Research on the Short-term Memory Effects on VR Tour Games

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ABSTRACT

This thesis mainly studies the impact of short-term memory in VR tour games on users. The thesis is based on VR tour games and short-term memory, using the literature research method, the practical research method, and the investigation method. First, the author designs and makes VR tour games on the Beijing-Hangzhou Grand Canal, and then conducts a questionnaire survey and designs a control experiment. The experiment explores the differences of the short-term memory level of individuals between the normal environment and the VR tour game environment. It verifies whether the influential hypothesis proposed by the research is correct. Research conclusions show that: VR tour games have an impact on short-term memory. Compared with the normal environment, the subjects have better performance in the VR tour game mode and can maintain a high short-term memory level for a longer time. Its conclusions should promote the cultural propaganda of scenic spots and provide theoretical support for tourists’ short-term memory of scenic spots culture.

Key words: VR tour game, Short-term memory, Gamification, Memory encoding

1. INTRODUCTION

1.1 Research background and purpose

The rapid development of virtual reality (VR) technology has enabled games to have more vivid forms of expression. Its high immersion and high sense of realism promote the better application of gamification, such as cultural promotion and scene simulation. Lugrin built a museum based on the VR environment. The VR museum supports 100 users online at the same time and also includes indoor and outdoor space design [1]. Cheng A then, By improving the existing 3D game Crystallize and establishing a VR system for Japanese learning, the author added a bowing session with Japanese cultural characteristics to the system, which enhanced the users’ sense of participation and the participants’ language learning efficiency [2]. Digital experiences are also increasingly implemented as communication and tour strategies, with important information presented in immersive or interactive formats such as AR, VR, or 3D simulation (Nayyar, Mahapatra, Le and Suseendran, 2018). In an ordinary tourist environment, people can only learn about historical culture by viewing real objects, two-dimensional text, pictures, or images, especially historical scenes and cultural relics that have disappeared. Standard tourist methods can no longer meet people’s daily needs. Tourism departments in many regions use virtual reality technology to spread local culture or educate tourists to protect heritage. These methods have been implemented in museums as a comprehensive and interactive learning experience (Kang&Yang, 2020). With the rapid development and application of virtual reality games in the commercial field in recent...
years, the cognitive publicity of tourism culture using gamified thinking has attracted attention. The practice of gamification is increasing dramatically in our daily lives, but there is only a little research to test the hypothetical impact of VR tour games on short-term memory.

1.2 Research methods

This paper will adopt the literature research method, the practical research method, and the survey method. First, the author searches for the information and conducts a case study on a theoretical basis. Based on the existing research theories, the current short-term memory, VR tour games, and the theory of memory promotion theory are analyzed. A VR tour game is designed for experimental analysis and verification. The thesis experiment quantifies the level of short-term memory to obtain data. It uses SPSS analysis to determine the importance, feasibility, and necessity of the relevant theories studied in this thesis. In the experiment, the same cognitive content is compared with the common cognitive model and the cognitive model of virtual tour games to demonstrate whether VR tour games impact short-term memory (Fig. 1).

2. THEORETICAL INVESTIGATION

2.1 The concept of short-term memory

Memory is part of the brain’s processing of various information, including encoding, storing, and extracting visual, auditory, and tactile information, and is characterized by repeatability [3]. The length of time can be divided into sensory memory, short-term memory, and long-term memory [4]. In our daily activities, we often need to temporarily store and rehearse the information in our mind and form a short-term memory system based on visual space and other materials in a short period. This flexible ability to store and manipulate information related to activities in different areas of the brain are called "short-term memory" [5]. Short-term memory is characterized by activated long-term memory or composed of recently perceived items (Jonides et al., 2008). There are many ways for humans to obtain external information. External information first enters sensory memory through different sensory channels. Sensory memory from vision is called image memory, and sensory memory from sound is called audiovisual memory. Sensory memory contains a large amount of information, but its retention time is usually only a few seconds, and it will quickly disappear. Memory is the process of encoding. "Encoding" refers to the process of placing the information to be remembered in an easily searchable information library. "Imaging" is the process of memorizing language information through visual images. These processes are all interrelated. A group of closely related information units is called an image or track. When the image is in short-term storage, closely related information in the long-term storage is activated and entered into the short-term storage [6] (Fig. 2).

2.2 Concept of the VR tour game

VR tour game is the application of virtual reality
technology in tourism, based on the development of information technology [7]. It builds a virtual environment through computer graphics processing technology, and lets visitors enter the virtual scene and feel the changes in the virtual scene through various sensing devices. The VR tour game involves 360° panoramic photography technology, 3D modeling technology, virtual interaction technology, sensor technology, Internet technology, and many other technologies [8]. It provides users with various intuitive and natural real-time perception and interaction methods such as vision, hearing, and touch at the same time. Maximum convenience for the user’s operation [9]. VR tour games can embed in-depth cultural content into game content and provide players with a virtual interactive experience with local cultural characteristics. It is no longer a traditional publicity and video marketing method that displays text, which has stimulated tourists’ interest in participating. It not only has a strong sense of substitution, but also the real familiar environment which can give the game an immersive and safe experience [10]. Since tourism is a product that ultimately leads to a real experience, purely analytical services and sensibility cannot promote the direct connection between users and tourist destinations. The VR tour game adopts the trinity marketing method of sensory stimulation, cultural experience, and information service, taking into account the user’s perceptual and rational needs, and can successfully stimulate the connection between the user and the tourist destination (Fig. 3-4).
2.3 The principle of VR tour games to promote short-term memory

VR technology has penetrated many application fields such as education, medicine, engineering, space exploration, and communication, and virtual reality technology is widely used in memory rehabilitation [11]. Intervention changes the role of the participant. It makes the participant no longer serve as an information channel, but take the initiative to encode, classify, interpret, store, extract and decode various information through their perception of information. And feedback after processing [12]. Virtual reality games are safe and interesting, and can provide rich stimuli, timely information feedback, and sound experience effects. More different scenarios and setting up different stimulation schemes have achieved good results in the fields of attention deficit, spatial perception impairment, memory impairment, Etc [13].

The simulation environment of the VR tour game provides a variety of sensory stimulation, which increases the activation of dopamine and neurotransmitter of the cholinergic system in the experiencer. It enhances the neurotransmitter conduction function of the dopamine and cholinergic system. The experiencer’s cerebral cortex is thickened, and a large number of axons and cell bodies are produced after the increase in dendritic branches. Therefore, the enhancement of spatial information coding and retrieval capabilities has promoted the initiation of procedural memory, allowing people to code during activities and enhance memory storage (Fig. 5).

The perceptual imaging in the VR tour game helps to encode and retell information and strengthen the memory effect. In memory, we usually encode information through auditory encoding, visual encoding, and semantic encoding. The perceptual interaction in the VR tour game experience brings visual, auditory, and tactile visual graphic imaging to the experiencer, structuring fragmented knowledge. The experiencers form a self-referential effect after sensory registration to actively generate information. This information is re-encoded into a short-term memory system with limited capacity and a slightly longer retention time. Passing through the game link is also a kind of test and inspection. The information is extracted, retold, and reprocessed to promote the transformation of short-term memory and form a state of high short-term memory level (Fig. 6).

3. EMPIRICAL STUDY

3.1 The design goal of the VR tour game of the Grand Canal

This VR tour game is designed for the history and culture of the Beijing–Hangzhou Grand Canal. The simulation restores the historical scenes and stories and allows the experiencers to understand the relevant historical culture through VR tour games quickly. Through the design of comparative experiments, the impact of VR tour games on the short-term memory of the subjects is comparatively explored. It is hoped that these practical studies will investigate the impact of VR tour
games on short-term memory and provide effective empirical data to develop VR tour games.

3.2 Design Ideas for VR Touring Game of Beijing–Hangzhou Grand Canal

According to the cultural context and content structure of the Beijing–Hangzhou Grand Canal cultural belt, the Beijing–Hangzhou Grand Canal is mainline, and the cultural places on the Beijing–Hangzhou Grand Canal are displayed one by one by regional division. The game consists of different scenes, and different settings in the scene determine the playability of the level. The level constructs the space and environment in the game. The level and the scene are inseparable. The level includes the scene and the game objectives, plot, and various objects in the game. Different options go to different historical segments, enhance user experience, and narrow the distance between culture and modern people (Fig. 7).

3.3 The design and production process of the VR tour game of the Beijing–Hangzhou Grand Canal

This design combines the theory of Chapter 2 and refers to the help of virtual reality for memory. It uses Unity3D game engine, 3DMax modeling software, Photoshop image editing software, Arduino single-chip microcomputer, biosensor, and many other software and hardware technologies to design a virtual reality game for visiting the Beijing–Hangzhou Grand Canal. This game is developed in the Windows 10 system environment. The game uses a first-person perspective, including scenes composed of the natural environments. All interface elements in Unity3D are in the Canvas component. Select the Canvas rendering mode as world space, adjust the canvas size and direction, convert the model file and export it to FBX format with information such as pictures and animations (Fig. 8-10).

Click on the main interface to start the game, and a selection interface appears, which contains
three modules: history module, river section module, and sightseeing module. Users can choose any module to start according to their interests. Then, the user clicks on the main interface, and the selection interface appears and can be selected at any time through the handle, which adds questions and answers, task games, testing, etc (Fig. 11–12).

In production, model import and interactive program settings (including import settings for identifying images, basic material parameters, logic programming, lighting scene debugging, background music settings, etc.) are tested. After debugging and modification, the final version has been completed. We can use HTC VIVE to enjoy it directly (Fig. 13–14).

4. RESEARCH AND ANALYSIS

4.1 Research questions

The question of this research is whether VR tour games have an impact on short-term memory. Due to the limitations of the research process, this research only conducts experiments on the games developed in this article, and more related experiments will be carried out in the future.

This research makes hypothetical conclusions: 1) Compared with the ordinary environment, the
participants have better memory performance in the VR tour game environment; 2) Compared with the ordinary environment, the participants tour the game in VR. The environment can maintain a high short-term memory level for a longer time. 2) Compared with the ordinary environment, the participants can maintain a high short-term memory level for a longer time in the VR tour game environment. We designed a comparative experiment for this hypothesis and concluded by analyzing the participants’ performance data in the experiment. It is hoped that through these experiments and studies, it can be verified that the VR tour game has a beneficial effect on short-term memory and can form a state of high short-term memory level. It can achieve sound cultural propaganda effects and provide effective empirical data to develop VR tour games in scenic spots.

In the experiment, we collected test data from 62 volunteers. It is assumed that the virtual reality experimental group has a significant improvement in short-term visual space memory compared with the control group and can maintain a high short-term memory level for a longer period.

(1) Original hypothesis (H0): The memory effect difference between VR tour games and ordinary environment tours is zero. H0: U1−U2=0

(2) Alternative hypothesis (H1): The memory effect difference between VR tour games and ordinary environment tour is not zero. H1: U1−U2≠0

4.2 Questionnaire design

The test sets up ten questions to verify the memory effect of the historical content, which is a percentage system. It sets questions about the historical and cultural knowledge of the Grand Canal displayed in the scenic spot. The survey method of the test is the field test verification 5 minutes after the tour and 30 minutes after the tour. The short-term memory test is a screening test designed to measure a person’s ability to store and retrieve information in a short time. Memory span is the best way to test short-term memory. This study established the following questionnaire based on the principles of the Benton Visual Retention Short-term Memory Test. Participants did not understand the history and culture of the Grand Canal. This questionnaire is set to allow game users to verify the memory effect after understanding the culture of the Grand Canal (Table 1).

4.3 Descriptive analysis

This research procedure enlisted 62 volunteers to verify the research questions, and they were divided into experimental groups and control groups. The average age is 22 years old, undergraduate degree, normal vision or corrected vision, and no knowledge of the history of the Beijing–Hangzhou Grand Canal. Comprehensive parameters and designs of various VR glasses equipment, the final choice of VR equipment is HTC–Vive, which includes a head–mounted display helmet, two handheld control handles, and two camera positioners. HTC Vive head tracking function is better than Oculus Rift, and the design is more suitable for Asian faces. The experience of spatial positioning is very shocking; the motion tracking handle is also excellent to use. The experimental group tested the Grand Canal VR tour game in a non-interference environment. The control group watched the historical text and picture introduction of the Grand Canal in a non-interference environment. The two groups took a set of memory tests 5 minutes and 30 minutes after the test, analyzed the two groups’ memory test data, and recovered questionnaires. Perform T–tex Analysis (Fig. 15).

4.4 Data analysis

62 volunteers conducted two tests respectively. The test score after using the VR tour game for 5 minutes was 79.6774, while the test score after 5 minutes without using the VR tour game was 68.3871; the test score after using the VR tour game for 30 minutes was 62.5806, and the test
Research on the Short-term Memory Effects on VR Tour Games

Table 1. Questionnaire settings.

<table>
<thead>
<tr>
<th>Cultural knowledge test of the Beijing-Hangzhou Grand Canal</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1</strong> The Sui Grand Canal centered on ( )</td>
</tr>
<tr>
<td>2 When was it first built</td>
</tr>
<tr>
<td>3 Across several provincial districts</td>
</tr>
<tr>
<td>4 Which ancient emperor and why did he build the Grand Canal</td>
</tr>
<tr>
<td>5 Which of the following river sections was not opened in the Sui Dynasty</td>
</tr>
<tr>
<td>6 Which part of the South Canal was built by Cao Cao during the Three Kingdoms period?</td>
</tr>
<tr>
<td>7 The Beijing-Hangzhou Grand Canal runs through no cities.</td>
</tr>
<tr>
<td>8 Sui Dynasty a Zhuojun scholar, to visit relatives to Yuhang, if the canal waterway, according to the order should be through the section is ( ) ①Yong Ji river ②Tong ji river ③Gan river ④Jiang Nan river</td>
</tr>
<tr>
<td>9 Xiaoming traveled to Hangzhou this summer vacation, mainly visiting the Grand Canal. Which section of the Grand Canal in the Sui Dynasty should he have visited.</td>
</tr>
<tr>
<td>10 The section from Tianjin to Linqing in the Beijing-Hangzhou Grand Canal is called ( )</td>
</tr>
</tbody>
</table>

score after 30 minutes without using the VR tour game is 44.8387 (Table 2).

Users who use virtual reality tour games have a difference of 14.7742 5 minutes after use, 18.92259 after 30 minutes of use, and a P value of 0 is less than 0.05 Table 3. Therefore, the null hypothesis that the mean values are equal is rejected. In the experimental group using virtual reality games, the memory score is higher than the control group that did not use the virtual game. After 30 minutes of use, the memory effect of the experimental group was significantly higher than that of the control group. The following conclusions are drawn: memory effects and persistence are significantly different, and visual attention and short-term visuospatial memory are significantly improved.

4.5 Data conclusion

This paper proposes hypotheses, designs VR tour games, and conducts effect evaluation in groups. The paired T-test is used to analyze and
verify the impact of VR tour games on short-term memory. By comparing the two sets of experimental data, the data results show that the VR group performs well in the short-term memory of the 5-minute test session and allows the experiencer to maintain a high level of memory within 30 minutes.

5. CONCLUSION AND FURTHER STUDY

The VR tour game helps to inspire the participants’ thinking and memory coding through the interaction between the participants and the simulation environment. They can obtain all kinds of spatial and logical information contained in the environment to form short-term memory. The breakthrough test of the game link extracts and retells short-term information, which consolidates the effect of short-term memory.

Through practical and empirical Analysis, the performance of the VR group at 5 minutes is 11.2903 points higher than that of the normal group, and the performance of the VR group at 30 minutes is as high as 17.7419 points than the normal group. This fully shows that VR tour games can help form efficient and continuous. The short-term memory effect of sex can better promote the culture of the scenic spot, which also shows the feasibility of using VR tour games for cultural promotion. Although this study is only aimed at the cultural tour...
promotion of the Grand Canal culture, it also broadens the scope of the application of VR tour games. There are many shortcomings in this research. The cultural content of the tour and the way to break through are relatively simple. The research in this article is not detailed enough and does not differentiate the population for targeted research. In 2019, Jinan University also conducted similar research in clinical psychology. It is tested separately from short visual–spatial memory, simple cognitive assessment, and spatial breadth memory. The experiment is only for the game developed this time. Later, we will continue to study the virtual reality game in the tourism field and do more experiments.

**REFERENCE**


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