VIRTUAL REALITY AS A TOOL FOR MEASURING SPATIAL TENDENCIES IN URBAN EXPERIENCE

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Abstract. Virtual reality (VR) enables the controlled acquisition of physical reality into the virtual environment and provides a means of measurement for understanding spatial tendencies. The 3D aspect of the VR technology creates links with real-life experiences. Therefore, the virtual built environment can stimulate people as physical urban experiences. Room-scale experience of HTC Vive HMD (Head Mounted Display) gives the opportunity of wandering around the urban space with its fully immersive feature. The purpose of this study is to determine the spatial tendencies of the individual through distance configurations in the virtual reality environment, which Baudrillard defines as "hyperreal", and which covers more than simulating reality. The distance structuring of the individual's unconscious relations with his environment is defined by cultural anthropologist Hall as the concept of proxemics. According to the concept of proxemics, individuals interact with the built environment and people through personal, social and public distances. The study provides a virtual space experience where users can navigate through the control via the VRSketch program, the virtual model of designed space, Google Sketchup's virtual reality plug-in. The designed space is a street with a road and buildings along the way both sides. It includes for the one side detailed models and the other side fewer details on the facades. It has been examined in the context of comprehending the tool at first participation in the experimentation. In the second participation, the user is expected to be acquainted with the environment. In the third participation, it was aimed to understand the distance configurations (proxemic tendencies) of the virtual individual. In this study, it is aimed to understand the proxemic tendencies of virtual individuals within the scope of these experiments. Users were recorded in video format during each experience. Approach and departure points are defined by distance configurations. The glance points and the pose points were determined and the users were asked about their behavior, and as a result, it was expected to understand how the architectural elements related to the distance configuration of the person. The results obtained from the experiences of virtual individuals were then compared with each other and it was aimed to determine the relationship-contradiction points. This study describes virtual reality as a tool for understanding user tendencies by recording user spatial behavior.

Keywords: *Virtual reality, virtual space, proxemics, HTC Vive, VRSketch*

1. Introduction

Virtual environments can be defined as media in which reality is reconstructed by means of computers (which can also be expressed as simulation). Simulation, as Baudrillard describes, is no longer a reference entity or substance, but a hyperreality which reality is reproduced through models (Baudrillard, 2011). As Bolt explains, modern "human" has become the decisive center of reality with technology and sees the world as something independent of itself (Bolt, 2013). While man is defined as being cared for by the existing, this situation changes with the modern age and man becomes spectator (Bolt, 2013). The spectator human

is the one who builds his own reality, and this helps him develop methods of understanding his own world. The human is in physical reality and forms the image of the world by the relationship of the world with himself. Heidegger's definition of being "being-in-the-world" defines *Dasein*[1], as Ökten states, the individual who is conscious of "being-here" or "human existence" (Ökten, 2012). It is inseparable from the existence of spatial tendencies of *dasein* within the built environment. *Dasein* in Baudrillard's hyperreality, on the other hand, can be reinterpreted in the context of being "being-in-the-virtual-world" (Coyne, 1994). In this study, the concept of virtual *dasein* is defined as a virtual individual. The virtual individual shows spatial tendencies associated with "being-in-the-virtual-world" in the virtual space. In this context, the virtual individual is the one who is aware of the virtual space in which it is immersed. The spectator is considered to be the one who found and provided his spatial movements here.

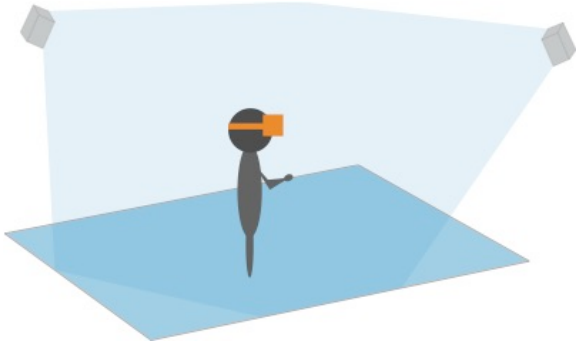

Figure 1. HTC Vive Head Mounted Display (HMD) room-scale installation

The three-dimensional possibilities of virtual reality enable the individual to immerse in different media. Human is physically present in physical reality with bilateral vision. Virtual reality head mounted display (VR HMD) brings the phenomenon of vision in the physical environment to the virtual environment with stereoscopic vision. This provides virtual reality, simulation of the physical built environment which we can call virtual built environment. It can provide excitations for users in a spatial context, such as a physically constructed environment. Spatial tendencies occur within the concept of presence and are evaluated in the context of virtual-presence. The HTC Vive virtual reality glasses can be installed in a defined space which is called room-scale (Fig. 1). The 360-degree vision (6DoF – six degrees of freedom) and spatial navigation possibilities provided by the glasses can be parallel to reality while providing a measurable environment in the virtual space. Virtual space can be used as a tool to measure physical behaviors and orientations.

[1] Dasein means "being there" or "presence": German: also means "there", sein means "being". It is often translated into English with the word "existence". It is a fundamental concept in Martin Heidegger's existential philosophy and in his work 'Being and Time'.

2. Proxemics Behavior

The proxemics behavior defined by cultural anthropologist Hall in 1963 was determined for the measurement definition of the study. Hall describes his proxemic behavior as a valuable term for understanding people who interact with each other and with their environment, "the organization of spaces in houses and buildings, and ultimately the settlement of [cities]" (Hall, 1963). As Hall describes, unlike most of the traditional subject of anthropological observation, proxemic patterns once learned are largely excluded from conscious awareness and therefore should be explored without the need to explore the conscious minds of one's subjects (Hall, 1963).

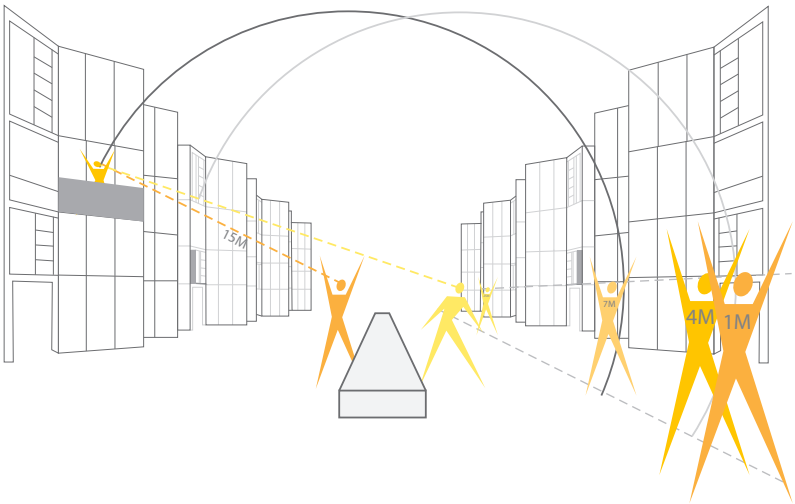

Figure 2. Proxemics Diagrams

Grosser (1951) describes how and why portraits in the western world are painted at specific distances, with reference only to intimate, personal and social distances (Hall, 1963). The distance an artist uses when placing elements in a picture's composition is designed to transmit certain characteristics of personality as well as to scan all other features, and Grosser fixes these observations to feet and inches (Hall, 1963). Hall studies how people unconsciously construct the distance between each other in carrying out daily operations, space organization and urban settlement (Hall, 1963) (Figure 3).

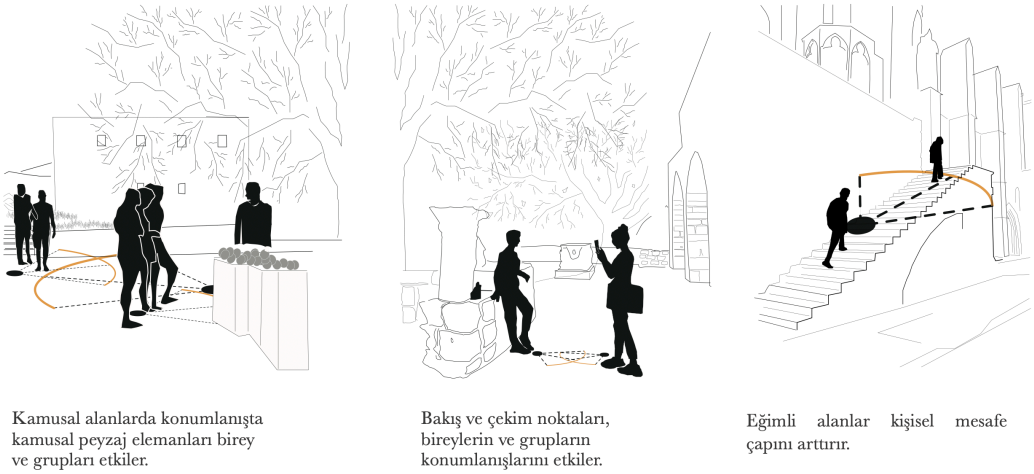

Figure 3. Proxemics in Built Environment

This research is designed in the context of measuring the distance structuring tendencies of the virtual individual (Figure 2). The concept of proxemic is defined as 1 m personal distance, 4 m social distance and 7 m public distance (Sussman & Hollander, 2015). Since these distances can vary in every culture and geography, they will be measured conceptually (personal, social and public) and not quantified. One of the studies in which distance configurations investigated in the proxemic context is re-evaluated in virtual environments, Hecht et al. experiments conducted by the virtual individual in the virtual environment is created through the avatar explores the distance configurations (Hecht, 2019) (Figure 4).

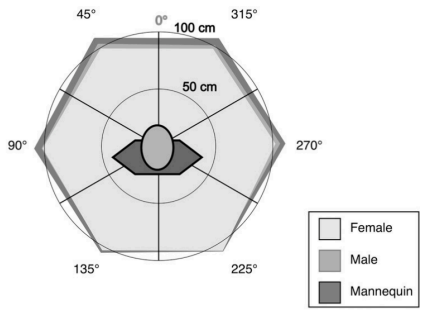

Figure 4. VR Avatar Plan (Hecht, 2019).

This research, supported by the controlled structure of the virtual reality environment, defines this environment as a tool to measure the spatial behavior of the virtual individual. Proxemic, distance studies in the virtual reality environment, presence, presence, being-in-the-world and virtual being studies were utilized (Figure 5). When user behavior and reactions are understood, spatial trends and the factors that affect them are explained. The controlled structure of the virtual space provides the opportunity to record and analyze the factors. The

aim of the study is to make the factors and stimuli affecting spatial tendencies understandable through behavior measurement and observation in virtual environment.

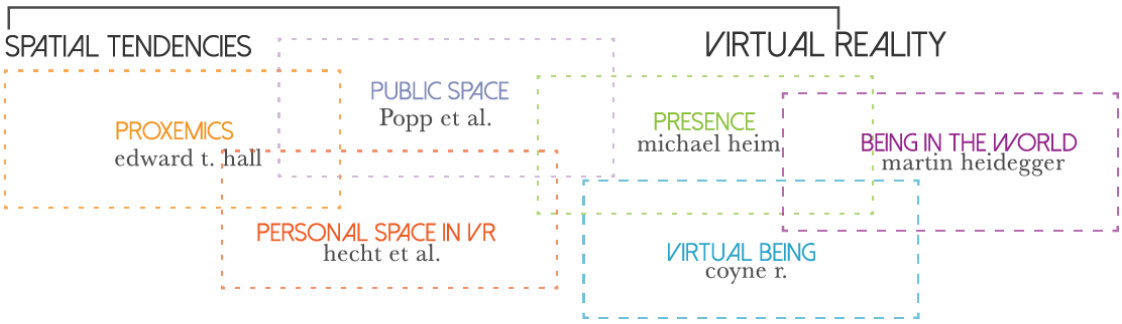

Figure 5. Concepts and Literature

3. Methodology

The virtual reality research procedure was carried out through a 3-stage experiment. In the first phase, a three dimensional model representing the physical environment was transferred to the virtual reality environment via VRSketch (Google Sketchup modeling program virtual reality plugin). In the second stage, this virtual space, using HTC Vive Virtual Reality Glasses by 5 people 3 min. and this experience was repeated 3 times with 1 day intervals. In order for the virtual individual to realize an experience that is independent of the effects of the first encounter with the tool, each user is provided to experience the space 3 times in order to grasp the tool and the environment. In the first experience, it is envisaged that the virtual individual normalizes the relationship established with the vehicle, that is, to grasp the vehicle. For each of the 5 people, the average duration of tool engagement is examined in terms of how the differences and similarities occur in these processes. In the second experience, it was aimed to comprehend the virtual urban environment, where differences and similarities were examined for 5 people. The third experience aimed to measure the distance configuration of virtual individuals. The proxemic tendencies of the virtual individual have been examined and the issue of identifying what is happening if there is a relationship or contradiction between the distance configurations of the 5 individuals has also been evaluated. The third stage is the analysis of spatial tendencies in the proxemic context.

During the analysis, posture-points of view were determined through the behavior of the virtual individual recorded in video format during the experience. Posture and viewpoints were applied to all 3 experiences for each person. The data of the three individual experiences of 5 people and their relationship and contradictions were determined. The analysis data included interviews with users.

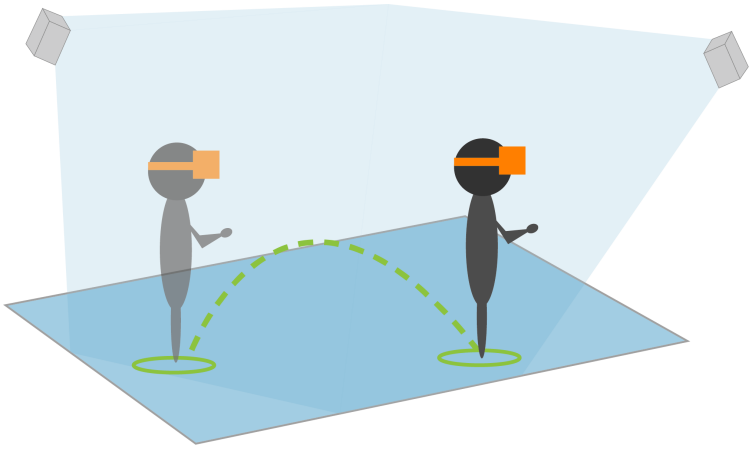

Figure 6. VR Navigation (Teleport)

The reactions / interactions of the users were observed and traces of behavior were identified to clarify proxemic tendencies. These traces have been created in the virtual space by means of circulation paths that can be drawn by instant identification of the user's coordinates. In addition, data such as points at which users direct their gaze (view points), waiting times at these points (standing points) were decoded through videos recorded during the experience (Figure 7).

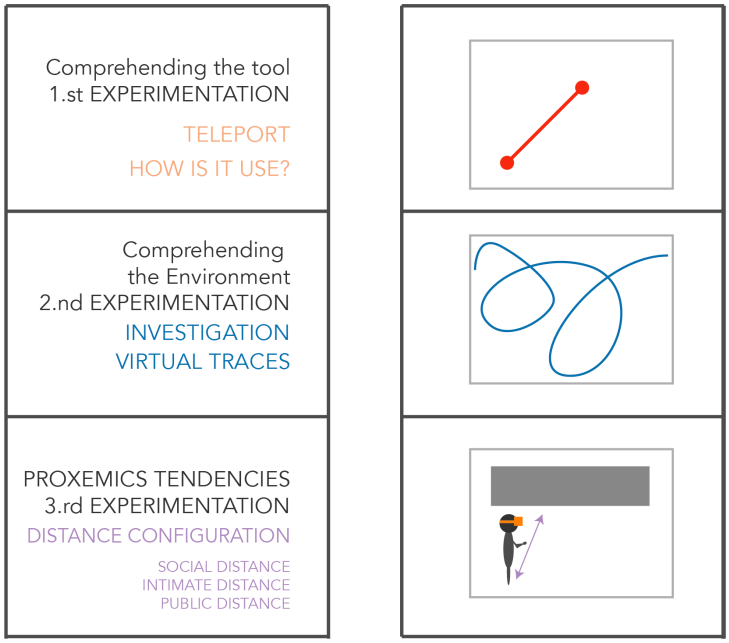

Figure 7. VR Analysis Methodology

Then, deep interviews were conducted and questions about the experience were collected to reveal data that could be associated with feelings and traces. The questions to be asked to the users in the interviews were compiled in order to make the reasons of view and posture points understandable. Parts of the videos during the virtual experience were shown and

asked to explain why. It is aimed to understand the relationship between architectural elements and the moments of view and posture. The questions are designed to provide more information about individual virtual experiences. Traces and interview data were evaluated together. This study questions how virtual reality can be defined as a tool for measuring proxemic tendencies in virtual space.

4. Virtual Reality Study

Spatial tendencies of the users were investigated in the context of proxemic with 5 people in virtual reality environment and 3 different times. Users, virtual space in 3 different time 3er min. taken and experienced in a virtual built environment. The reality level of the model is defined as the limitation of the study. The material and details of the model are a bit far from reality, one side of the road is designed with more detailed facades and real alike plants, while the other side is constructed with flat and only empty facades and low-poly trees.

Figure 8 VR Experimentation

In the first experience, the tool (VR HMD) was expected to grasp. Users are shown the navigation command (Teleport [Fig. 6]). It is provided to navigate in the model through the command for 3 minutes. The grip of the tool was very fast for all users. Everyone has been accustomed to the vehicle in 30 seconds. The users who discovered the navigation command, after realizing that the command can be irradiated to the points on the horizontal surfaces, were found to have approaches such as climbing on the garden wall and looking from the balcony to examine the detailed facades. After the navigation command was learned, it started to be done without focusing on the command (such as normal walking) and this situation increased the feeling of walking. Users mentioned the proximity of teleportation to walking as if walking. They expressed that it was an exciting experience to be able to beam to horizontal planes and observe buildings from different points.

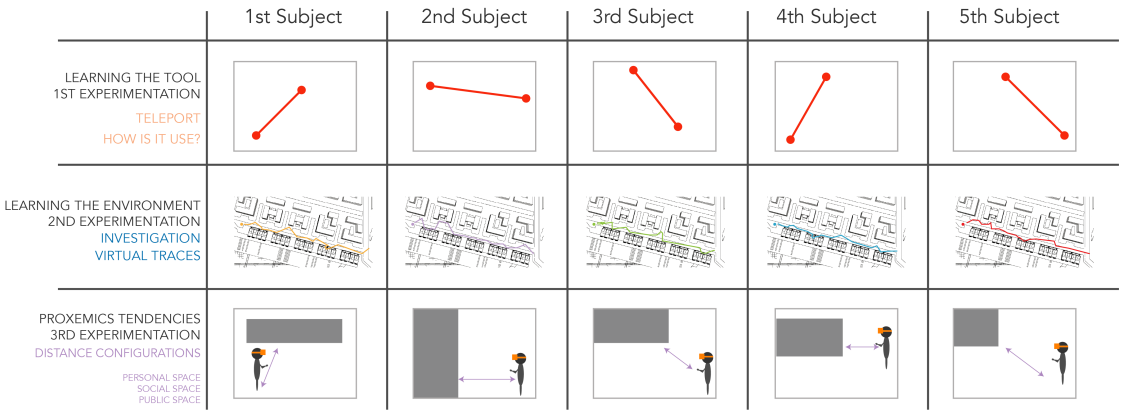

Figure 9 The analyses of 5 users for 3 experimentation

In the second experience, users tended to move around the entire map and wanted to leave the experience with the end of the model. Repeated patterns caused monotone experience for all the users. They realized that all buildings, detailed and without details, are repetitions of each other. The biggest similarities was the recognition of monotonous and attempting to enter the spaces, while the contradictions were that some of the users followed the roads and some of them tended to move through the spaces and all the openings they found.

In the third experience, it was observed that the users placed the details (such as the door number) at their personal distance and looked closely at them. They examined the places of transparency (window, space etc.). Users wanted to navigate to horizontal surfaces through navigation and look at places in ways that could not be real life. Leaning on the balconies, they constructed different angles. At this point, the comfort of not having the risk of falling in the virtual reality environment allowed different positions. The common reaction of all users was to look at places from different angles and surfaces. The points that users wanted to establish proximity were the detail points of the model.

The biggest similarity among the findings from all experiences is that all users tend to look to the left and right using the 6DoF feature in 9 min. along, while looking at the upside-down status is quite low (Figure 11).

5. Results

At the end of the three experiments, virtual individuals expressed where they wanted to perceive the structures through the points they tried and preferred (viewpoints) and angles. They talked about angles and heights that wouldn't be possible in real life, and it was seen in the video recordings that were taken in order of experience that they tried most of them.

Providing the situations that cannot be in real life in a virtual environment and the perception of the experienced place from different angles enriched the user results.

Figure 10 Chosen point of view for analyze

Users tended to stop and look as the amount of detail increased. On the other hand, they have structured their points according to different angles. When the whole facade was wanted to be perceived, they were teleported to a point on the opposite sidewalk and stayed at public distances. According to the level of detail that users want to see, that is, when they want to perceive a large element like a facade as a whole, it is observed that it positions it as public distance, that it places the detail element as a door number at its personal distance and that it places its social distance at different horizontal planes, that is, garden walls.

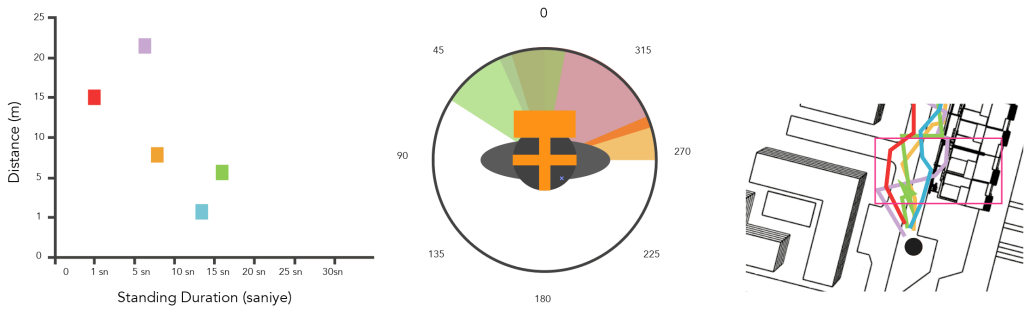

Figure 11 Chosen point to analyze for 5 users

As a result of this pilot study, the potential status of virtual space as a tool for measuring spatial tendencies is discussed and it is concluded that it is functional as a tool. In the continuation of these studies, the reality level of the model will be increased, modeling details will be considered at different levels and the architectural / urban elements will be adapted to this model. It will be explored how users participating in virtual experience construct

distance configurations with each element. Distance configurations will be scaled in the context of proxemic behavior and the aim is to decipher the spatial behaviors.

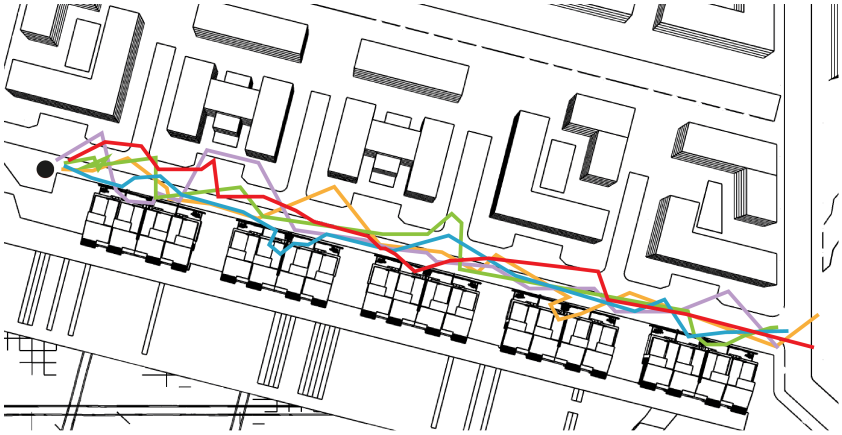

Figure 12. The traces of the 5 users

Thanks to the controlled change of parameters and the ability to measure the effects of all virtual elements, the virtual reality environment is also an advantageous tool for the integration of instruments used in the neuroscience field (EEG [Electroencephalography], ECG [Electrocardiography] and GSR [Galvanic Skin Response], motion data). It is possible to define a proxemic behavior in response to the collected signals.

REFERENCES

Arnheim, R. (2015). Visual Thinking. Berkeley :University of California Press.

Bailenson, J. N., Blascovich, J., Beall, A. C., & Loomis, J. M. (2003). Interpersonal Distances in Virtual Environments. Personality and Social Psychology Bulletin, 29(7), 819–833. https://doi.org/10.1177/0146167203253270

Baudrillard, J. (2011). Simülakrlar ve Simülasyon. (3rd ed.). DOĞUBATI.

Bolt, B. (2013). Yeni Bir Bakışla Heidegger. İstanbul: Kolektif Kitap.

Carmichael, O., & Lockhart, S. (2012). Mapping Social Interactions: The Science of Proxemics. Brain Imaging in Behavioral Neuroscience, (November 2011), 289–320. https://doi.org/10.1007/7854

Coyne, R. (1998). Cyberspace and Heidegger ' s pragmatics From identity to Dasein From proximity to care. *Technology*, *11*(4).

Conn, C., Lanier, J., Minsky, M., Fisher, S., & Druin, A. (1989). Virtual environments and interactivity: windows to the future. ACM SIGGRAPH 89 Panel Proceedings on - SIGGRAPH '89, 23(5), 7-18.

Coyne, R. (1994). Heidegger and Virtual Reality: The Implications of Heidegger's Thinking for Computer Representations. Leonardo, 27(1), 65.

Eberhard, J. (2008).Brain Landscape: The coexistence of Neuroscience and Architecture. 1 Ed. Oxford University.

Firestone, C., & Scholl, B. J. (2015). Cognition does not affect perception: Evaluating the evidence for top-down effects. Behavioral and Brain Sciences, 39(2016). https://doi.org/10.1017/S0140525X15000965

Franz, G., von der Heyde, M., & Bülthoff, H. (2005). An empirical approach to the experience of architectural space in virtual reality—exploring relations between features and affective appraisals of rectangular indoor spaces. Automation in Construction, 14(2), 165-172.

Gibson, W. (1984). Neuromancer. Gollancz. ISBN: 1473217385.

Groat, L. N., & Wang, D. (2013). Architectural research methods (Vol. 2). Hoboken: Wiley.

Guest, Ann Hutchinson. (2005). Labanotation: The system of analyzing and recording movement. Fourth Edition ed. New York; London: Routledge.

Hall, Edward T. (1963). "A System for the Notation of Proxemic Behavior". American Anthropologist. 65 (5): 1003–1026. doi:10.1525/aa.1963.65.5.02a00020.

Han, D.-I. D., Weber, J., Bastiaansen, M., Mitas, O., & Lub, X. (2019). Virtual and Augmented Reality Technologies to Enhance the Visitor Experience in Cultural Tourism. 113–128. https://doi.org/10.1007/978-3-030-06246-0_9

Hecht, H., Welsch, R., Viehoff, J., & Longo, M. R. (2019). The shape of personal space. Acta Psychologica, 193(December 2018), 113–122. https://doi.org/10.1016/j.actpsy.2018.12.009

Heim, M. (1993). *Metaphysics of Virtual Reality*. New York: Oxford University Press.

Iachini, T., Ph, D., Coello, Y., Frassinetti, F., Senese, V. P., Galante, F., & Ruggiero, G. (2016). Peripersonal and Interpersonal Space in Virtual and Real Environments: Effects of Gender and Age. https://doi.org/10.1016/j.jenvp.2016.01.004.This

Interrante, V., Ries, B., & Anderson, L. (2006). Distance Perception in Immersive Virtual Environments, Revisited. IEEE Virtual Reality Conference .

Kim, J. (2015). *Phenomenology of Digital-Being.* Human Studies *24*(1), 87–111.

Kuliga, S. F., Thrash, T., Dalton, R. C., & Hölscher, C. (2015). Virtual reality as an empirical research tool — Exploring user experience in a real building and a corresponding virtual model. Computers, Environment and Urban Systems, 54, 363-375s

Lynch, K. (1990). The Image of the City. Cambridge, Massachusetts, and London, England: The M.I.T. Press Massachusetts Institute of Technology.

Mania, K., & Chalmers, A. (2001). The Effects of Levels of Immersion on Memory and Presence in Virtual Environments: A Reality Centered Approach. CyberPsychology & Behavior, 4(2").

Mallgrave, H. (2011).The Architect's Brain: Neuroscience, Creativity and Architecture. 1.Ed. Wiley – Blackwell.

Mallgrave, H. (2015). Enculturation, Sociality and Built Environment, In: Architecture and Empathy. Edited by: Tidwell, P. Finland: Taplo Wirkkata Rut Bryk Fundation.

Mul, J. De. (1999). Virtual Reality. The Interplay Between Technology, Ontology and Art. *Filozofski Vestnik*, *20*(2), 165–184.

Ökten, K. H. (2012). Heidegger'e Giriş. İstanbul. Agora Kitaplığı.

Rodriguez, A., Camacho, A. C., Hinojos, L. J., Afravi, M., & Novick, D. (2019). A proxemics measurement tool integrated into VAIF and unity. ICMI 2019 - Proceedings of the 2019

International Conference on Multimodal Interaction, 508–509. https://doi.org/10.1145/3340555.3358663

Salesses, Philip, Katja Schechtner, and César A. Hidalgo. (2013). "The Collaborative Image of The City: Mapping the Inequality of Urban Perception." PLoS ONE 8 (7): e68400.

Sanchez-Vives, M. V., & Slater, M. (2005). From presence to consciousness through virtual reality. Nature Reviews Neuroscience, 6(4), 332-339.

Sussman, A., & Hollander, J. (2015). Cognitive Architecture: Designing for how we respond to the Built Environment. Routledge Taylor & Francis Group.

Sussman, Ann, and Janice Ward. (2016). Planning for the Subconscious Using Eye Tracking and Other Biometric Tools for Better Understand Ourselves. Planning 82 (6): 31-34.

Tuan, Y. (2001). Space and Place: the Perspective of Experience (8th ed.). Minnesota: The University of Minnesota.

Van Dongen, R. P., & Timmermans, H. J. P. (2019). Preference for different urban greenscape designs: A choice experiment using virtual environments. Urban Forestry and Urban Greening, 44(August). https://doi.org/10.1016/j.ufug.2019.126435

Wei, W., Qi, R., & Zhang, L. (2019). Effects of virtual reality on theme park visitors' experience and behaviors: A presence perspective. Tourism Management, 71(August 2018), 282–293. https://doi.org/10.1016/j.tourman.2018.10.024

Whyte, J., & Nikolic, D. (2002). Virtual reality and the built environment. Oxford: Architectural Press.

Witmer, B. G., & Singer, M. J. (1998). Measuring Presence in Virtual Environments: A Presence Questionnaire. Presence: Teleoperators and Virtual Environments, 7(3).

Yaremych, H. E., & Persky, S. (2019). Tracing physical behavior in virtual reality: A narrative review of applications to social psychology. Journal of Experimental Social Psychology, 85(July). https://doi.org/10.1016/j.jesp.2019.103845.

Zahorik, P., & Jenison, R. L. (1998). Presence as being-in-the-world. *Presence: Teleoperators and Virtual Environments*, *7*(1), 78–89. https://doi.org/10.1162/105474698565541.