Architecture and Planning Journal (APJ)

Volume 28 Issue 3 *ASCAAD 2022 - Architecture in the Age of the Metaverse – Opportunities and Potentials*
ISSN: 2789-8547

Article 36

March 2023

MEMORABILITY OF SPATIAL FEATURES IN VIRTUAL REALITY - SÜLEYMANIYE EXPERIENCE

ASENA KUMSAL ŞEN BAYRAM
Department of Architecture, Faculty of Architecture and Design, Maltepe University, Türkey,
asenakumsalsenbayram@maltepe.edu.tr

ORKAN ZEYNEL GÜZELCİ
Digital Fabrication Laboratory, Faculty of Architecture, University of Porto, Portugal, oguzelci@arq.up.pt

SEMA ALAÇAM
Department of Architecture, Faculty of Architecture, Istanbul Technical University, Türkey, alacams@itu.edu.tr

MEMORABILITY OF SPATIAL FEATURES IN VIRTUAL REALITY - SÜLEYMANIYE EXPERIENCE

Abstract

The goal of this study is to uncover and understand the user's perception of spatial features as they interact with cultural heritage in a virtual environment. The virtual reality (VR) experience adopted Kaufmann's three-fold imagery conception to structure the research methodology, which suggests that linguistic representation, visual imagery representation, and exploratory activity all have a strong relationship during the problem-solving/creative process. Since it has distinctive spatial features, the Süleymaniye Mosque in Istanbul was chosen for the VR experience as part of the scope. Following the VR experience in two sessions, it was analyzed using semi-structured interviews, sketching, and route extraction. The initial findings of this study revealed differences in individuals' perception and memorability of spatial qualities in the VR environment.

Keywords

virtual reality, immersive experience, memorability, cultural heritage, virtual heritage.

MEMORABILITY OF SPATIAL FEATURES IN VIRTUAL REALITY
SÜLEYMANIYE EXPERIENCE

ASENA KUMSAL ŞEN BAYRAM[1], ORKAN ZEYNEL GÜZELCİ[2], AND SEMA ALAÇAM[3]

[1] Department of Architecture, Faculty of Architecture and Design, Maltepe University, Türkiye
asenakumsalsenbayram@maltepe.edu.tr

[2] Digital Fabrication Laboratory, Faculty of Architecture, University of Porto, Portugal
oguzelci@arq.up.pt

[3] Department of Architecture, Faculty of Architecture, Istanbul Technical University, Türkiye
alacams@itu.edu.tr

ABSTRACT

The goal of this study is to uncover and understand the user's perception of spatial features as they interact with cultural heritage in a virtual environment. The virtual reality (VR) experience adopted Kaufmann's three-fold imagery conception to structure the research methodology, which suggests that linguistic representation, visual imagery representation, and exploratory activity all have a strong relationship during the problem-solving/creative process. Since it has distinctive spatial features, the Süleymaniye Mosque in Istanbul was chosen for the VR experience as part of the scope. Following the VR experience in two sessions, it was analyzed using semi-structured interviews, sketching, and route extraction. The initial findings of this study revealed differences in individuals' perception and memorability of spatial qualities in the VR environment.

Keywords: virtual reality, immersive experience, memorability, cultural heritage, virtual heritage.

ملخص

الهدف من هذه الدراسة هو كشف وفهم تصور المستخدم للسمات المكانية أثناء تفاعلها مع التراث الثقافي في بيئة افتراضية. اعتمدت تجربة الواقع الافتراضي مفهوم كاوفمان للصور ثلاثية الأبعاد لهيكلة منهجية البحث، والتي تشير إلى أن التمثيل اللغوي وتمثيل الصور المرئية والنشاط الاستكشافي جميعها لها علاقة قوية أثناء حل المشكلات أو العملية الإبداعية. نظرًا لأنه يحتوي على ميزات مكانية مميزة، فقد تم اختيار مسجد السليمانية في اسطنبول لتجربة الواقع الافتراضي كجزء من نطاق البحث. بعد تجربة الواقع الافتراضي في جلستين، تم تحليلها باستخدام المقابلات شبه المنظمة والرسم واستخراج المسار. كشفت النتائج الأولية لهذه الدراسة عن اختلافات في إدراك الأفراد وتذكر الصفات المكانية في بيئة الواقع الافتراضي.

الكلمات المفتاحية: الواقع الافتراضى، التجربة الغامرة، تجربة التذكر، التراث الثقافى، التراث الافتراضى.

1. INTRODUCTION

Immersive technology advancements provides numerous advantages in documentation, presentation, and visualization (Addison, 2000) and open up a new research area for cultural heritage (CH). This digital CH, known as virtual heritage (VH), creates computer-based reflections of objects, buildings, built environments, and sites with archaeological, aesthetical, and historical value (Tan and Rahaman, 2009). VH creates exceptional interactive experiences that facilitate users' learning, creativity, and collaboration, often through entertainment. Educational purposes, documentation against destruction, reconstruction of damaged or demolished monuments, interacting with monuments, and observing artifacts from various scales/angles are some of the reasons why cultural heritage objects are visualized in computer environments (Noh et al., 2009).

Previous VH research in architecture had primarily focused on design activities in virtual environments (Dorta, 2004; Schnabel et al., 2004). Although VH experiences offer numerous opportunities, integrating them with design and educational activities can be challenging (Champion, 2006; Chen and Kalay, 2008; Tan and Rahaman, 2009). This integration raises the question of whether novel ways of interacting with the physical environment change users' perceptions, comprehension, or spatial experiences.

Spatial experience shapes memory's architectural organization. Remembering architectural images is an important memory device for materializing and preserving the flow of time and making it visible; concretizing remembrance by containing and projecting memories; and inspiring reminiscence and imagination (Treib, 2009). As a result, the purpose of this study is to discover the implicit and minor differences between individuals in their perception of spatial features during the immersive experience of CH in VH.

2. SPATIAL EXPERIENCE IN VR ENVIRONMENT

In a virtual reality (VR) environment, the observer mentally separates from reality and enters an artificial three-dimensional world (simulation). Due to these interactions, this shift engages in various interactions such as being present, moving around, changing the location and properties of objects, and receiving sensory reactions as in the real world. VR environments are computer simulations made from images that act as if the senses are experiencing physical reality (Sherman et al., 2009). According to Pimentel and Teixeira (1993), the three essential characteristics of VR are "immersion," "interaction," and "three-dimensional graphic world." Sherman and Craig (2003) add "emotional feedback" to this list of characteristics. *Immersion* is frequently used to describe an emotional or mental state. It refers to mentally leaving the real world and entering the virtual world (Sherman and Craig, 2003). *Immersion* is the selective focus on the studied knowledge while excluding outside influences. According to Pimentel and Teixeira (1993), it also acts as a powerful lens for extracting knowledge, transforming it from input into experience. *Interaction* refers to various actions performed in a virtual reality environment. Depending on the goal of creating the VR environment, the mode of interaction varies. *Three-Dimensional Graphic World* is the creator's mental space. This environment can be based on a real or imagined place. Finally, *Emotional Feedback* is the perception of the observer's feelings as a result of their presence and actions.

In natural environment perception, the observer is surrounded by spatial information from different points. Alavesa et al. (2017) present a study that connects VR and spatial experience, with a focus on the concept of memorability. Their findings indicate that spatial similarity influences memorability in virtual reality environments (Alavesa et al., 2017). Unlike their study (Alavesa et al., 2017), this study does not include an active gameplay session in the case studies. Reggente et al. (2020) introduce a variant of the well-known loci method for assessing the memorability of non-spatial elements in a spatial virtual environment. Reggente et al. (2020) discover a link between the presence of landmarks in the spatial environment and the memorized 3D object, as well as verbal recall and memorability. This study differs from Reggente et al. ‘s (2020) work in the following ways: I use of a CH as a spatial environment, (ii) recall of architectural elements rather than arbitrary 3D objects, (iii) experiment set in two stages of 10

minutes and 1 minute rather than 20 seconds, and (iv) use of Kaufmann's (1980) imagery conception as part of the research method.

3. METHODOLOGY

As previously stated (Pimentel and Teixeira, 1993; Tan and Rahaman, 2009), perception, comprehension, memorability, and spatial experience in VR environments differ from person to person. Aside from the movement route and the detail of the spatial environment features, the duration and frequency of an experiment may influence user memorability. A qualitative research framework is developed to better understand the differences between individuals following the immersive experience of CH in VH. Geir Kaufmann (1980) contributes to theoretical debates with his concept of verbal, visual, and experiential imagery, which considers the restructuring of individual information from one domain to another. The VR experience in the scope of this study used Kaufmann's (1980) three-fold imagery conception to structure the research methodology.

The basic principles of Kaufmann's (1980) theory are illustrated in Figure 1, which suggests that linguistic representation, visual imagery representation, and exploratory activity all have a strong relationship during the problem-solving/creative process. According to Figure 1, a pure verbal representation is superior when an individual has a high level of familiarity with the task at hand, allowing for quick, stable, and generalizable problem-solving performance. Visual imagery as a symbolic system becomes more prominent as new features emerge in a problem situation, assisting the verbal symbolic function. The requirement for open, exploratory activity grows in direct proportion to the novelty of a problem.

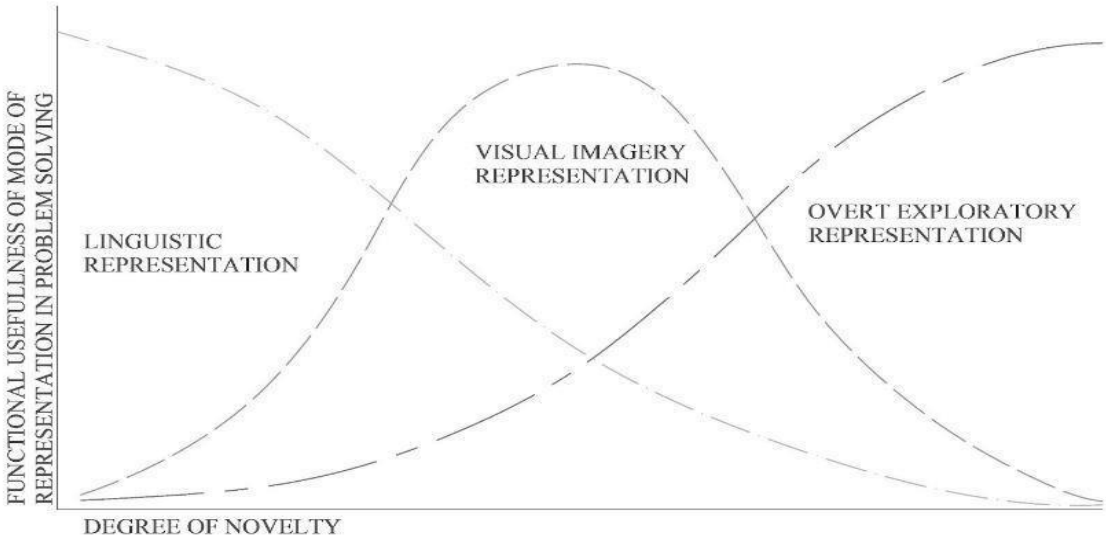

Fig.1: Kaufmann's (1980) three-fold representation modes

Since experience is subjective and holistic, it is hard to isolate any modes of representation from others. Keeping these difficulties in mind, Kaufmann's conception of imagery (Table 1) is used in this study in the data collection and analysis part of the experiments. In other words, Kaufmann's (1980) concept of imagery has been adopted for data collection structuring in relation to actions of memorizing and remembering the space.

Table 1: Layers of data collection.

Modes of representation	Data collection method
Verbal imagery	Semi-structured interview
Visual imagery	Sketching
Experiential imagery	User route extraction as a part of their spatial experience

Kaufmann (1980) emphasizes the significance of familiarity and repetition in the experiments and their results. In contrast to Kaufmann's proposition, this study focuses on the available features of CH's spatial experience in a VR environment rather than problem-solving or creative processes. In the scope of this study, a case study, Süleymaniye Experience, was designed to understand the verbal, visual, and experiential factors of spatial memory in VH VR environments. Figure 2 illustrates the experiment setup framework.

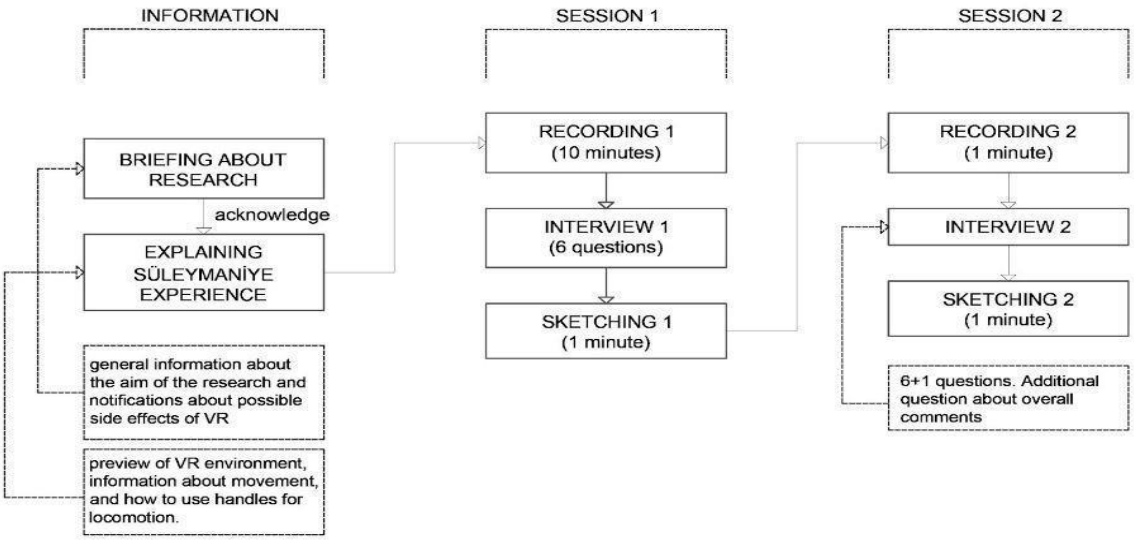

Fig.2: Diagrammatic illustration of the case study

4. CASE STUDY: SÜLEYMANIYE EXPERIENCE

4.1. Aim and Scope

The purpose of this research is to reveal and understand the user's perception of spatial features as they interact with CH in VH. As part of the scope, the Süleymaniye Mosque in Istanbul, built between 1551 and 1557 by Architect Sinan, was chosen for the VR experience. The Süleymaniye Mosque was chosen due to its distinct spatial characteristics in comparison to other Ottoman Mosques. This spatial richness is expected to keep multiple levels of perception active throughout the experience. Another reason for selecting this monument is that it is accessible to a variety of users for a wide range of purposes throughout the day. Süleymaniye Mosque is a part of both locals' and tourists' daily lives, and it still functions as a mosque.

4.2. Environment and Tools

To create virtual environments, various hardware, software, and techniques can be used. According to Pimentel and Teixeira (1993), selecting these components can increase or decrease immersion. In this study, an interactive journey for Süleymaniye Mosque was created using Unreal Engine 5 (a game engine), allowing the user to experience the interior and exterior of the building. Before initiating on this VR journey, the authors created a 3D solid model of the Süleymaniye Mosque in the Rhinoceros CAD environment. Ali Saim Ülgen's (1989) 2D drawings (surveys) were the primary source for the 3D modeling task.

Users can move around in virtual space using teleport-style locomotion. This movement was made possible by *Oculus Quest 2* and its hand trackers. These tools used a 'arc-like' digital indicator, allowing users to move around in the permitted areas, including predefined teleportation points such as minaret balconies, domes, portals, and shadirvan. For locomotion, the authors defined 22 points for the exterior and 12 points for the interior (Figure 3). These points were highlighted in the model with 3D labels. Users were free to move on/around the walkable surfaces that comprise the mosque's overall form in addition to the teleportation experience (Figure 4).

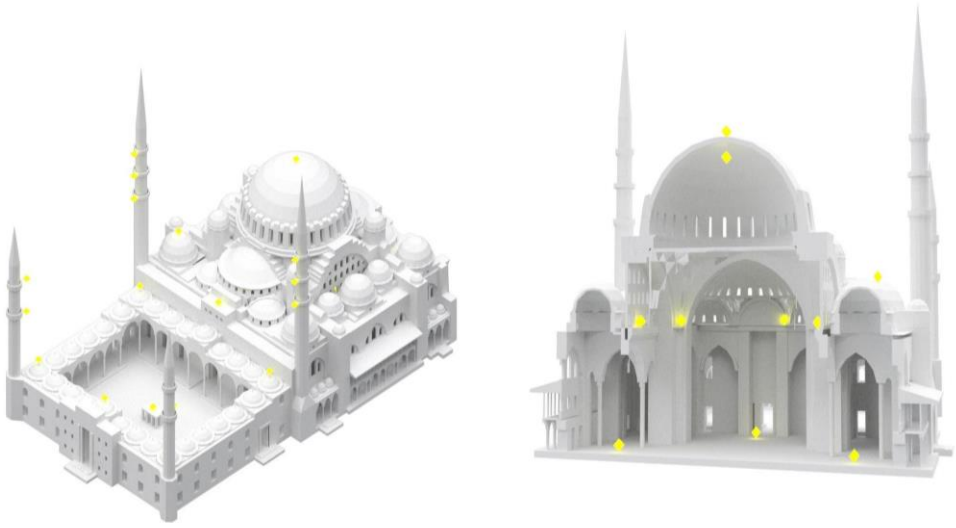

Fig.3: Locomotion points defined on the digital model

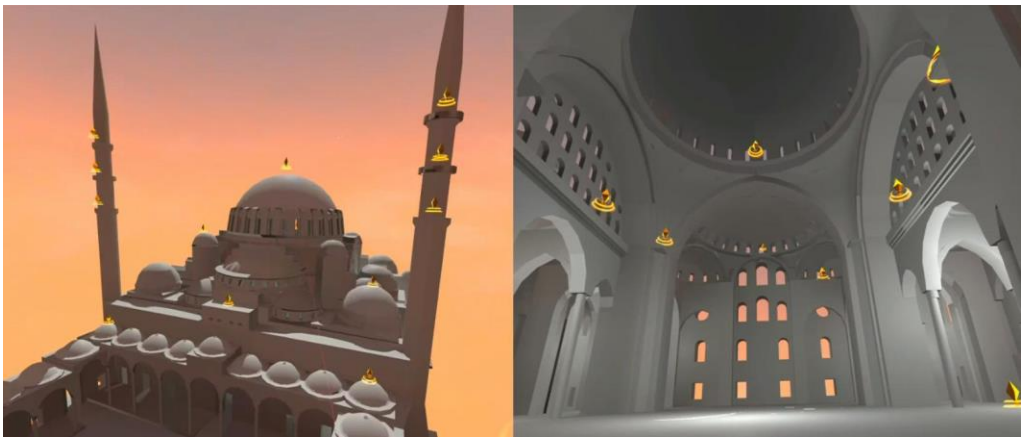

Fig.4: Locomotion points in VR environment

4.3. Experiments

The virtual experiment was divided into two sessions. The respondents in this study were eight undergraduate architecture students who had visited the Süleymaniye Mosque at least once. Since the Süleymaniye Mosque is well-known among Istanbul residents, finding unfamiliar respondents for the study was difficult. As a result, it was decided that the structure should be familiar to all respondents. The corridors of Taşkşla Campus (Faculty of Architecture at Istanbul Technical University) were chosen for the experiment because of their large area, which allows walking long distances with the VR headset and trackers, implying movement in the VR.

During the first session, respondents were allowed to remain in the virtual environment for 10 minutes. Their experience was documented using Oculus Quest 2, and after 10 minutes, respondents were surveyed using a semi-structured survey.

Finally, for 1 minute, respondents were asked to draw a scale-free hand sketch of their experience (referring to Kaufmann's "visual imagery"). Then, in the second session, respondents were allowed to stay one minute in the virtual environment. For the second experience, the recording, survey, and sketching were repeated.

The following questions about the qualitative and quantitative architectural features of Süleymaniye Mosque were included in this prepared survey:

1. Which architectural element(s) did you observe?
2. Which space(s) of the monument did you visit?
3. If you visit more than one space, can you put them in an order according to their sizes?
4. Which space was the brightest/most luminous?
5. Which space(s)/viewpoint(s) did you visit most often?
6. Which space(s)/architectural element(s) did you perceive both from the interior and exterior?
7. What are your overall comments considering these two experiences?

4.4. Outcomes and Findings

Based on the recorded sessions of the respondents, the authors mapped their movements (both moving around and teleporting) and created line-based diagrams. Then, these line-based diagrams were superimposed to see the similarities and differences between the experiences (Figure 5).

Respondents became acquainted with the tool, interface, and Süleymaniye Mosque during the first 10-minute session. Despite this training session, respondents were able to give adequate answers to all questions. Following the first session, respondents were confronted with the six questions. Given this, the respondents were informed about the questions before beginning the one-minute second session. Tables 2-7 show the responses of respondents to questions 1–6. The common denominator of the responses to the seventh question was that the respondents tended to count the spatial components that can be counted in the second stage and expressed this verbally.

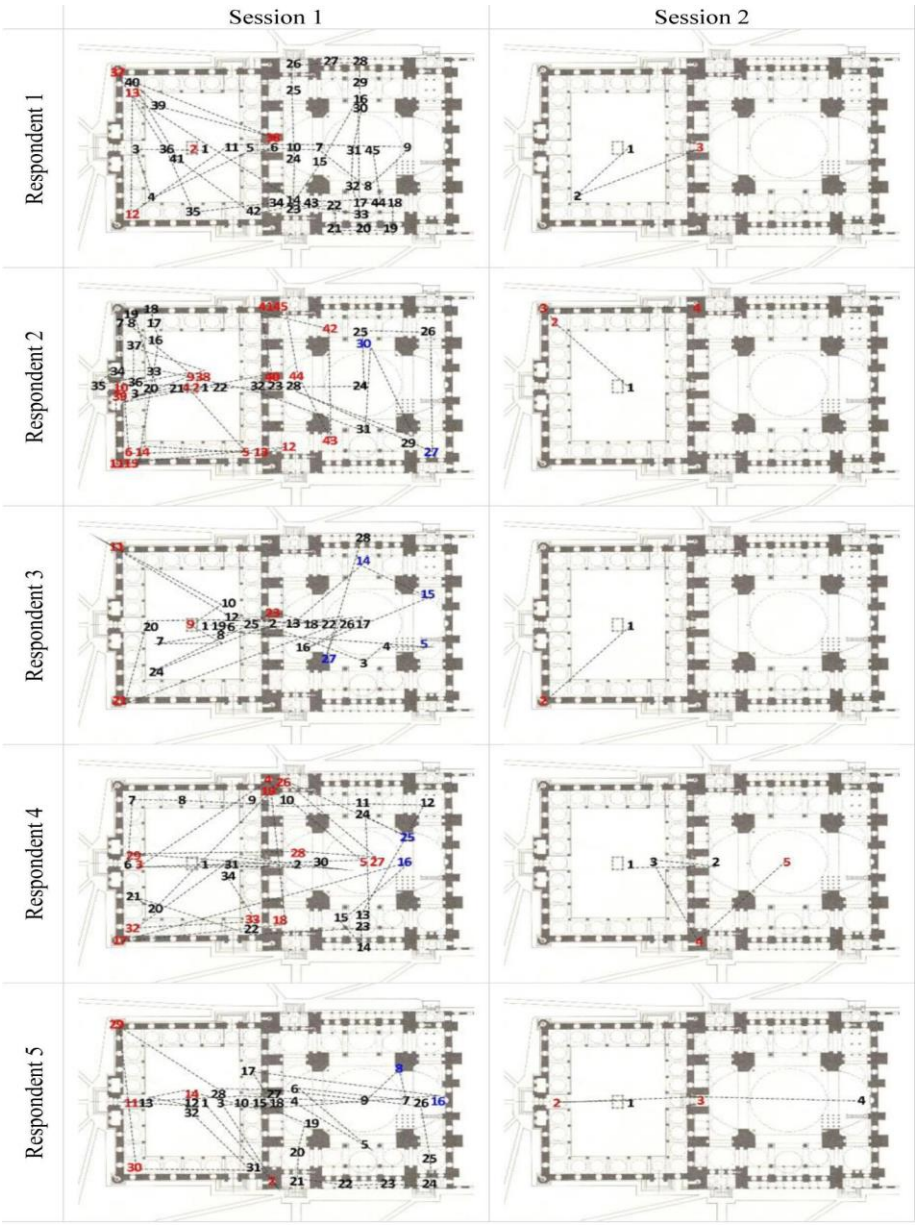

Fig.5: Route extraction from the VR experiment of the respondents (continues).

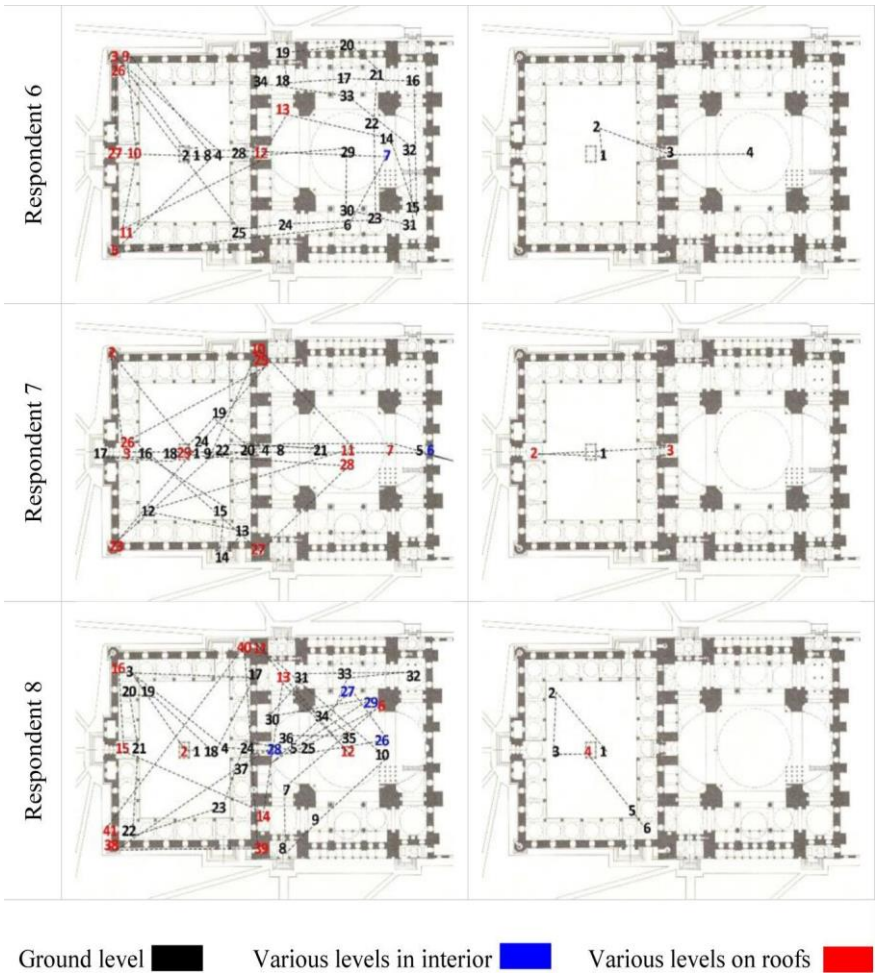

Fig.6: Route extraction from the VR experiment of the respondents

The results of the sketching phases were also similar to the results of the interviews. Respondents' sketches in the first session were primarily concerned with the experience and atmosphere. In contrast, in the second session, they concentrated on the quantitative aspects of architectural elements (Table 8).

Table 2: Responses to survey question 1

Respondents	Sessions	Observed architectural elements													
		Arch	Buttress	Column	Crown Gate	Dome	Dome Drum	Door	Facade	Half Dome	Mihrab	Minaret	Shadirvan	Shadow	Stoa (Revak)	Window
1	Session 1			●		●						●	●			
	Session 2			●		●			●			●				●
2	Session 1	●				●								●		●
	Session 2	●				●							●			
3	Session 1			●								●				
	Session 2					●										
4	Session 1			●		●	●									●
	Session 2			●		●										
5	Session 1	●		●		●	●	●				●	●		●	●
	Session 2					●					●					●
6	Session 1					●						●				
	Session 2					●						●				
7	Session 1			●	●	●						●	●		●	
	Session 2		●	●		●				●		●	●		●	●
8	Session 1					●						●				●
	Session 2			●											●	

Table 3: Responses to survey question 2

Respondents	Sessions	Visited spaces						
		Courtyard	Dome	Emptiness	Interior	Minaret	Shadirvan	Stoa (Revak)
1	Session 1	●	●		●	●		
	Session 2	●				●		
2	Session 1	●	●		●			
	Session 2		●			●		
3	Session 1	●			●			
	Session 2					●		
4	Session 1	●			●	●	●	
	Session 2	●	●	●	●	●		
5	Session 1	●	●		●	●		
	Session 2	●	●		●			●
6	Session 1	●	●		●	●		
	Session 2	●			●			
7	Session 1	●	●		●	●	●	
	Session 2	●	●					
8	Session 1	●	●		●	●		
	Session 2	●						

Table 4. Responses to survey question 3

Respondents	Sessions	Sizes of Spaces (1 Largest 4 Smallest)			
		Courtyard	Interior	Minaret	Shadirvan
1	Session 1	2	1	3	4
	Session 2				
2	Session 1	1	2		
	Session 2				3
3	Session 1	1	2		
	Session 2	2	1		
4	Session 1	1	2	4	3
	Session 2				
5	Session 1	2	1		
	Session 2				
6	Session 1	1	1		
	Session 2	2			
7	Session 1	1	1		2
	Session 2	2			
8	Session 1	2	1		
	Session 2				

Table 5. Responses to survey question 4

Respondents	Sessions	Brightest/most luminous space(s)	
		Courtyard	Interior
1	Session 1		●
	Session 2	●	
2	Session 1	●	
	Session 2	●	
3	Session 1		●
	Session 2	●	
4	Session 1		●
	Session 2		●
5	Session 1	●	
	Session 2	●	
6	Session 1		●
	Session 2	●	
7	Session 1	●	
	Session 2	●	
8	Session 1	●	
	Session 2		●

Table 6. Responses to survey question 5

Respondents	Sessions	Repeatedly visited spaces					
		Courtyard	Dome	Ground	Interior	Minaret	Reason
1	Session 1		●				To observe the site better
	Session 2		●				
2	Session 1		●				To observe the site better
	Session 2					●	
3	Session 1				●		To experience being on a higher level/flying
	Session 2					●	To observe the site better
4	Session 1			●			To feel secure
	Session 2			●			
5	Session 1					●	To experience being on a higher level/flying
	Session 2		●				To observe the site better
6	Session 1					●	To observe the site better
	Session 2					●	
7	Session 1		●				To observe the site better
	Session 2		●				
8	Session 1				●		To find different views and perspectives
	Session 2	●					To focus interior space

Table 7: Responses to survey question 6.

Respondents	Sessions	Perceived architectural spaces/elements both from interior and exterior					
		Courtyard	Dome	Interior	Minaret	Shadirvan	Window
1	Session 1		●				
	Session 2		●				
2	Session 1	●					
	Session 2				●		
3	Session 1				●	●	●
	Session 2				●	●	●
4	Session 1		●				
	Session 2		●				
5	Session 1	●	●		●		
	Session 2						●
6	Session 1	●					
	Session 2			●			
7	Session 1		●				
	Session 2		●				
8	Session 1		●				
	Session 2		●				

Table 8: Sketch observations by the authors.

Respondents	Observations based on sketches
1 & 2	In both sessions, the first two respondents have similar sketches drawn from the top of the dome towards the courtyard. While the first sketch is less detailed, the second includes quantitative interpretations such as the numbers and heights of the domes that cover the stoa.
3	The respondent concentrated on the environment and experience during the first session. As a result, the first sketch includes atmospheric elements such as clouds, an image of the respondents' feet, and a portion of the minaret. In the second sketch, the respondent maintains the same viewpoint but depicts a greater number of architectural elements associated with the mosque, such as domes, şadrvan, and minarets.
4	The courtyard view from the top of the dome, including the handles, was sketched in the first session. The proportions and number of architectural elements were also considered as well. The second sketch included more architectural features than the first, as well as a plan of the mosque.
5	The first sketch, which shows the courtyard from a dome, emphasizes being above ground level. The courtyard was drawn from a high window in the second sketch, along with the quantitative aspects of architectural elements.
6	The respondent draws the mosque's central dome from the interior space in the first sketch and places a human figure to explain the scale of the central dome. The second sketch provides insights into the atmosphere while concentrating on the same architectural element. Furthermore, the light coming in through the windows and the shadows dropping on the dome are illustrated.
7	The courtyard view from the minaret was illustrated in the first sketch. Highlight signs and expressions that reveal the human scale's decrement were added. The second drawing shows a perspective view of the interior space from the dome pulley. The number of niche openings and their formal typologies were projected.
	The first drawing is looking from the courtyard towards the mosque's front facade. The shape and number of openings were taken into account. The second illustration conveys a similar point of view, with a focus on the entrance facade. The details of columns and column capitals were added in the second drawing, in addition to the openings.

5. DISCUSSION & CONCLUSION

This study presents the findings and outcomes of qualitative research to reveal differences in individuals' perception and memorability of spatial qualities in the VR environment. The qualitative method is based on Kaufmann's (1980) conception of imagery, but it is used to analyze the experience in the VR environment rather than problem-solving or creative processes. During the experimental phase, the duration of the VR experience was examined at 10-minute and 1-minute intervals, but no significant difference was found between these two experiences. It was discovered that the order of the two sessions had a significant impact on the users' motivation to focus on quantitative aspects of the architectural space. In this sense, the duration and frequency of the experiments can be reconsidered in future studies to achieve better results.

To outline the study's limitations, experiments were carried out with a white solid digital model rather than a fully textured model due to the required permissions to document monuments such as the Süleymaniye Mosque. The presence of photorealistic textural details may have an effect on the overall experience. Furthermore, the contextual and environmental parameters are neglected. Without the limitations mentioned above, the study is expected to show more detailed results about perception and memorability in a VR environment in the following studies.

REFERENCES

- ADDISON, A., 2000. Emerging Trends in Virtual Heritage. *IEEE Multimedia*, 7 (2), 22-25.
- ALAVESA, P., PAKANEN, M., VIRISHILOV, A., KUKKA, H., SAMADELKIN, A., OJALA, T. AND POUKE, M. 2017. City knights: Spatial realism and memorability of virtual game scenes in pervasive gameplay. *In: 2017 9th International Conference on Virtual Worlds and Games for Serious Applications*. IEEE, 71-78.
- CHAMPION, E., 2006. *Evaluating Cultural Learning in Virtual Environments*. PhD dissertation, University of Melbourne.
- CHEN, X. AND KALAY, Y., 2008. Making a Liveable 'Place': Content Design in Virtual Environments. *International Journal of Heritage Studies* 14 (3), 229-246.
- DORTA, T., 2004. Drafted Virtual Reality: A New Paradigm to Design with Computers. In: *Proceedings of the 9th International Conference on Computer Aided Architectural Design Research in Asia (CAADRIA 2004)*, Seoul, South Korea, 829-844.
- KAUFMANN, G., 1980. *Imagery, language, and cognition: Toward a theory of symbolic activity in human problem-solving.* Berlin: Universitetsforl.
- NOH, Z., SUNAR, M.S. AND PAN. Z., .2009. A Review on Augmented Reality For Virtual Heritage System, *Edutainment 2009*, LNCS 5670, 50-61.
- PIMENTEL, K. AND TEIXEIRA, K., 1993. *Virtual Reality: Through the New Looking Glass.* NY: McGraw-Hill.
- REGGENTE, N., ESSOE, J.K., BAEK, H.Y. AND RISSMAN, J., 2020. The method of loci in virtual reality: explicit binding of objects to spatial contexts enhances subsequent memory recall. *Journal of Cognitive Enhancement*, 4 (1), 12-30.
- SCHNABEL, M.A., KVAN, T., KUAN, S.K.S. AND LI, W., 2004. 3D Crossover: exploring objets digitalisé. *International Journal of Architectural Computing*, 2 (4), 475- 490.
- SHERMAN, WR AND CRAIG AB, 2003. *Understanding Virtual Reality*. San Francisco, CA: Morgan Kauffman.
- SHERMAN, WR, CRAIG AB AND WILL, JD, 2009. *Developing Virtual Reality Application*s. China: Morgan Kaufmann Publication.
- TAN, B.K. and RAHAMAN, H., 2009. Virtual Heritage: Reality and Criticism. *In: Proceedings of the 13th International Conference on Computer Aided Architectural Design Futures (CAAD Futures 2009)*. Montréal, Canada, 143-156
- TREIB, M. 2009. *Spatial Recall: Memory in Architecture and Landscape*. London: Routledge.
- ÜLGEN, A.S. 1989. *The Buildings of Mimar Sinan*. Ankara: Türk Tarih Kurumu Basımevi.