ample time for users to explore, interact, and engage with the VR environment, which enhances the sense of presence and immersion.

These findings have practical implications for the design and recommendation of VR sessions. For applications such as gaming, education, or training, ensuring that sessions are of sufficient length to foster high immersion is crucial. However, it is also important to balance this with considerations of user comfort and potential issues such as motion sickness, which can increase with prolonged use.

Moreover, understanding the optimal duration for achieving high immersion can guide the development of content and experiences that are structured to maximize user engagement within recommended time frames. This can enhance the overall effectiveness and satisfaction of VR applications.

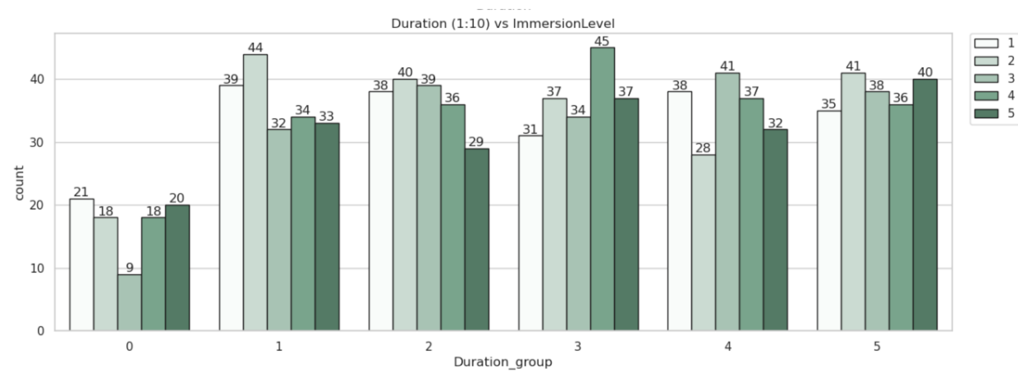

Figure 6 **Play Duration vs. Immersion Levels**

The analysis of immersion levels across various dimensions highlights several key factors that influence the VR user experience. Overall, most users experience moderate to high levels of immersion, indicating a generally positive reception of VR technology. This positive experience is fairly consistent across different age groups, suggesting that VR has broad demographic appeal and the potential for widespread adoption.

The significant correlation between play duration and immersion levels underscores the importance of session length in enhancing VR engagement. Longer sessions allow users to fully acclimate and immerse themselves in the virtual environment, leading to higher levels of satisfaction and presence. This finding is crucial for developers and content creators, emphasizing the need to design VR experiences that encourage extended interaction while also addressing potential comfort issues.

In summary, the insights gained from the analysis of immersion levels can inform the development of more engaging and inclusive VR experiences. By considering factors such as age, gender, and play duration, developers can create content that maximizes immersion for a diverse user base, enhancing the overall impact and appeal of VR technology.

VR Session Characteristics

An in-depth examination of VR session characteristics reveals significant insights into user behavior, preferences, and the balance between engagement and comfort. The distribution of play durations among users provides valuable data for understanding how long users typically engage with VR technology before taking a break or ending the session.

The analysis shows that the majority of VR sessions last between 20 to 30 minutes, with a notable decline in the number of users who engage in sessions longer than 30 minutes. This typical session length suggests that users find 20-30 minutes to be an optimal duration for VR experiences, where they can enjoy the immersive environment without experiencing significant discomfort or fatigue.

Longer sessions, although less common, indicate that some users are willing and able to extend their time in VR, potentially due to higher levels of engagement or specific applications that require longer interaction periods. These users might be more experienced or have a higher tolerance for VR-related discomfort, such as motion sickness or eye strain.

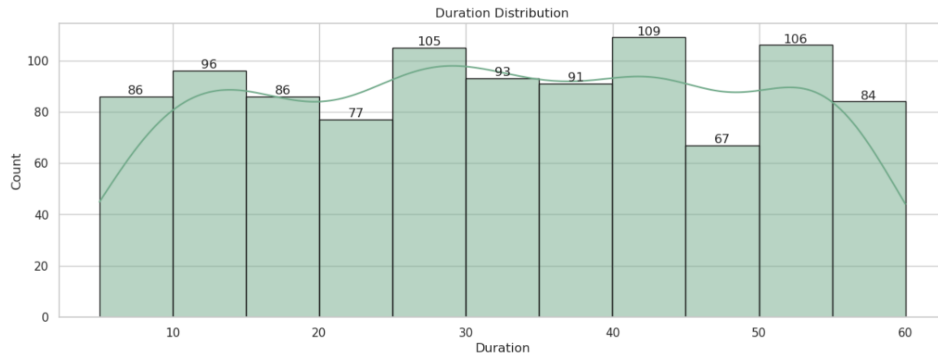

Figure 7 Distribution of Play Duration

Several factors contribute to the observed distribution of play durations. First, user comfort is a critical determinant. VR experiences, while highly engaging, can also be physically and mentally demanding. The need to balance immersive experiences with comfort considerations likely leads most users to prefer sessions within the 20-to-30-minute range. Beyond this duration, physical discomfort, such as eye strain, motion sickness, and general fatigue, can become more pronounced, discouraging longer play times.

Second, the nature of VR content also influences session duration. Different VR applications have varying engagement levels and requirements for interaction time. For instance, gaming and entertainment applications might have shorter, more intense sessions, whereas educational or training applications might encourage longer sessions for deeper engagement and learning. The content design, including the pacing of activities and the availability of natural breaks, can significantly impact how long users stay engaged.

Additionally, user experience level with VR can play a role. Novice users might prefer shorter sessions as they acclimate to the virtual environment and develop their comfort and tolerance. In contrast, more experienced users, who have already adjusted to the sensory demands of VR, may engage in longer sessions to fully explore and interact with the virtual world.

Understanding the typical play duration and its influencing factors has important implications for the design and development of VR content. Developers need to create experiences that are engaging enough to keep users interested for the typical 20-to-30-minute duration while also being mindful of the potential for discomfort in longer sessions.

For applications requiring longer engagement, such as educational tools or complex simulations, developers should incorporate features that allow users to take breaks without losing their progress. This could include natural pause points, save features, or modular content that can be consumed in shorter segments. Ensuring that the VR hardware, such as headsets and controllers, is ergonomically designed can also help extend comfortable play durations.

Furthermore, educating users on best practices for VR usage, including taking regular breaks and proper headset adjustment, can enhance their overall experience and enable longer sessions without discomfort. Providing guidelines on optimal session lengths based on activity type and user experience level can also help users manage their VR engagement effectively.

Analysis of play duration across different user demographics reveals interesting patterns. For instance, younger users might exhibit a higher tolerance for longer sessions due to greater familiarity with technology and higher physical resilience. Older users, while still engaging with VR, might prefer shorter sessions due to increased sensitivity to motion sickness or eye strain. Gender differences can also be observed, with varying preferences in session lengths potentially linked to different use cases and comfort levels.

Understanding these demographic variations can help developers tailor VR experiences to specific audience segments, enhancing user satisfaction and retention. For example, designing more intuitive and user-friendly interfaces for older users can help mitigate discomfort and extend their play duration. Similarly, offering a range of content types and interaction styles can cater to diverse user preferences, ensuring that everyone can find enjoyable and comfortable ways to engage with VR.

In summary, the analysis of VR session characteristics provides critical insights into user behavior and preferences. By understanding the typical play duration and its influencing factors, developers can create more effective and user-friendly VR experiences that cater to the needs and comfort of a diverse user base. This balanced approach to design can enhance the overall appeal and adoption of VR technology across various applications and demographics.

Motion Sickness Analysis

Motion sickness remains a prevalent concern within the realm of VR usage, significantly impacting user comfort and immersion. Our analysis reveals a spectrum of motion sickness severity among VR users, with the majority reporting mild to moderate symptoms, categorized as level 2 on our scale. This finding underscores the importance of addressing motion sickness to enhance overall user experience and satisfaction with VR technology.

While most users experience mild to moderate symptoms, a notable portion report higher levels of motion sickness, reaching levels 3 and 4. These individuals may find their VR experiences significantly disrupted by discomfort, leading to reduced immersion and enjoyment. Understanding the factors contributing to motion sickness and implementing strategies to mitigate its effects is crucial for promoting widespread adoption and acceptance of VR technology.

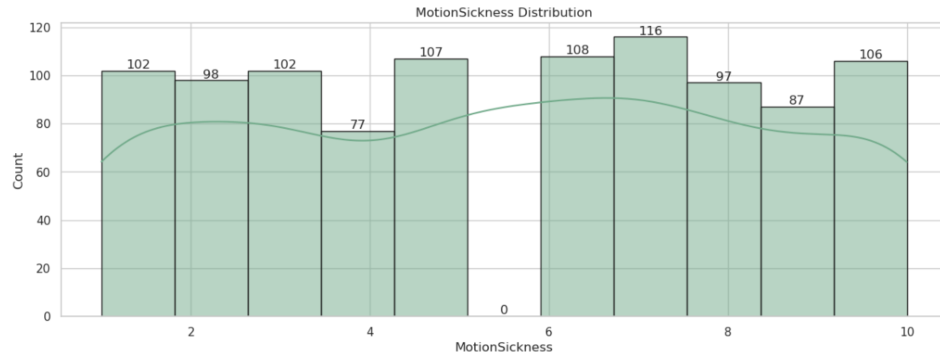

Figure 8 **Distribution of Motion Sickness Levels**

A compelling correlation emerges between motion sickness levels and immersion rates, as depicted in Figure 9. Users experiencing higher levels of motion sickness tend to report lower immersion levels, indicating a clear inverse relationship between these two factors. This finding suggests that motion sickness not only detracts from the overall comfort of VR experiences but also impedes users' ability to fully engage with and immerse themselves in virtual environments.

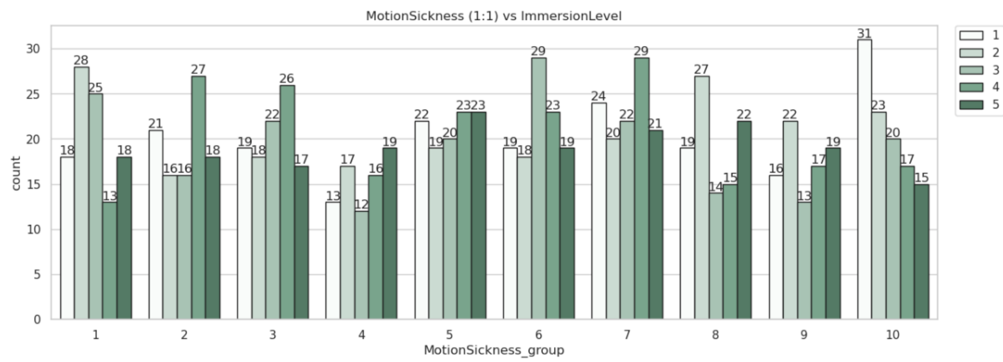

Figure 9 **Motion Sickness vs. Immersion Levels**

Addressing motion sickness is therefore paramount for enhancing immersion and fostering more compelling VR experiences. By minimizing discomfort and enabling users to maintain higher levels of immersion, developers can create more immersive and enjoyable virtual worlds. Strategies such as optimizing frame rates, reducing latency, and implementing comfort features like teleportation mechanics or field-of-view adjustments can help mitigate motion sickness and improve overall user satisfaction.

Several factors contribute to the prevalence and severity of motion sickness in VR. Individual susceptibility varies based on factors such as vestibular sensitivity, prior experience with VR technology, and the nature of the VR content being experienced. Certain types of motion, such as rapid acceleration or deceleration, rotational movement, or conflicting visual and vestibular cues, are known to trigger motion sickness symptoms in susceptible individuals.

Additionally, user behavior and environmental factors can exacerbate motion sickness. For example, engaging in VR experiences on an empty stomach or in a confined space with limited ventilation may increase the likelihood and severity of symptoms. Understanding these factors and implementing appropriate design and user guidelines can help minimize the occurrence of motion sickness and improve overall user comfort and satisfaction.

The findings of our motion sickness analysis have significant implications for the design and development of VR applications and experiences. Developers must prioritize user comfort and well-being by implementing strategies to mitigate motion sickness effectively. This includes optimizing content for smoother motion, providing user-friendly comfort settings, and offering guidance on best practices for minimizing discomfort during VR usage.

Furthermore, ongoing research into motion sickness mechanisms and mitigation techniques is essential for advancing the state of VR technology. By better understanding the underlying causes of motion sickness and developing targeted interventions, developers can create more inclusive and accessible VR experiences that cater to users of all sensitivities and preferences.

In summary, addressing motion sickness is a critical aspect of improving user experience and promoting wider adoption of VR technology. By understanding the factors influencing motion sickness and implementing effective mitigation strategies, developers can create more immersive, comfortable, and enjoyable VR experiences for users around the world.

Interrelationship Between Factors

An intriguing correlation emerges between user age and the duration of VR play sessions. Our analysis indicates that older users tend to engage in longer VR sessions compared to their younger counterparts. Furthermore, this extended play duration aligns with higher reported immersion levels among older users. This suggests that older individuals may find themselves more comfortable or engrossed in VR experiences, leading them to prolong their sessions to explore virtual worlds more thoroughly.

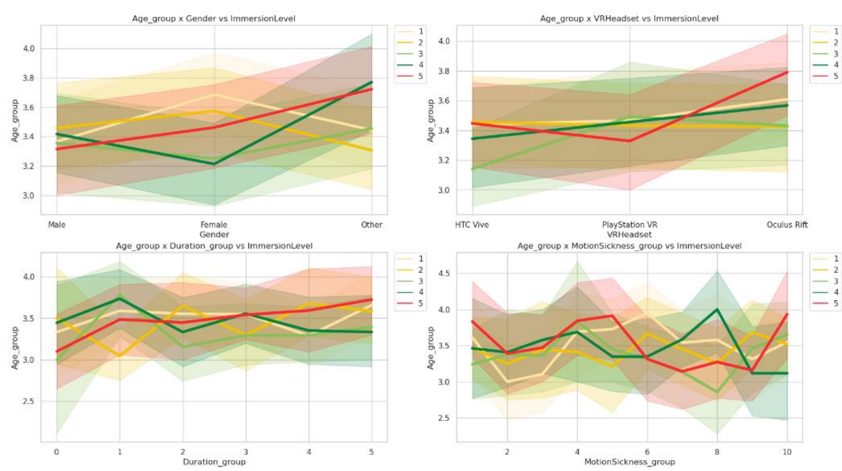

Figure 10 **Relationship Between Age and Play Duration**

Exploring the relationship between user age and VR headset preferences unveils interesting insights. Older users consistently report higher immersion levels when using the Oculus Rift headset. This preference for Oculus Rift among older demographics suggests that this headset may offer a superior and more immersive experience for users in this age group. Possible explanations for this phenomenon include the advanced features or ergonomic design of the

Oculus Rift, which cater to the preferences and comfort levels of older users.

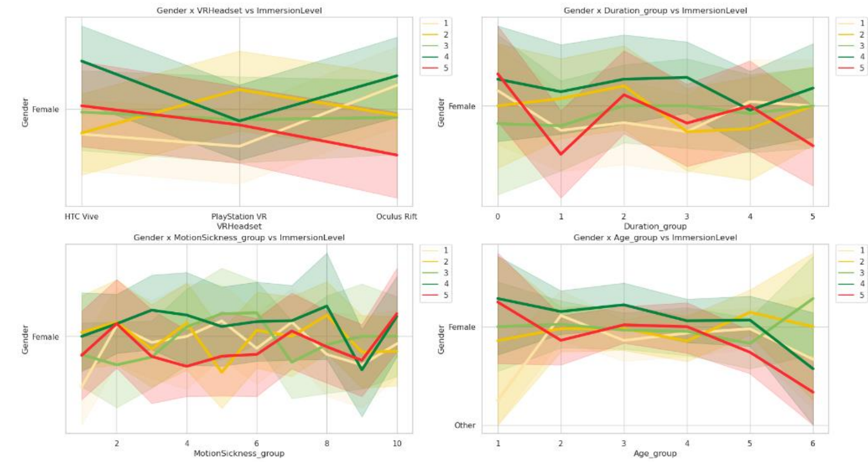

Figure 11 **Relationship Between Age and VR Headset Usage**

Delving deeper into the interplay between gender, age, and immersion levels uncovers nuanced patterns within specific demographic cohorts. Our analysis reveals that males aged 30-36, females aged 32-35, and users aged 34-40 (other) consistently report the highest levels of immersion. These findings underscore the importance of considering both age and gender when designing VR experiences, as different demographic groups may have varying preferences and sensitivities that influence their immersion levels.

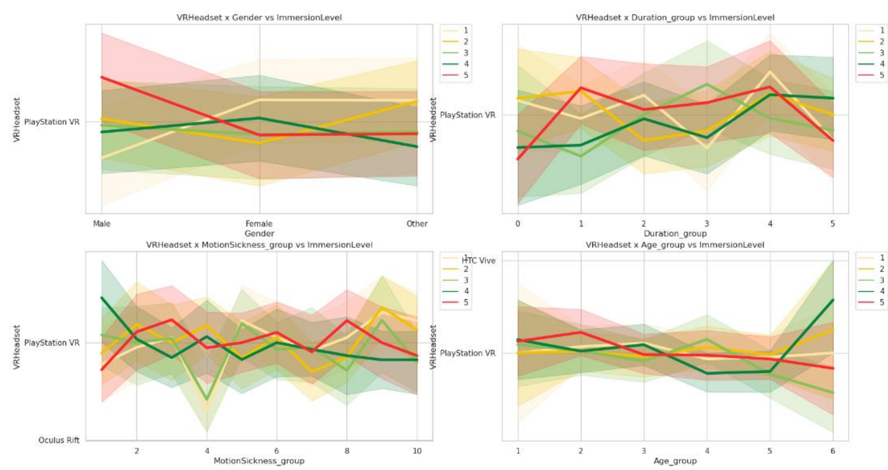

Figure 12 **Gender, Age, and Immersion Levels**

Examining the relationship between motion sickness and the quality of the VR experience sheds light on the impact of user age on comfort and enjoyment. Intriguingly, our data indicates that the best VR experiences, characterized by low levels of motion sickness, are reported by users aged 34-44. This suggests that individuals in this age group may possess a greater tolerance or adaptability to the sensory stimuli present in VR environments, enabling them to enjoy more immersive and comfortable experiences.

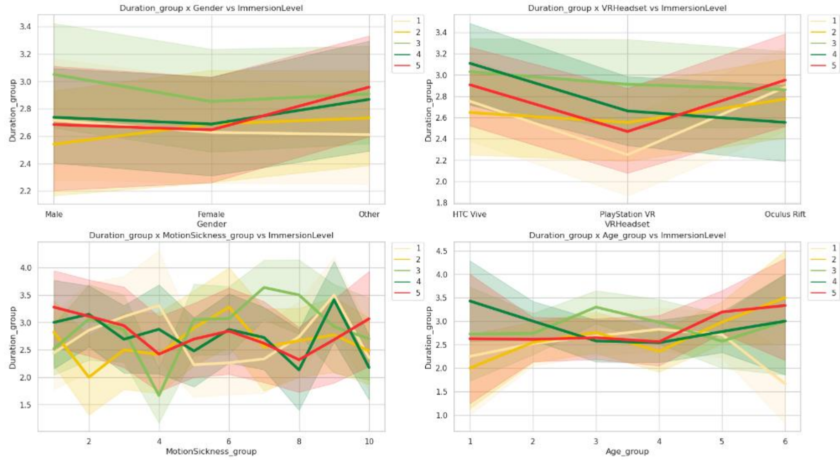

Figure 13 **Motion Sickness and Experience Quality**

Analyzing the relationship between VR headset usage and play duration reveals interesting usage patterns among different user demographics. Our findings indicate that the Oculus Rift headset provides the optimal experience for sessions lasting under 10 minutes and over 40 minutes, while the HTC Vive is preferred for durations ranging between 10-40 minutes. This suggests that different VR headsets may be optimized for specific session lengths, catering to the diverse preferences and usage habits of VR enthusiasts.

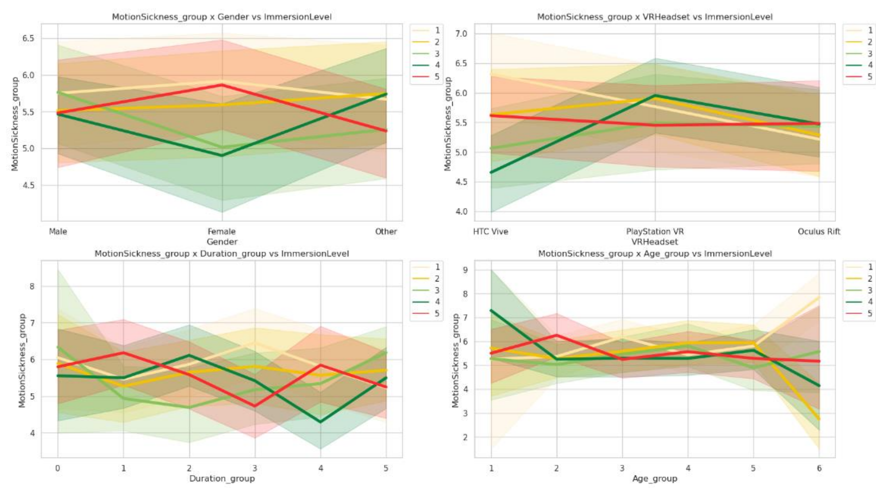

Figure 14 **VR Headset and Play Duration**

The intricate interplay between age, gender, VR headset preferences, play duration, and motion sickness has profound implications for the design and development of VR applications and experiences. By understanding and leveraging these interrelationships, developers can tailor VR experiences to better suit the preferences, comfort levels, and immersive needs of diverse user demographics.

Addressing the unique preferences and sensitivities of different demographic groups can enhance the accessibility, comfort, and enjoyment of VR experiences, ultimately fostering greater adoption and engagement among users. Moreover, ongoing research into the interrelationship between these factors is essential for advancing our understanding of user behavior in virtual environments and optimizing VR technology to meet the evolving needs of users worldwide.

Conclusion

In conclusion, this research provides valuable insights into the diverse dynamics of VR user experience, spanning user demographics, immersion levels, session characteristics, and motion sickness analysis. The findings underscore the nuanced interplay between various factors and their impact on the quality of VR experiences.

The demographic analysis reveals a predominant user base in the 30-40 age range, indicating a strong affinity for VR technology among young to middle-aged adults. Gender distribution is relatively balanced, although differences in immersion levels between genders suggest potential avenues for further exploration into gender-specific preferences and engagement levels.

Oculus Rift emerges as the preferred VR headset among users, likely due to its superior user experience. Longer play durations correlate positively with higher immersion levels, highlighting the importance of extended sessions in fostering deeper user engagement and immersion in VR environments.

Despite the widespread appeal of VR, motion sickness remains a notable challenge, with higher levels of motion sickness associated with reduced immersion rates. However, users aged 34-44 reported the lowest motion sickness levels and the most favorable overall experiences, hinting at age-related factors that may influence adaptation to VR environments.

The intricate relationships between age, VR headset usage, play duration, and immersion levels underscore the need for tailored approaches to VR development and user experience optimization. Understanding these dynamics can inform the design of more immersive and inclusive VR applications that cater to diverse user preferences and demographics.

In summary, this research contributes valuable insights into the multifaceted nature of VR user experience, laying the groundwork for future studies aimed at addressing key challenges and enhancing the overall quality and accessibility of VR technology for users across different demographics and preferences.

Declarations

Author Contributions

Conceptualization: R.A.P., and D.S.; Methodology: R.A.P.; Software: R.A.P.; Validation: R.A.P.; Formal Analysis: R.A.P.; Investigation: D.S.; Resources: R.A.P.; Data Curation: D.S.; Writing Original Draft Preparation: R.A.P.; Writing Review and Editing: R.A.P. and D.S.; Visualization: D.S.; All authors have read and agreed to the published version of the manuscript.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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