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PERCEPTIVE BEHAVIOR IN A VIRTUAL ENVIRONMENT OF A REGION WITH LOCAL CULTURAL CHARACTERISTICS

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ABSTRACT

Local culture, with specific local characteristics, is one of the most important cultural assets. It records the history and development process. However, some assets are disappearing or being forgotten gradually as time goes on. One way to address this is through digital reconstruction to reproduce monuments or heritage as seen worldwide. In Taiwan, there are many regional cultural characteristics that have been protected, and using a digital reconstruction of local characteristics could continue to be carried out with preservation and promotion in the future. In this study, we reconstructed the decline of a region's culture characteristics via a virtual environment to explore the user's perceptive behavior (presence and spatial perception). Experiment, EEG detection and questionnaire survey research methods were used to assess users' perception. A total of 57 local residents and tourists ages 11-76, were analyzed regarding their perception experiences in the virtual environment system. The result showed that local residents had excellent performance in the sense of presence and spatial perception. Without a doubt, perception in a virtual environment is better when the user was familiar with the environment. Additionally, there was no gender difference. Overall, the virtual environment system allowed users to have a good experience and the local culture was effectively communicated to the users. It is believed that the digital reconstruction of a region's local culture characteristics will be more effective regarding the preservation of culture when it connects to the user's perception.

Keywords: Presence, perception, virtual environment, local cultural characteristic region, EEG

1 PREFACE

Current computer technology offers a virtual environment that depicts an increasingly realistic scene. The simulated virtual environment can assist in rehabilitating historical buildings in different visual presentations. It is one of the most frequently used techniques in rehabilitation (Mitchell, Beamish & Allibhai, 2007; Moltenbrey, 2001). Many scholars have reconstructed 3D models of historical sites, combined with virtual environment to setup a navigation system. This enables people to know the local history via the system and to enhance the local cultural sense (Bruno et al, 2010). The virtual environment not only digitalizes the region's current local characteristics but also rehabilitates the region's characteristics. It could achieve the purpose behind historical memory inheritance.

Schilit, Adams and Want (1994) defined the degree of perception that the user would have with varying behaviors based on context when he or she interacts with the virtual environment. The factors of presence and immersion are very important for the user to integrate into the virtual environment. “Presence,” an indicator of successful virtual experience, is a feeling of being there in the virtual experience (Lombard & Ditoon, 1997). Presence experience will become more real when the media becomes more interactive, realistic and immersive (Riva, Davide & Ijsselsteijn, 2003). These three elements of presence, immersion and spatial perception are often used to judge the perceived degree of connection between the user and virtual environment, and also as an indicator of virtual environment design. The quality of design could be understood by measuring user’s spatial perception in a virtual environment (Kober & Neuper, 2012a). When the user has higher presence and immersion that means the virtual environment was effectively attractive.

Spatial perception is the user’s experience of space, including the ability to negotiate distance and spatial sense, size determination and spatial orientation. The virtual environment would provide the user with a good experience when the difference between the user’s spatial perception is smaller. A questionnaire is one of the most common methods to assess the user’s presence (Mel et al, 2009; Van Der Land et al, 2013; Witmer & Singer, 1998). However, some scholars considered that the questionnaire neglects the initial state of the user. Some scholars suggested that using electroencephalography (EEG) associated with the questionnaire would provide a more comprehensive understanding of the user's perception (Clemente et al, 2013; Kober & Neuper, 2012b).

In order to obtain objectivity, EEG along with a questionnaire was used to analyze the user’s perception of experiencing the virtual environment in this study. The purpose of this study was to observe the user’s presence and spatial perception via an interactive virtual environment system. The “Recall playful Journey” of a virtual environment system presents “Xin-Si Street” scene from 60 years ago. Users were divided into local residents and tourists who navigated the scene, saw a video introduction and played an interactive game bike in the virtual environment, and then their perception was analyzed.

2 RELATED WORKS

2.1 LOCAL CULTURAL AND DIGITAL TECHNOLOGY

The virtual environment has been gradually applied to the local cultural field, such as digitized monuments and ancient cities through 3D reconstruction. The cultural heritage and historical sites could be rebuilt and preserved effectively as an interactive navigation system (Bogdanovych et al, 2011; Bruno et al, 2010; Davies, Miller & Allison, 2012; De Reu et al, 2013; Hermon, & Kalisperis, 2011; Koutsoudis et al, 2013; Pollefeys et al, 2008;). There is a trend that the 3D associated with the virtual environment provides users with a different experience (Koutsoudis, Arnaoutoglou & Chamzas, 2007; Lok, 2001). The reconstruction would induce the historical memory to the resident, would strengthen residents' sense of preservation of local culture, and seek to preserve the purpose of historical heritage (Bruno et al, 2010).

2.2 THE PERCEPTION AND PRESENCE IN VIRTUAL ENVIRONMENT

There is a different level of perception for the user when experiencing the virtual environment given the visual and auditory stimuli. The user does not explore the

environment passively, but actively observes in the virtual environment. This increases the user's degree of perception (Dankert & Wille, 2001). Balcetis and Dunning (2006) considered that perception concerns subjective and selective characteristics. Therefore, it is necessary to use a method of objectivity to assess perception. Spatial perception, as one indicator, is used to compare the difference between the real and virtual environment. Henry and Furness (1993) divided spatial perception into three dimensions—size of volume, spatial orientation and description (feel of individual spaces) to understand the degree of user's perception. Linn and Petersen's study claimed that the degree of male's spatial perception was higher than female's (Linn & Petersen, 1985; Waller, Hunt & Knapp, 1998). In recent years, Kober and Neuper (2012a) found there was no difference in spatial perception between males and females in the experiment of virtual environment regarding brainwave observation. Therefore, a good design of a virtual environment should not generate gender differences.

"Presence" is one index of the virtual environment, as the users' interest in a scene or a task and their concentration should not interfere in experiencing the virtual environment (Steuer, 1992). "Presence" is a subjective experience that the user feels in a virtual environment akin to being there (Kober, Kurzmann & Neuper, 2012; Witmer & Singer, 1998). Factors affecting the sense of presence include control, immersion, and authenticity. Presence will be stronger when these factors are stronger (Riva, Davide & Ijsselsteijn, 2003). Scholars have tried to measure presence since the 1990s. The questionnaire developed by Slater, Usoh and Steed (SUS) (Usoh et al, 2000), they proposed the SUS average, Witmer and Singer (1998) proposed four factors of control, sensory, distraction, and reality as standards for designing a Presence Questionnaire (PQ). There are many scholars citing Witmer and Singer and Usoh et al's research as their assessment indictor for analyzing the user's presence in a virtual environment (Mel et al, 2009; Peperkorn & Mühlberger, 2013; Schifter, Ketelhut & Nelson, 2012).

On the other hand, there are many scholars using EEG to measure presence in the virtual environment for an objective reason (Baumgartner et al, 2006; Clemente et al, 2013; Havranek et al, 2012; Kober, Kurzmann, & Neuper, 2012; Kober & Neuper 2012a; Kober & Neuper 2012b;Zacharis, Mikropoulos & Priovolou, 2013). The initial strength of presence could be obtained from EEG in a virtual environment (Clemente et al, 2013), and be a good judgment for the virtual environment.

The user's degree of spatial perception and presence were understood through analysis of questionnaire and EEG data in a virtual environment. The difference between local residents and tourists was further compared in this system.

3 RESEARCH METHOD

3.1 ASSESSMENT FOR THE VIRTUAL ENVIRONMENT SYSTEM

The "Recall playful Journey" of a virtual environment system presents the "Xin-Si Street" scene from 60 years ago. The user navigated the space, watched a video introducing the scene and interacted with a game bike in the virtual environment. Before quasi-experimental, in order to confirm the viability of the system, there were 141 random subjects aged 11-60 included in an experiment when the system was completed. The results showed that the overall average score was 4.26, meaning the majority of subjects felt positively about the system.

3.2 SUBJECTS

Subjects were divided into two groups: group A comprised 34 tourists with random sampling; group B comprised local residents of 23 with purposive sampling among the elderly. There were a total of 57 people in this study. Then 20 were randomly selected in each group to be assessed with an EEG. All subjects had been asked to sign an agreement before the experiment.

3.3 QUESTIONNAIRE

A questionnaire included the presence scale and spatial perception scale. The presence scale was based on the four factors of control, sensory, distraction, and realism proposed by Witmer and Singer (1998). Spatial perception scale was based on three dimensions: Size of Volume, Spatial Orientation, and Descriptive-Feel of individual spaces proposed by Henry and Furness (1993). Three experts with 10, 18, 25 years seniority, assessed and carried out a three-stage process using the Delphi method. The assessment showed that Cronbach's Alpha was 0.875 in the 3rd stage and achieved reliability.

3.4 TOOL OF MEASUREMENT AND ANALYSIS

The system was set up in a 50 year old local hotel—one of the old buildings preserved in Xin-Si Street. The hotel is nearby the train station with a variety tourists which facilitated collecting the sample of local residents. The average operating time was about 5 minutes for each experiment, as shown in Figure 1. Cronbach's alpha was used to analyze the questionnaire, and then test whether there was a significant difference between presence and spatial perception using an independent t-test. The brainwaves recorded the change of theta, alpha, & beta waves per second.

Figure 1 –experimental situation (without-left and with-right brainwave)

4 ANALYSIS AND DISCUSSION

4.1 RELIABILITY AND VALIDITY OF SCALE

The questionnaire had 29 questions, the Cronbach's Alpha reliability estimate was .932. The construct validity was KMO=.729; Bartlett Spherical = 922.3; significant=0.000 less than 0.05. Accumulation of the explanation of variance was 71.191%. The factor loadings associated with indicators for all respective latent variables were above .5; the convergent validity and discriminant validity of the measurement model was considered to be acceptable.

4.2 QUESTIONNAIRE ANALYSIS FOR GROUP A

Group A had a total of 34 participants, including 18 males and 16 females. 68% of the sample was between 21 and 30 years old.

4.2.1 ***Presence analysis for Group A***

— Presence of Xin-Si Street

Regarding familiarity with Xin-Si Street, Group A had 59 % who knew and 41 % who were unfamiliar with this region. Subjects who knew had higher presence, however, there was no significant difference in presence between familiar (mean = 4.0896) and unfamiliar (mean=4.0354).

— Gender differences

Both males and females had good presence. Males in the control of the navigation system experienced a high degree of selflessness. Females considered the realism of the virtual environment as higher. The presence in this system was not different between genders across all dimensions, and was suitable for everyone.

4.2.2 *Spatial perception analysis for Group A*

— Spatial perception of Xin-Si Street

Table 3 shows Group A's spatial perception of variable dimensions in Xin-Si Street. Result showed no significance; subject's familiarity with the environment or not did not impact spatial perception.

Table 3 Group A's spatial perception of variable dimensions in Xin-Si Street

DIMENSION	FAMILIAR OR UNFAMILIAR WITH XIN-SI STREET	NUMBER	AVERAGE	STANDARD DEVIATION	STANDARD DEVIATION OF MEAN
Size of Volume	know	20	4.312	.5433	.1215
	Unknown	14	4.267	.5044	.1348
Spatial Orientation	Know	20	3.675	.9357	.2092
	Unknown	14	3.892	.7119	.1902
Descriptive-Feel of Individual Spaces	Know	20	3.993	.5742	.1284
	unknown	14	4.080	.5317	.1421

— Analysis of Spatial Perception

Size of volume and descriptive spatial perception were high for Group A. Females had better perception of building size than males in the virtual environment; and males had a better sense of direction in the navigation. There was no difference in spatial perception for gender in Group A ($t = .095$, $p > .05$).

For the evaluation of system interface for Group A, the order of positive factors was graphic→ operation→ interface→ background music. A better spatial perception experience occurred when the visual sense was good.

4.3 QUESTIONNAIRE ANALYSIS FOR GROUP B

Group B subjects were local residents. Group B had 23 participants including 13 males and 10 females. 43% of subjects had lived there for over 50 years.

4.3.1 *Presence analysis for Group B*

Females had higher visual effect, selflessness, and realism in the virtual environment than males, while males had higher operation skill in the control factor.

— Residence time and presence

The single-factor analysis of variance was used to study the relationship between residence time and presence. Results showed that the subjects who lived in Xin-Si Street for 41-50 years had better presence due to having a deeper feeling about one's environment.

4.3.2 *Spatial perception analysis for Group B*

— Spatial perception difference by gender

Local female residents had better spatial perception in experiencing the system, especially on the Size of Volume and Descriptive-Feel of Individual Spaces, but was not significant. This meant that all people had a good navigation experience in this system and results are shown in Table 4.

Table 4 – Analysis of spatial perception scale for local residents

DIMENSION	GENDER (M/F)	AVERAGE	STANDARD DEVIATION	STANDARD DEVIATION OF MEAN
Size of Volume	M	4.192	.3558	.0986
	F	4.525	.4322	.1366
Spatial Orientation	M	4.307	.5219	.1447
	F	4.550	.4972	.1572
Descriptive- Feel of Individual Spaces	M	4.141	.3459	.0959
	F	4.333	.4779	.1511

4.3.3 *Residence time and spatial perception*

People residing there between 31 and 40 years had better spatial perception in Group B. The results further showed that residence time of around 11 to 20 years had a better description of size of volume, and those less than 10 years had better descriptive-feel of individual spaces. The spatial perception was not different by time of residence.

Regarding the evaluation of system interface for Group B, the order of positive factors was graphic→ interface → operation → background music. Better spatial perception experience occurred when the visual sense was exquisite.

4.4 PERCEPTION ANALYSIS OF TOURISTS AND LOCAL RESIDENTS

Table 5 shows the variable dimensions of presence for the two groups and Table 6 shows the variable dimensions of spatial perception. Group B had higher system operation, visual effect, and realism than Group A; Group B's familiarity with the environment was inferred to effect presence and spatial perception.

The overall presence of Group B was significantly higher than Group A, as shown in Table 6. Local residents were familiar with the environment for decades, and would carefully observe the navigation process integrating their living environment.

Table 5 – The variable dimensions of presence for the two groups

DIMENSION	GROUP	MEAN	STANDARD DEVIATION	STANDARD DEVIATION OF MEAN
Control factor	A	4.110	.6036	.1035
	B	4.130	.5428	.1132
Sensory factor	A	4.158	.5135	.0880
	B	4.247	.4611	.0961
Distraction factor	A	4.117	.5328	.0913
	B	4.269	.4247	.0885
Realism factor	A	3.882	.6711	.1150
	B	4.173	.5111	.1065
Presence	A	4.067	.4878	.0836
	B	4.337	.4170	.0869

Table 6 – The variable dimensions of spatial perception

DIMENSION	GROUP	MEAN	STANDARD DEVIATION	STANDARD DEVIATION OF MEAN
Size of Volume	A	4.294	.5203	.0892
	B	4.413	.5146	.1073
Spatial Orientation	A	3.764	.8459	.1450
	B	4.000	.5838	.1217
Descriptive-Feel of Individual Spaces	A	4.029	.5505	.0944
	B	4.223	.3789	.0790

4.5 EEG ANALYSIS

The alpha and theta waves reflected the perception of presence and spatial perception, respectively; beta waves were associated with attention. 20 subjects were randomly selected from each group. The whole tour according to scenes was divided and coded into 13 stages as shown in Table 7.

Table 7 – The coding of attractions

CODE	1.	2.	3.	4.	5.	6.	7.
SCENE	Video introduction	Navigate 1	Video-Wu Ancestral Hall	Navigate 2	Video-Historical Restaurant	Dice Game	Navigate 3
CODE	**8.**	**9.**	**10.**	**11.**	**12.**	**13.**	
SCENE	Video-Historical Attic	Navigate 4	Game-Divination blocks	Navigate 5	Video-Historical Hotel	Navigate 6	

4.5.1 ***Alpha wave analysis for Group A***

Alpha waves reflected the image recognition. Higher strength implies higher watching of the virtual environment. Tourists' alpha waves ranged on average from 25,000~37,000, and the highest occurred at code 9 (Navigate 4), as shown in Figure 2. Some of the subjects had higher alpha waves when navigating the environment, some had higher alpha waves in video introduction. The navigation of the system could indicate good presence for tourists.

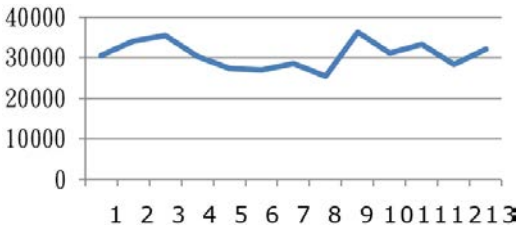


Figure 2 – Average alpha waves for tourists

4.5.2 ***Theta wave analysis for Group A***

Theta waves reflected presence associated with spatial perception. A stronger theta wave would be generated when the subject saw the landmarks in conducting spatial navigation (Kober, 2012b). Tourists' theta waves ranged on average from 120,000 - 170,000, as shown in Figure 3. The wave intensity was highest in the beginning stage, due to the navigation system of visual stimulation. When subjects navigated landmarks the theta waves increased. The navigation 4 (code 9) had a lower intensity with 140,000 which was a straight route with only one landmark, and with fewer decision points. The spatial perception depended on the quantity of landmarks and of route marks, also lowered by fewer decision points.

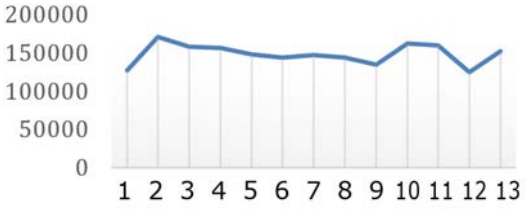


Figure 3 – Average theta waves for tourists

4.5.3 ***Beta wave analysis of Group A***

Higher beta waves were associated with higher attention. There was higher intensity of beta waves in navigating points, as shown in Figure 4. The subject's attention would decrease gradually with experiencing navigation until the divination blocks game. This was necessary to enhance the attention of navigation in the design. The subjects paid more attention to the game as reflected by higher intensity of beta waves with higher challenges.

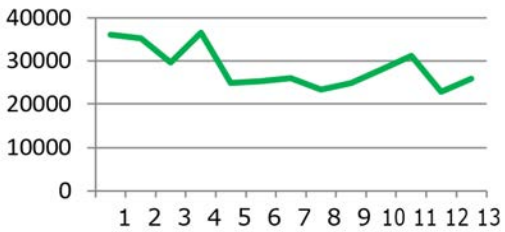


Figure 4 – Average beta waves for tourists

4.5.4 ***Alpha wave analysis for Group B***

Group B's alpha waves ranged on average from 25,000 - 34,000, as shown in Figure 5. There was a higher intensity of alpha waves when the subject entered

the Historical Restaurant (code 5). This was the biggest restaurant and was demolished in 1969, where only a wall remains now and a blurry impressions is left for most people. However, the Historical Restaurant has a different memory from other buildings in Group B, thus obtaining higher alpha waves at this stage.

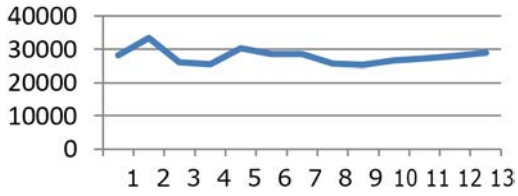
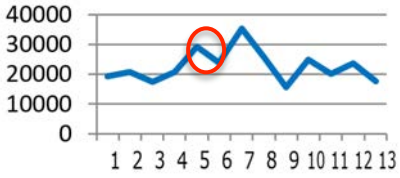
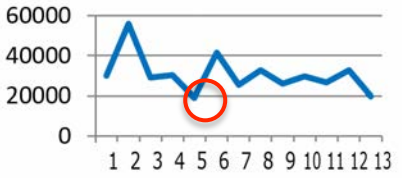


Figure 5 – Average alpha waves for local residents

Brainwaves of subject 02 (age of 20) and subject 12 (age of 70) were taken as comparisons, as shown in Table 10. Subject 12 who was born and lived at Xin-Si Street, and saw the demolished historical restaurant, could link the memory of the real building to obtain higher presence (with the second high point); subject 02 had never seen the whole restaurant (with the lowest point).

Table 10 – Comparison of alpha waves for two local residents

OBJECT 12 (AGE OF 70, SEEN RESTAURANT)	OBJECT 02 (AGE OF 70, NEVER SEEN RESTAURANT BUT A WALL)
	

4.5.5 ***Theta wave analysis for Group B***

Theta waves of Group B ranged on average from 120,000 - 160,000, as shown in Figure 6. No low point occurred for theta waves implying the navigation of the system had good spatial perception and was independent of quantity of landmarks and route marks. There were 13 people with similar theta waves on average; theta waves during video introduction were higher than in navigation. This also implied that the virtual environment and real environment were very similar in configuration space.

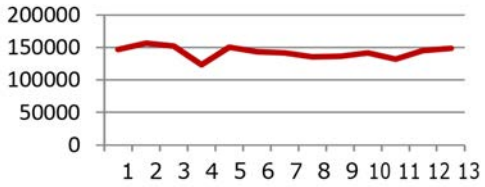


Figure 6 – Average theta waves for local residents

4.5.6 ***Beta wave analysis for Group B***

Attention was maintained at a high level reflected in high average beta waves for local residents, as shown in Figure 7. The subjects paid great attention when experiencing the buildings and video introduction in the virtual environments. The beta waves showed the highest intensity at the Historical Attic (code 8)-the

only Japanese-style restaurant building with a boat-shape, which meant subjects paid the greatest attention to this building.

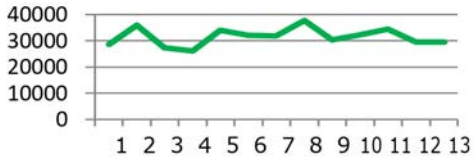
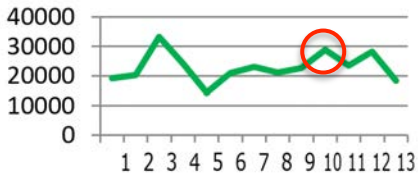
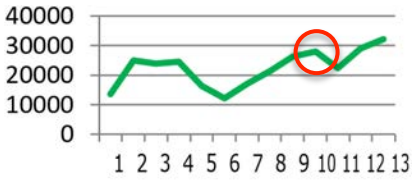


Figure 7 – average beta waves for local residents

Subjects had higher beta waves in the interactive game of land temple (code 10), as shown in Table 12. Subjects paid more attention to the divination blocks game based on content from local beliefs thus increasing the intensity of beta, even when the subject was older. The game increased attention not limited by age.

Table 12 – The beta waves of subject 03 and subject 07

SUBJECT 03	SUBJECT 07
	

4.5.7 ***Comparison of brainwaves between Group A & Group B***

Group B spent the most time and paid more attention than Group A. The brainwaves were smooth, and alpha and theta waves were maintained at higher intensity. The virtual environment was close to local residents' cognition, which provided good presence and spatial perception for the user.

Tourists navigated the interactive system with higher spatial perception, due to their need to rely on landmarks in an unfamiliar area, including more route decisions. This resulted in higher intensity of theta waves. On the other hand, local residents had smooth theta waves due to their familiarity with the area, as shown in Figure 8.

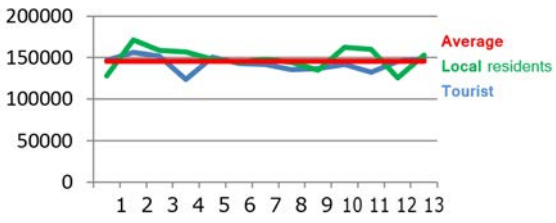


Figure 8 - Comparison of theta waves between tourists and local residents

Group A showed higher attention observed from the beta waves due to the need to pay more attention in the unfamiliar area. Group B showed higher attention during the video introduction and interactive game, having more experience with the historical background. The degree of presence, spatial perception and attention impacted better perception in the experience.

5 CONCLUSION

In this study, a region's local cultural characteristics from the landscape 60 years ago was reconstructed in a virtual environment, and added a video introduction and interactive game. The overall perception increased during the experience for both tourists and local residents. The presence and spatial perception of local residents was higher than tourists, implying that the familiarity with environment had a positive impact on perception. The familiarity could increase attention, which resulted in a higher degree of presence and better spatial perception. The digital reconstruction could reproduce the local cultural characteristics of the region that let the user learn historical and culture aspects during the experience. While not only providing a preliminary understanding for the tourist, furthermore, this experience helped local residents to recall their local culture and thus the inheritance of the historical aspects could be achieved.

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