How the Cognitive Styles Affect the Immersive Experience: A Study of Video-Watching Experience in VR

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Abstract. In VR, the analog cinema experience is a common design method for video-watching function. However, will this approach increase user experience? We conducted 2 phases of experiments. First, from user interview, we found that the users' evaluation of the viewing experience in VR is polarization. Second, studies were carried out with 24 users to find what caused the big difference. Through experiments, we found that different cognitive styles affect the immersive experience of users in VR cinema video-watching, and the Spatial Presence has a more significant impact on the Sense of Being There than the other factors, thus, affecting immersion. Our findings suggest that the design of virtual scenes should consider the different cognitive styles of users, and our research provide insights into future research on user experience of video-watching in VR.

Keywords: Virtual reality · Cognitive styles · Video-watching · Immersion · Sense of Being There

1 Introduction

With the development of virtual reality technology and expansion of market, virtual reality devices are becoming everyday consumer items, and have provide a new approach to video-watching following the mobile devices, PC equipment, and cinema. Currently, the form of VR video-watching is mainly to imitate the environment and experience of cinema in reality, allowing users to watch movies in a virtual cinema without much input. The commercialization of VR cinema is mainly depending on the demand for video content and user experience that VR cinema could provide [1]. In terms of visual and auditory experience, the main reason that people go to cinema to watch movie is the shocking and immersive experience brought by the huge screen and the other facilities of cinema, which the other devices like mobile devices cannot offer. VR cinema achieve a virtual visual experience by putting the screen close to the human eye, building an "infinity" size of screen that is not constrained by the physical environment. As long as the screen is clear enough, the visual experience could surpass IMAX movies in cinema. Comparing to watching movies in cinema, people could use

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VR in more life scenes, such as at home, in car, or in other public place. VR expand the user scenarios for people who are looking for a movie experience at any time and place.

VR video can be divided into three categories according to user perspectives: cinematic effect video, panoramic video and panoramic interactive video. Cinematic effect video can be transcoded from traditional video such as film and television content. Panoramic video refers to the video that is recorded by the professional panoramic camera and then processed by the computer for post-processing. The video that can realize the three-dimensional (3D) space that can display the 360° panoramic image for the audience. Panoramic interactive video is a true virtual reality video of both immersion and interactivity. However, because of the high production cost and the immature technology, the panoramic videos are few and short. The average duration is about 3 min. The panoramic video cannot meet the need of users both in quantity and quality. Thus, the cinematic effect video with low production cost has become the main consumer content in VR video-viewing function [2].

Our experiments were based on a VR headset, and the experimental video are cinematic effect video and panoramic video. The VR headset we used is iQUT, a one-machine VR headset launched in China market and which main feature is video-watching. It can provide users virtual scenes as film theater and has rich video contents online. We hope to explore whether the experience in VR video-watching can reach the excellent immersive experience of cinema, and to further discover user needs so as to refine the user experience of video-watching in VR.

Our research is divided into two sections, the face to face interview and the user testing. We first conducted an in-depth interview with users who have VR machine. We found that users who purchase VR devices pay more attention to the viewing experience, and have a higher frequency of movie viewing in the cinema. When they pursue large-screen experience, IMAX will be preferred. For them, online viewing of movies is the main purpose to use VR devices. However, users' evaluation to the experience of VR video watching is polarization. Some users feel that they are immersed in the scene and feel like watching movie at cinema, while some users think that the VR cinema effect is far from reality. Moreover, these two types of people have different tolerances for the equipment errors and show different preferences to the device. Therefore, we hope to study what factors affect attitudes and experiences of users besides video content and performance of hardware. At present, there is few researches on the evaluation of video-watching experience in VR. Our research mainly focused on the Sense of Being There (Presence) of users to evaluate the immersion of VR video-viewing experience. In the second section of our research, we invited 24 users, half of which had experienced VR while the others had no experience with VR. First, we measure the user's cognitive style to divide users into two groups by their different cognitive style. Then we measured the two user groups' Sense of Being There by the IPQ scale (Igroup Presence Questionnaire) [3] to find whether the user's cognitive style had an impact on the immersion of VR video-viewing experience. Finally, we analyzed the user immersive experience and product usability satisfaction data, explored the relationship between VR product satisfaction and user experience, and identified the most important subjective sensory indicators that affect the product experience. Compared with Experienced Realism and Involvement, Spatial Presence most affects user immersion.

From our study, we conclude that the user's cognitive style could affect the user's immersion in VR video-viewing. There is a significant difference between users of the field- independence and the field-dependence in the Sense of Being There and Experienced Realism. This difference suggests that to construct the scenes of VR video-viewing, even the various other scenes in VR, it is necessary to consider different cognitive styles of users, for the experience differences caused by different cognitive styles.

2 Literature Review

2.1 The Evaluation of Immersion and Presence

Immersion is the objective degree to which a VR system and application projects stimuli onto the sensory receptors of users in a way that is extensive, matching, surrounding, vivid, interactive, and plot informing [4]. Presence, is a sense of "being there" inside a space. In Jason's opinion, immersion is technical while the presence is internal psychological. Presence is a function of both the user and immersion; however, presence is limited by immersion; the greater immersion a system/application provides, the greater potential for a user to feel present in that virtual world [5].

From the perspective of user perception, to assess the immersion of the VR video-watching experience, it can be reflected in the user's sense of presence using the product. Schubert, Friedmann and Regenbrecht established the IPQ scale (Igroup Presence Questionnaire) to evaluate the "Sense of Being There". The IPQ has three subscales and one additional general item not belonging to a subscale. The three subscales emerged from principal component analyses and can be regarded as fairly independent factors. They are:

1. Spatial Presence - the sense of being physically present in the VE.
2. Involvement - measuring the attention devoted to the VE and the involvement experienced.
3. Experienced Realism - measuring the subjective experience of realism in the VE.

The additional general item assesses the general "Sense of Being There" and has high loadings on all three factors [6].

2.2 The Evaluation of Cognitive Style

The evaluation methods of user experience of hardware products are mainly qualitative, quantitative methods, and the combination of the two is the most widely used. Mahlke believes that the user experience should include cognitive and emotional factors. Cognitive factors include technical and non-technical factors of human-computer interaction: technical factors such as system usefulness and ease of use; non-technical factors such as enjoyment and visual aesthetics. Emotional factors include direct and indirect emotional responses; they also include more complex emotional outcomes produced by cognitive processes [12, 13]. In terms of emotions, the user's satisfaction with the product's experience directly affects the user's attitude and willingness to the

product. Kuniavsky Mike believes that it is difficult to accurately portray the user experience because it changes dynamically as the environment changes or interacts. Therefore, different experts and scholars have different definitions of user experience factors because of their different knowledge structures and cognitive abilities. But in general, they are mostly elaborated from the perspective of design and application [14]. John Brooke's System Usability Scale (SUS) is widely used in usability evaluation because of its simple and intuitive problems and small samples [15].

2.3 The Evaluation of Product Usability

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2.4 VR One-Machine Headsets with Video-Watching Function in China Market

At present, from sales data of China's biggest e-commerce platforms Tmall (https://www.tmall.com/) and JD (https://www.jd.com/), the mainstream of the middle and high-end brands VR One-machine headsets are Pico Neo, HTC Vive Focus, Xiao mi and iQUT. More consumers choose to buy high-end brand products, no longer blindly pursue low prices, and the user requirements for the quality of experience have increased. The high-end brand VR One-machine often provides users with a better experience at a relatively moderate price, becoming the most cost-effective choice for consumers. At the end of 2017, HTC Vive Focus and Pico Neo VR all-in-one machines were released and sold. In May 2018, Oculus Go was launched overseas, followed by its domestic version of Xiaomi VR machine on June 1. Various prices and brand VR continue to enter the Chinese market, providing consumers with more choices [16, 17]. All of the four mainstream one-machine Headsets have the basic functions of watching videos and playing games. Among them, iQUT has a 4K screen which could provide a clearer visual experience than the others. The default video-playing environment of iQUT is the giant screen, and provide other three modes: the universe starry sky, the home theater, and the normal cinema. It is convenient to directly watch videos online.

HTC Focus comes with a VIVE Video player that has two scenes, cinema and nature. The default is cinema mode, which is a relatively empty lobby with a sense of technology. The player is only used to play local files. Xiaomi's video center defaults to the cinema environment and the scene cannot be replaced. The viewing position is similar to iQUT, and can also access videos online. Both iQUT and Xiaomi have their own web players. On the video playing interface, in addition to the basic functions of Xiaomi, iQUT also has voice command functions, including play, pause, fast forward and backward, volume addition and subtraction, etc. Because of the specific market orientation and the significant advantages in video-watching functions, we choose iQUT as the experimental equipment for VR video-watching study.

3 Research Design

We designed a mixed research methodology to answer our research questions, including interviews and scale tests for users. We conducted 2 phases of research. First, by the semi-structured deep interview, we discovered the expectations and reasons for users to pursue the VR devices, and their general and video-viewing experience after pursuing. In the second phase of the study, we mainly use scales to measure and analyze the user's viewing experience indicators, comparing the Sense of Being There of users with different cognitive styles, to evaluate the immersive experience of VR video-viewing.

3.1 Study 1: Interviews of VR Users

To recruit participants for our study, we used an online questionnaire to find the potential participants, then invited who meet the criteria to come to join the research at our laboratory. We conducted 1 to 1 interview until we reached data saturation after the 10th interview. The participants consisted of three women and seven men between 19 and 40 years old, with a median age of 29. All of them have at least one VR device, and they all locate in Beijing, China. During the interview sessions, we asked the participants about their feelings of using VR and the experience of VR video-viewing, the selection criteria of VR device for video viewing and the purpose of their purchase, moreover, the consumption in VR. Then we asked them to wear iQUT and observed their behavior and operation.

From the interview section, we found that:

1. Pursuing a better viewing experience and the curiosity about new technology are the main buying motive of VR hardware.
2. The initial factors affecting user purchases are the hardware indicators such as device clarity and sound effects, and equipment convenience, content richness, and social reputation can also influence user's decision.
3. When using the same hardware, individual user experience is significantly different, which is mainly caused by non-video viewing experience such as comfort (equipment wearing and sitting posture) and physical cause (Motion sickness, dry eyes).

In general, the interview indicated that the differences of individual experience are obvious, and the attitude of watching movies is seriously divided. Through previous interviews, we wanted to explore in the following study: whether the viewing scene has an impact on the user's differentiated experience? How the different cognitive styles of the user affect the user experience? How to improve the immersion of viewing experience to satisfy users' satisfaction with VR products.

3.2 The Quantitative Study Towards Cognitive Style

Through interviews, we found that different users have great differences in the perceptions of virtual theater scenes and experiences in VR. Some users think that video watching in VR HMD has the feeling of watching movies in the cinema, but other users think that only the scenes are designed similar to cinema. Why do the same scenes make such a big difference? We tried to find answers from people's cognitive styles. We invited 24 users and divided them into two groups by conducting an Embedded Figure Test (EFT). After completing tasks such as watching movies in VR, participants were asked to fill the IPQ scale and the SUS scale.

3.3 Participants

Participants were randomly selected from the movie watching crowd, who watch movie at least once a week, to avoid research results that are affected by whether the users like watching movie or not. According to the mainstream age distribution of movie watching population (data was from iQIYI video data system), the participants were chosen from the age of 20 to 40, and the average age was 26. In order to exclude the experimental results from the user experience of using the device, we limited the user experience of using VR: 8 one-machine VR headset users, 8 VR HMD (works with PC or console) and VR glasses (like Google Cardboard) users, and 8 people who had no experience of VR. First, every participant needed to complete Embedded Figures Test (revised by Beijing normal university's psychology department, the internal reliability of the test is 0.90, and rod box test score is 0.49). According to the revised evaluation method (Qingmao Meng, etc., 1988), the user is divided into the field independent and the field-dependent by their scores, including 13 field-independent and 11 field-dependent Participants.

3.4 Research Material

In our study, the experimental equipment we used is iQUT, designed and produced by iQIYI, and it is a Headset that doesn't need a console or PC to work with. iQUT has launched in China market and already have a certain number of users. In terms of operation, the device uses a 3 DOF remote control and can be operated by using a head control in some specific scenes. In terms of screen, the model has a 4K resolution screen. In terms of video-viewing, the device builds a virtual cinema effect, visually close to the cinema. The user is "sitting" in the cinema auditorium and can take a 360° view of the cinema scene. The brightness of the surrounding environment in the cinema scene can be adjusted by the users (see Fig. 1).

Fig. 1. The cinematic effect of giant screen mode in iQUT, visually close to the cinema in reality. The user is "sitting" in the cinema auditorium and can take a 360° view of the environment.

In terms of content, users can watch movies, animations, and TV dramas online. Except the panoramic interactive video customized for VR, most of the video content is also available on the mobile device, PC, TV, etc. This provides convenience for us to compare the viewing experience between VR and other devices with the same video contents. Finally, we chose the 2D video Later Us and panoramic video Fishing Village as the experimental content. In the test, we connected iQUT to the computer through a screen capture software to observe the view and operation of the users in the VR device (see Fig. 2).

Fig. 2. Participants were wearing iQUT and their view and operation in the virtual scene could be observed by the staff from a PC which was connected to iQUT

3.5 Evaluation Tool

The Igroup Presence Questionnaire (IPQ) scale, compiled by Schubert, Friedmann, and Regenbrecht (2006), is used to assess students' Sense of Presence when using immersive virtual reality scenes. The scale is 7 points likert scale, having a total of 14

items in four dimensions. The internal consistency reliability of IPQ scale of is 0.87. Through the measurement, we can understand the immersive experience of VR device in Spatial Presence, Involvement, Experienced Realism and Presence.

SUS scale is used to evaluate the usability of the product. The questions in the scale were adjusted for the VR device. A number of empirical studies have shown that SUS works better. Tullis et al. have shown that when the sample size is limited, SUS can achieve the fastest results, and a large sample of studies (Bangor 2008) shows that the reliability coefficient of SUS is 0.91. The scale can understand the user's assessment of VR device availability, ensures device availability levels, eliminates the impact of device operations on the user's viewing experience, and understands whether the immersive experience affects user impact on product availability satisfaction.

3.6 Experimental Procedure

In this study, participants were divided into two groups according to the Embedded Figure Test results. After entering the conference room, the staff explained the purpose and procedure of the experiment and help participants to adjust the wearing of the VR equipment to ensure their comfort. After the VR device is activated and the viewing of picture is clear, participants were asked to learn the tutorial of VR, to familiarize the operation of the handle, the head control and the voice control. Then, participants were asked to find the 8K panoramic video Fishing Village and watch it. After the viewing, the user was asked to find the Later Us in the future theater, and to watch the movie for 5 min. During their watching, staff were observing their facial expression. After the viewing, participants were asked to answer the IPQ scale according to their viewing experience, and then to answer the SUS scale according to the overall experience of the usage. Finally, a brief interview was conducted to understand the participant's viewing behavior and emotion.

4 Findings

4.1 The Influence of Different Cognitive Styles on the Presence of Users After Watching Movies

Children The scores of the sense of presence after viewing the video by different cognitive styles can be seen in Table 1.

Table 1. Independent group t-test between field-dependent and field-independent.

	Field-dependent		Field-independent		T-test
	M	SD	M	SD	
Spatial Presence	3.06	0.62	3.02	1.10	ns
Presence	3.08	1.32	4.73	1.27	3.10**
Involvement	3.40	0.98	3.09	0.79	ns
Experienced Realism	2.63	0.52	4.00	0.47	2.68*

*p < .05, **p < .01, ns. = not significant

Note: M = Mean. SD = Standard Deviation.

There is a significant difference between the field-independents and the field-dependents in Presence and Experienced Realism scores after watching movies in VR. The field-independent users (M = 3.08, SD = 1.32) experience worse than field-dependent users (M = 4.73, SD = 1.27) in terms of Presence ($t = 3.10$, $p < 0.01$). Field-independent users (M = 2.63, SD = 0.52) experience worse than field-dependent users (M = 4.00, SD = 0.47) in terms of Experienced Realism ($t = 2.68$, $p < 0.05$). It shows that in the VR cinema viewing mode of iQUT, the stronger the field-independent feature, the worse the sense of Presence and Experienced Realism, and the lower the experience scores. This means the user's preferred cognitive style has an impact on the user's immersive experience. For field-dependent users, virtual reality scenes are more likely to give users an immersive experience, while field-independent users are less affected by the virtual environment. This result is consistent with the user cognitive processing theory. Previous studies on field-dependent cognitive styles have shown that individuals with different cognitive styles tend to use different strategies in the information processing process, and field-independents prefer analysis strategies, while field-dependents prefer the overall strategy. Field-dependent style users tend to rely on the external environment to make judgments, that is, rely on the original field structure, and are not good at providing new structures. The external reference is similar to the real scene, and the dependent user processes it based on this overall information, resulting in a more intense experienced realism and presence [11].

There is no significant difference between the field-independent and the field-dependent in Spatial Presence and Involvement scores after watching movie.

Between field-independent users (M = 3.06, SD = 0.62) and field-dependent users (M = 3.02, SD = 1.10), there is no difference in Spatial Presence. Field-independent users (M = 3.40, SD = 0.98) and field-dependent users (M = 3.09, SD = 0.79) have no difference in involvement (Table 1). This result might be affected by the experimental material used in the study, because the test viewing content did not involve panoramic interactive video, users didn't need interaction during the viewing process, and there was no interactive experience operation. Therefore, the viewing process didn't involve the user's exploration of the virtual space, resulting in no significant difference in involvement. This deserves more attention in the choice of content in the future test.

4.2 The Relationship Between Immersion and Usability

According to the correlation analysis by scores of different dimensions of the immersion scale and SUS scores in Table 2.

Table 2. Pearson correlations of the SUS scale and IPQ scale

		Spatial Presence	Experienced Realism	Presence	Spatial Presence
SUS scale	Pearson correlation	0.38	−0.06	0.057	0.48*
	Sig. (2-tailed)	0.07	0.80	0.793	0.017
	N	24	24	24	24

*Correlation is significant at the 0.05 level

There was a significant positive correlation between the Spatial Presence and the satisfaction of the products ($r = 0.48$, $p < 0.05$). This is reflected by the SUS scale score. It shows that the better the Spatial Presence is, the higher the satisfaction of the product. That is to say, user experience satisfaction is highly affected by the subjective experience of Spatial Presence.

5 Discussion

VR viewing allows users to experience high-quality viewing experience without leaving their homes, which is currently not available on the other mobile devices. The cost of building an IMAX auditorium in the real world is huge, and it takes time to popularize the viewing effect of the giant screen. We believe that the development space of VR video-viewing is huge, and enhancing the product viewing experience is of great significance to the application of VR devices. Our research attempted to understand the reasons for users' cognitive differences in the virtual theater scenarios, and the expectations of users for VR interactions. Our findings provide insights into future research on recognition and experience design of VR.

5.1 The Impact of High Fidelity Virtual Scene on Field-Independent Users

The construction virtual scene based on objective reality has a positive effect on the field-dependent users, but for the field-independent users, it might affect the user's cognitive judgment. Field-independent users tend to use analytical processing strategies, and they are good at analyzing organized fields. Because the VR cinema scene provides a true benchmark for the virtual environments - Cinema, and when the experience of virtual environment and the reality have details of the difference (such as the seat height, the theater audience, etc.), it weakens the user's realism experience. The more high-fidelity visual effects, the other dimensions of the user experience must also achieve the same high fidelity, in order to meet the expectations of the body which is enhanced by the visual effect. Therefore, in the subsequent research, non-high-fidelity style design, such as low poly style, can be provided to the experiment to see if this kind of scenes can enhance the viewing experience of field-independent users.

5.2 The EFT Methods and Cognitive Style

In our study, we divided users into field-independent and field-dependent types, this is a dichotomy study method. In the measurement of cognitive style, we categorized the research methods used in previous articles on field independent/field-dependent cognitive style research. In 75 articles, there are 35 articles in quantitative research, accounting for 46.6% of the total number of articles, and only 2 articles in qualitative research and mixed research, accounting for only 5.4% of the total. In the study of cognitive style, quantitative research has been widely applied; qualitative research and mixed research methods have gradually gained attention in recent years, but they are not used much. There are 21 articles using the measurement tools for the Embedded

Figures Test (EFT) [18] compiled by the Department of Psychology, Beijing Normal University in December 1981. These show that it is feasible to divide the cognitive style into field-independence and field-dependence.

Individual differences in cognitive style are empirically reflected in brain science. The differences in cognitive styles are different in brain science, the consistency of the overall strategy, the volatility of brain regions, and the distribution of left and right brain processing. In the process of face cognition, on the initial stage of face recognition, field-dependents are faster than field-independents in the starting face recognition processing [19].

Cognitive style individual outcomes are normally distributed, but may change with age, and the same person may have two or more cognitive styles. Brown pointed out that it is unreasonable to regard the lack of field independence as the existence of field dependence, because they do not have complementary relationships. People may have strong field-independent style and strong field-dependent style at the same time, but they will show different types of cognitive styles in different occasions [20]. Skehan pointed out that the opposite of field independence or field-dependence may be non-field-independent or non-field-dependent. Field-independence and field-dependence can be represented by two independent continuums, each of which represents field-independent and non-field- independent, field-dependent and non-field-dependent [21]. In EFT, the division of field- independence and field-dependence is mainly based on the level of scores, people are either field-independent or field-dependent. In fact, a person may have two or more cognitive styles at the same time, but in a certain situation, they will only show a style that matches this occasion. Therefore, dividing people into field-independent and field-dependent types cannot meet the need of people's flexible transformation style.

5.3 The Video Content Used for Testing Did not Fully Demonstrate the Characteristics of VR

The 3D movie we can access is not satisfactory because of the serious picture delay and the poor 3D effect, while the 2D content playing experience is smooth and clear, and is closer to the cinema viewing effect, so the video content used in our test is mainly 2D videos. However, the 2D videos cannot highlight the absolute advantage of VR video-viewing, which is the effect that other mobile devices can't provide, such as 3D stereo effect, panoramic effect, and interactivity. The VR products have three characteristics of immersion, imagination and interactivity. VR products are characterized by immersion, imagination and interactivity. Immersion is what makes the user feel that they are part of the virtual world created by the computer system, allowing the user to become a participant from the observer, immersing in it and participating in the activities of the virtual world. Interactivity is the natural degree to which a user can manipulate an object within a simulated environment and get feedback from the environment. Imagination is imaginative and illusory, and its content varies according to the subject. The 2D video content lacks immersion and interactivity, and the virtual cinema scenes might also limit the user's imagination. These may have an impact on our assessment of user satisfaction and immersion in the video-watching experience. Moreover, with the improvement of VR devices hardware and the richness of VR

panoramic interactive video, we may wonder whether different cognitive styles have the same impact on the panoramic interactive video, if the user with different cognitive style will experience the difference in polarization or not. If not, what is the reason to eliminate this experience gap. Although we did not answer these questions at this time, this work might open the way for the further studies in this area.

5.4 The Limitations of Technology and Interaction of the Experimental Device

According to the result of our study, user experience satisfaction is highly affected by the subjective experience of Spatial Presence. We think this is partly due to the user's dissatisfaction with the operation in virtual world when using the product. Through interviews and observations, we found that the users spontaneously attempted to fast forward the movie by shaking the remote control instead of the traditional click and slide operation. This indicated that as immersed in the virtual environment, people would take a more natural way of interaction by human instinct. The sense of Spatial Presence is mainly the user's judgment that he is real in the virtual space of VR, so he will try to operate the things in the virtual space directly with the action in reality. In terms of input and interactive devices, the current mainstream interaction methods are handle buttons and sliding operations, and are still in the exploration stage for more complicated gesture recognition and motion capture. In the video-viewing function design of VR, it is necessary to further optimize the natural interaction according to the user behavior to enhance the user's sense of Spatial Presence, so as to facilitate the immersion of VR.

5.5 The Potential Social Needs of Users in Video-Viewing

Through interviews, we found that the cinema has natural sociability, and it is a social place for many users. Sometimes, going to the movies together is a social act, even greater than the cinema's superior viewing experience. People who watch movie together have a common topic, which can continue to discuss and communicate at or after watching, while VR is only a medium of video playing. From the user's point of view, the virtual cinema in the VR world looks just like the offline cinema, and the viewing mode and experience are very similar. When users wear the VR device, going to the virtual cinema, they naturally think about everything related to the offline cinema, including the social behavior, but the VR devices are currently unable to meet their communication needs. This also affects the user's evaluation of the VR viewing experience. Moreover, the cinema can't fully meet the users' communication needs. The quiet viewing environment constrains the form of communication between the audiences. People can only make a modest laughter or exclamation when the movie plays to the key picture, but no more than that. It is believed that the functions of interaction and socialization in the follow-up VR cinema will certainly make up for the pain points of the limited communication in the offline cinema and become the core advantage of VR movie theater, bringing more vivid and interesting viewing experience to users.

5.6 Future Work

Based on a large number of experimental studies and evidence from observations, Witkin et al. proposed a theoretical model of interpreting field-dependent and field-independent cognitive styles—a psychological differentiation model, in which the differentiation of individuals is in various fields of psychological activity, and field-dependence, and field-independence are the result of individual differentiation in the field of structured cognitive function [22]. Differentiation theory believes that in cognitive activities, it is reflected in the difference between field-dependence and field-independence and manifested as one side of brain function in neurophysiology. According to this theory, it is predicted that field-dependence and field-independence are related to the degree of functional differentiation of the two hemispheres [23]. In this study, we mainly measured the user's immersion and product usability satisfaction by scales, and only investigated two aspects of the user experience. In the future work can look at other aspects of behavior on user's behavior data and user physiological indicators. Therefore, the future work can more fully understand the impact of scene and cognitive style preferences on the VR viewing experience through other methods such as user behavior data and user physiological indicators. For example, whether different cognitive style individuals have differentiation in brain function during movie viewing, and Will this differentiation be affected by different VR content types.

In the interview, we learned that the high immersive viewing experience will allow users to have a stronger emotional response and have a deeper memory of the content. Future work can also look at the emotions and memory of user in VR video-viewing and analyze their impact on user experience. Whether a stronger emotional experience will have an impact on product satisfaction, and how the presentation of VR content will positively contribute to user memory. Our work is among the early work of VR video-viewing research, and we hope that our findings act as a springboard for future VR video-viewing research.

6 Conclusion

Video-viewing in VR devices has been vigorously developed in recent years and is becoming more and more popular among users, and major VR hardware manufacturers are deploying the VR device market in China. At present, VR-related research mainly focuses on the nature, characteristics, principles, application prospects and commercial value of virtual reality, research on VR viewing experience is very rare. We hope our study will take the first step in the video-viewing experience in VR and provide insight for future study. We use a combination of qualitative and quantitative methods to investigate the gap between user's viewing experience in VR virtual cinema, explore what causes this gap, and how to optimize the user experience through design. We assumed that the user experience difference may be affected by the user's cognitive style preference and used the Embedded Figure Test to measure the user's cognitive style. Then we asked the users to watch the video contents we prepared for the experiment. After watching, we asked the users to complete the IPQ scale according to the viewing experience, and to answer the SUS scale according to the product

experience. The staff observed the user's operational behavior and emotional feedback during the whole process of viewing and using the VR device.

Our study found that under the VR cinema viewing mode which is built according to the actual cinema, the stronger the field-independent feature, the worse the sense of Presence and Experienced Realism, and the lower the experience score. This means the user's preferred cognitive style has an impact on the user's immersive experience. For field-dependent users, virtual reality scenes are more likely to give users an immersive experience, while field-independent users are less affected by the virtual environment. Moreover, the Spatial Presence has a more significant impact on the user experience, the better the Spatial Presence is, the higher the satisfaction of the product. Our findings suggest that the design of virtual scenes should consider the different cognitive styles of users and provide insights into future research.

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