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Published in:
Landscape and Urban Planning

DOI:
10.1016/j.landurbplan.2020.103996

Published: 01/03/2021

Document Version
Publisher's PDF, also known as Version of record

Landscape and Urban Planning 207 (2021) 103996

Contents lists available at ScienceDirect

Landscape and Urban Planning

journal homepage: www.elsevier.com/locate/landurbplan

Research Paper

Sense of presence and sense of place in perceiving a 3D geovisualization for communication in urban planning – Differences introduced by prior familiarity with the place

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HIGHLIGHTS

- Perception is not only dependent on the realism but also on prior information.
- We show interplay between the sense of presence and sense of place in perception.
- Familiarity alters sense of presence and sense of place, and ideas on urban planning.
- Familiar respondents were more likely to prefer preserving planning outcome.
- 3D geovisualizations are best used as supportive tools and secondary to a real visit.

ARTICLE INFO

Keywords:
Sense of place
Photorealism
Communication
Urban planning
3D geovisualization
Sense of presence

ABSTRACT

Technological development towards increased visual quality and accessibility has made photorealistic 3D geovisualizations an interesting tool for communication in urban planning. Particularly the ability to support perception is important in assessing 3D geovisualizations' effectiveness for communication. We applied both the concept of sense of presence, i.e. effectiveness of the medium, and sense of place, i.e. meanings and affordances, in a user study conducted through a web-based 3D geovisualization. The study addressed a shopping mall in Helsinki, Finland. We collected a sample of adolescent respondents (n = 122), both familiar and unfamiliar with the geovisualized place in question. Adolescents responded to a survey addressing their perceptions of the mall after the virtual visit. The results indicate that prior familiarity with the place affects the results with the sense of presence, sense of place and preferred urban planning outcome. Familiar respondents were more likely to prefer preservation of the mall. The results show how sense of presence and sense of place work in interplay in the perception of a photorealistic 3D geovisualization. Perception is not only dependent on the realism the 3D geovisualization is able to transmit but also on the individual knowledge and experiences of the audience. According to the results, 3D geovisualizations are best used as supportive tools in communication for urban planning and secondary to a real visit.

1. Introduction

We live in an increasingly visual culture (Nicholson-Cole 2005) where the visualization of information has become an integral part of decision-making processes (Sheppard et al., 2011; Bishop, Pettit, Sheth, & Sharma, 2013; Herbert & Chen, 2015; Billger, Thuvander, & Wästberg, 2017). Through technological advancement, 3D visualization is increasingly being adopted to assist visual communication in urban planning. Concerning digital 3D representations of the physical environment, research has addressed, for example, their technical

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https://doi.org/10.1016/j.landurbplan.2020.103996
Received 28 February 2020; Received in revised form 11 November 2020; Accepted 18 November 2020
Available online 3 December 2020

development (e.g., Zhu et al., 2011), applicability for specific tasks (e.g., Boulos, Hetherington, & Wheeler, 2007; Biljecki, Stoter, Ledoux, Zlatanova, & Çöltekin, 2015; Urech, Dissegna, Girot, & Grêt-Regamey, 2020), and related user experience (e.g., Sylaiou, Mania, Karoulis, & White, 2010). In this article, digital 3D representation of the physical environment is referred to as 3D geovisualization (e.g., Bleisch, 2012; Rautenbach et al., 2016; Kubíček et al., 2019).

3D geovisualizations have been developed on different scales, from global (e.g.,(Mahdavi-Amiri et al., 2015) Müller et al., 2016) and city-wide visualizations (e.g., Glander & Döllner, 2009; Singh, Jain, & Mandla, 2013; Alatalo, Koskela, Pouke, Alavesa, & Ojala, 2016) to urban scenes consisting of single buildings (e.g., Xiong, Adan, Akinci, & Huber, 2013; Malihi et al., 2016) or indoor spaces (Tashakkori, Rajabifard, & Kalantari, 2015). One of the current areas of research is the enrichment of 3D geovisualizations with interactive and multimodal content, such as storytelling and audio installations (Virtanen et al., 2018) aiming to support understanding and exploration (Thöny, Schnürer, Sieber, Hurni, & Pajarola, 2018). Also, recent technological developments have enabled and popularized the creation and publishing of 3D geovisualizations on the web (Julin et al., 2019), making them more accessible for the wider public. In applying interactive, real-time 3D geovisualizations, the limitations of computing power, preparation time of the 3D models, and the facility requirements of display systems have been seen as issues potentially hindering their use (Lovett et al., 2015). However, one inspiration for this study is the technological development leading to enhanced visual quality, improved computing power, and accessibility. Photorealistic 3D representations of the environment can now be more easily and automatically produced through 3D measuring and modeling, namely laser scanning and photogrammetry, and related data processing software. Further, 3D visualizations are nowadays easily shareable and accessible, for instance as 3D viewer applications on the web (Julin et al., 2019).

The potential of 3D geovisualizations for enhanced participation and communication in planning has been acknowledged for several decades (e.g., Batty, Dodge, Doyle, & Hudson-Smith, 1998; Pettit, Cartwright, & Berry, 2006; Neuenschwander, Hayek, & Grêt-Regamey, 2014). 3D visualizations can be divided into three topics according to their functionality in participatory planning: functions (1) to support individual information processing, for instance to motivate and focus the attention of the viewer on extracting the relevant information and contextualizing it (treated in this article as perception), (2) to stimulate participant discussions, and (3) to achieve the objectives of information transfer and planning tasks in different phases of the planning process, such as aiding in collecting, exploring, and analyzing problem-relevant information as well as choosing possible solutions (Andrienko et al., 2007; Dransch, 2007; Wissen et al., 2008, cited in Hayek, 2011). Within the context of applications, the human dimension of 3D visualizations is important for assessing their effectiveness in participatory planning, that is to say, "how the tools support perception and communication" (Hayek, 2011). For 3D geovisualizations, many studies have thus far focused on user experience (Zanola, Fabrikant, & Çöltekin, 2009; Lokka, Çöltekin, & Halounova, 2016; Hruby, Ressl, & de la Borbolla Del Valle, 2019). However, the findings regarding their communicative functionality, that is, individual information processing, participant discussions, and information transfer in the planning process, still need further exploration. Previous research has emphasized the need to investigate different visualization types and their various audiences to enhance communication (Hayek, 2011; Lovett et al., 2015; Çöltekin, Lokka, Zahner, & Halounova, 2016).

Visual realism is an important part of the discourse on 3D geovisualizations (Çöltekin et al., 2016; Appleton & Lovett, 2003), which has also been studied in terms of communication in planning. Realism in 3D geovisualizations aids both in the comprehension of complex spatial relations and estimation of the effects of planned projects (Drettakis et al., 2007; Virtanen et al., 2015). To examine perceived realism, the concept of sense of presence has been applied in virtual environment-(VE-)related research to study the subjective perception of being in a particular place, even if situated physically somewhere else, in other words, to assess the level of immersiveness (Witmer & Singer, 1998; Slater, 1999; Lessiter et al., 2001). Sense of presence is usually studied with the support of virtual reality (VR) glasses, but 2D screen approaches can also be applied (e.g., K.D. Williams, 2014). Researchers have questioned whether visual quality is a dominant factor in immersiveness and sense of presence. Hence, it has been pointed out that sense of presence also consists of spatial experience, including, for instance, the possibility to move freely, soundscape, social interactions, and interactions with objects (e.g., Wirth et al., 2007; Saunders, Rutkowski, van Genuchten, Vogel, & Orrego, 2011; Cummings & Bailenson, 2016; Lindquist et al., 2016).

However, the realism-centric discussions of 3D geovisualizations have been contested (e.g., Ervin, 2001), and sense of presence is not the only way to reflect on the impact of a digitally produced environment on perception and communication. To harness 3D geovisualizations for communication in planning and to assess their role in them, we suggest that there is a need for a viewpoint that opens up and addresses the ability to transmit the human connections to a place, that is, the perceived meanings and affordances of a place. Sense of place is a useful concept for grasping the urban environment, not only as a technical and physical construct, but also as a socially constructed and perception-dependent entity (e.g., Tuan, 1979; Massey, 1994; Jorgensen & Stedman, 2001; Stedman, 2003). The definitions for sense of place vary among different disciplines (e.g., Gustafson, 2001). However, scientific research in such fields as geography, sociology, and psychology is usually based on the idea that "places represent *not only* physical settings and activities within those settings, but also the meanings and emotions people associate with settings, influencing e.g. environmental planning and participation processes" (Davenport & Anderson, 2005).

Traditionally, sense of place includes ideas of socially constructed and shared place attachment and place meanings (Kudryavtsev et al., 2012; D.R. Williams, 2014; Sebastien, 2020). While most discussions on sense of place have noted that it takes time to develop (e.g., Falconer, 2017), several studies have addressed the immediately perceived and sensory dimensions of sense of place. Raymond, Kyttä and Stedman (2017) have found that while scholars focusing on sense of place usually concentrate on the aspects of sense of place that develop slowly and over time, several aspects speak to the rapid and immediately emerging perceptions of a place. Thus, the research tradition on sense of place has also considered perceived affordances (i.e., direct and contextual, as dealt with in scientific realism) along with place meanings (i.e., collective, individual, and socio-cultural, as dealt with in hermeneutics or phenomenology) and place attachment (i.e., place dependence and place identity, as dealt with in positivism or post-positivism). According to Kyttä (2004), there are two kinds of affordances: those that are actively used and shaped and those that are passively perceived. In this case, the study setting favors the latter ones, as our study case does not include features supporting the so-called digital twin approach, in which the user of a 3D geovisualization is able to interact with the real physical setting while using a digital presentation of it (Qi et al., 2019; Batty, 2018).

Sense of place as a concept has been addressed in studies of virtual environments (e.g. Zhang & Clear, 2014), mobile technology-assisted tasks, and AR (augmented reality) (Chang, Hou, Pan, Sung, & Chang, 2015), as well as in gamification-related study settings (e.g., Bowser et al., 2013). The findings suggest that these approaches have a positive effect on participants' or learner's sense of place, learning motivation, and learning achievements. However, only a few studies have explored the relationship between 3D geovisualizations and sense of place (Newell, 2017). Newell and Canessa (2015) noted that by understanding 3D geovisualizations as platforms that interact with people's sense of place, it is possible to identify key visual elements and perspectives that resonate with different stakeholders. Furthermore, sense of presence is linked to sense of place in 3D geovisualizations, as sense of presence

enables cognitive processes via observation that in turn allow 3D geovisualizations to connect to people's sense of place through their subjective perceptions and personal knowledge. Thus, sense of presence highlights 3D geovisualization as a *medium* and offers an interesting point of view for assessing the effectiveness of a photorealistic 3D geovisualization in communication. However, for urban planning purposes it is essential to grasp the importance of sense of place, that is, place-based *meanings* and *affordances*, in relation to sense of presence (Fig. 1).

By far we know that different users require different 3D geovisualizations based on their differing needs (Voinov, Çöltekin, Chen, & Beydoun, 2018; Ugwitz et al., 2019), and the type of visualization should be carefully assessed if applied for urban planning-related communication (Hayek, 2011; Lovett et al., 2015). Furthermore, previous familiarity with the real physical setting can affect communication. For example, place-based meanings generated by 3D geovisualizations were studied by Pouke et al. (2019). They applied in situ tests and qualitative analysis to examine the perception of a realistic VE in its real setting in Finland. According to the user test conducted with a VR headset, familiarity increases expectations about the use of a VE, and on-site experience has both reinforcing and degenerative effects on sense of presence; for instance, when background noises did not contradict the VR stimuli, then the real soundscape supported sense of presence. Bishop and Rohrmann (2003) found that users visiting an urban park prior to viewing it via 3D geovisualization were more impressed by the realism and presentation quality of the computer simulations than those who did not visit the physical space prior to viewing the simulation. Similarly, Newell (2017, p. 190) noted that "experiences with real-world places influence how we regard and interact with virtual representations of these places," and thus, recent place experiences of the users of 3D geovisualizations should be considered when using them for planning purposes. Falconer (2017) performed a study with a 3D simulation of the historical landscape of Avebury (UK), which the study participants then explored. She observed that familiarity matters also when the real site is not familiar but the virtual site is. Visiting virtual historical Avebury prior to visiting today's Avebury was noted to influence the visitor's sense of orientation and sense of familiarity in a positive way.

The motivation behind this paper is the recognition that while studies have focused on the communicative functionality of 3D geovisualizations, there is still a need for further research that takes into account perception and understanding of reality-based 3D geovisualizations when using them in communication for urban planning. This is the case especially when advancing easy public access techniques, such as web-based 3D model platforms on a 2D screen. Such platforms are important because if collaborative urban planning is to use photorealistic 3D representations (e.g., Billger et al., 2017), it will likely apply and advance techniques that are cross-platform compatible and straightforward in application deployment (Mouton et al., 2011; Evans et al., 2014), convenient for public use, and adopted by a larger audience. Thus, our particular interest is anchored in the photorealistic 3D geovisualizations presented via easily accessible web-based applications on a 2D screen.

The focus of this paper is a web-based photorealistic 3D geovisualization that includes multimodal video content. We are interested in whether having prior knowledge about or having visited a real physical place influences how a 3D geovisualization is perceived, and the extent to which a 3D geovisualization with embedded videos creates visual realism and immersiveness, that is, a sense of presence. We also aim to understand what kinds of meanings and affordances associated with a place, that is, sense of place, such a 3D geovisualization creates and reveals. Finally, we study what kind of urban planning-related opinions the 3D geovisualization-assisted visit (virtual visit) generates in combination with any possible prior information on the respective place. Our study addresses the Puhos shopping mall in Helsinki, Finland, and the related "Puhos 3D" application, a web-based photorealistic 3D geovisualization created from the mall.

More specifically, our objectives are as follows:

(1) to explore perceptions related to a virtual visit to Puhos 3D in terms of the sense of presence, sense of place and the future of the mall;
(2) to identify differences in responses between respondents familiar and unfamiliar with the Puhos shopping mall;
(3) discuss perception of Puhos 3D in terms of familiarity, sense of presence (effectiveness of medium), and sense of place (meanings and affordances) for the use of photorealistic 3D geovisualizations in communication on urban planning.

2. Methods

2.1. Case: Puhos shopping mall

Puhos shopping mall (officially the Puotinharjun Puhos shopping mall, hereinafter Puhos mall), located in Helsinki, Finland, is an architecturally modernist shopping mall originally opened in 1965. At the time, it was the largest shopping mall in Finland. Until the 1980s, the Puhos mall flourished, but it eventually fell on hard times as the new metro station and the more modern, larger shopping mall Itis (formerly Itäkeskus) opened nearby. By the 1990s, the value of the Puhos mall had considerably decreased. Since the 2000s, many entrepreneurs with immigrant backgrounds opened up businesses in Puhos. By the late 2010s, the Puhos mall offered a remarkable selection of ethnic goods, restaurants, and a mosque. During the final years of the 2010s, political discussions of the Puhos mall became increasingly animated, as the rental agreement with the city of Helsinki is ending in 2020 and the city began putting pressure on the current property owners to plan for refurbishment. The public concern is that the existing small entrepreneurs might lose their ability to run a business, as the property value rises with the refurbishment. (*Helsingin Sanomat*, November 13, 2018.)

The colorful history and the complexity of the situation make the Puhos mall an interesting and topical urban development case. Enriching 3D geovisualization with multimodal elements, Puhos 3D was published as part of a news article by the Finnish public service media company Yle, which covered the history of Puhos (*Yle,* October 22, 2017, available at https://yle.fi/uutiset/3–9891239). The storytelling aspect was part of the journalistic narrative of Puhos 3D, and thus it included a communication-enhancing purpose. The Yle reporters aimed to deliver the atmosphere and story of the generally not so well-known urban site to the wider public in Helsinki and the rest of Finland. The 3D geovisualization-assisted news story was planned and implemented in close cooperation with Yle.

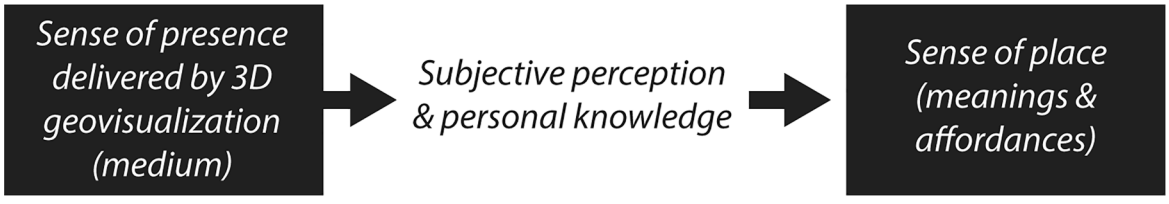

Fig. 1. Sense of presence and sense of place in the context of 3D geovisualization-assisted communication in urban planning.

2.2. 3D model of the Puhos mall

The 3D model of Puhos was created using terrestrial laser scanning (TLS) and close-range photogrammetry as source data, while at the same time relying on manual 3D modeling to obtain a low-polygon model suitable for web-based visualization. Photo textures were extensively used in the model to attain a realistic appearance. In addition, a highly detailed 3D mesh model was created in RealityCapture (version 1.0.3.5735 RC) using a hybrid approach that combined the TLS data and photogrammetric images. Segments of this dense model were used to add organic details, such as booths and bicycles, to the manually created low-polygon model. Locals of Puhos and some animals, such as dogs and pigeons, were added to the scene as simple 2D cut-out models to enliven it. The data acquisition campaign and the data pre-processing have been described in more detail by Julin et al. (2019).

The completed 3D model of Puhos 3D was presented via Sketchfab (Sketchfab, 2019), a popular 3D model publishing platform based on WebGL (WebGL, 2019). Finally, videos were embedded in the Sketchfab model and numbered for identification (Fig. 2). The final web experience of Puhos 3D consists of a web-based 3D environment with embedded videos, in which locals describe their daily life at Puhos. Video material was produced by Yle at the Puhos mall, and the interviewees were recruited with the help of a local guide, with the aim of involving local stakeholders with differing backgrounds (language, gender, age). The videos present the ideas voiced mainly by the local shop owners and people active in the Puhos community.

2.3. Study design and ethics

To simulate and study a 3D geovisualization-assisted communicative and participatory urban planning task, we gathered perceptions of Puhos 3D and the real mall as well as opinions considering the future of the real mall. We targeted adolescents and young adults. In Finland, young people attend compulsory primary school up to the 9th grade, and studies (e.g., Kilpi-Jakonen, 2012; Marks, 2006) show that the differences between Finnish schools are relatively low, and thus, the equality of the educational system is relatively high. Middle school students in the 8th (14–15 years old) and 9th grades (15–16 years old) were chosen as the target group since the educational differences between those age groups are smaller than among older age groups, making it an interesting target group since even though they are close to adult age, they generally still have fairly similar life situations. With this choice, we aimed to lessen the impact of other background factors on the results. Adolescents' role as users of future technology was also of interest to the research team, in addition to the fact that they often are considered quick adopters of new technologies and many of them are accustomed to using technology in their daily life. In the pedagogical sense, young people are an interesting group in planning related communication. The need for young people's voices to be better reflected in urban planning has been underlined recently. For example, Kallio and Häkli (2013, p. 4) make the following argument: "The sub-fields of children's geographies and geographies of youth accentuate the recognition of children as active 'beings' rather than policy objects, institutional recruits or future 'becomings'. The research stresses children's competence as social and cultural beings who may act as full members of their communities and societies alongside with adults." We have advocated this idea in our study.

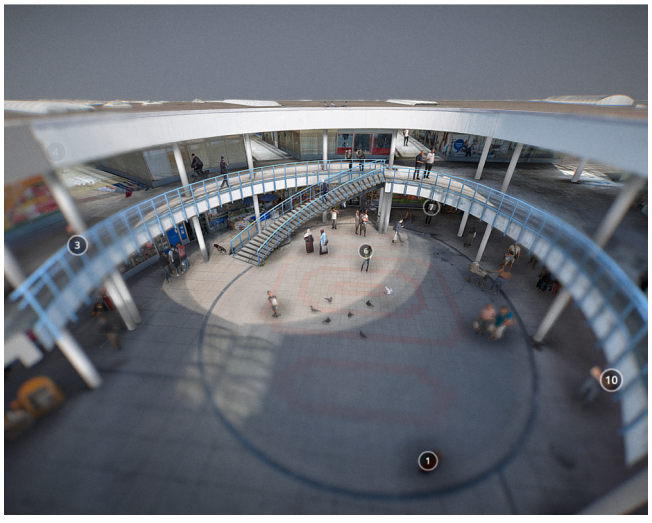

Fig. 2. A view of the mall in Puhos 3D.

We developed an online survey targeting adolescents and young adults. After the respondents individually used and explored Puhos 3D with videos, they were instructed to respond to a survey. The survey targeted both those without any prior knowledge of the Puhos mall and those already familiar with it.

The study was conducted in accordance with the ethical principles of research in the humanities and social and behavioral sciences promoted by the Finnish National Advisory Board on Research Ethics (2009), according to which children 15 years and older can participate in a research study on their own volition. For children under 15, a guardian's permission is required, and this was taken into consideration when conducting the study.

2.4. Survey design

A survey operating on the Webropol (version 2.0) platform was designed to include questions that give information both on the respondents' sense of presence and sense of place. In addition, questions related to urban planning were asked. The questionnaire form along with the respective topics is provided in the Appendix A (translated from Finnish into English) and the original in the form in the Appendix F (in Finnish). The respondents' relatively young age was taken into account when designing the questionnaire. We avoided using complex sentences and difficult concepts and included a variety of question types (from Likert scale questions to multiple-choice and open-ended questions) to make responding easier.

According to Lessiter et al. (2001), sense of presence can be addressed through the following topics: sense of space, involvement, attention, distraction, control and manipulation, realness, naturalness, and negative effects. These items were applied when formulating the survey parts on sense of presence, while at the same time taking into account the study topic and photorealistic nature of Puhos 3D (i.e., that the place really exists, that it is a case of topical urban planning questions, and that some of the respondents may have prior knowledge of it or have visited it). Sense of presence is typically measured subjectively through rating statements on a Likert scale (e.g., Witmer & Singer, 1998; Lessiter et al., 2001; North & North, 2016). Along with a multiple-choice question and open-ended question, we formulated five statements addressing understanding and navigation in and the immersiveness of Puhos 3D (Appendix A) using a five-point Likert scale (Lessiter et al., 2001; Salter, Campbell, Journeay, & Sheppard, 2009; Nakevska et al., 2017). In addition to the Likert scale questions, we asked the respondents to indicate which items and properties of the environment they perceived in Puhos 3D to assess the transmission of information. Finally, we asked about usability and their preferred way of moving.

Sense of place was studied both through place-related meanings and affordances. To study how place meanings individually form and/or are collectively shared, disseminated, and deployed (Shamai & Ilatov, 2005; Turner & Turner, 2006; Brown & Raymond, 2007; Lewicka, 2011; Raymond et al., 2017) via Puhos 3D, we applied both deductive and inductive approaches. We formulated items describing the Puhos mall that the respondent could freely choose, that is, meanings and affordances of the place, and gave respondents the chance to add their own

items, too. The terms also contained conflicting descriptions, but they could be evenly chosen. This was designed on purpose since perception of one's sense of place can also include contradictory elements (Dwyer, 1999; Antrop, 2006). Using a multiple-choice question, we asked the respondents to evaluate their interest in the mall and how they assess their desire to potentially visit the mall. Finally, we gave respondents the option to, in their own words, describe Puhos as a place based on their experience in Puhos 3D. Unlike for sense of presence, we did not use scales to detect the complexity of sense of place (Davenport & Anderson, 2005; Trell & Van Hoven, 2010) but instead, concentrated on the richness, that is, multiplicity of the items through open and multiple-choice questions. Also, we merged structured and open questions considering the adolescent respondents and their capability to respond. The structured questions were developed to capture the fast approach to sense of place including both the perceived meanings and affordances. The latter still does not have a similar established methodological tradition in the studies on sense of place (Raymond et al., 2017), especially in the context of 3D geovisualizations, which led us using mainly inductive approach in forming the items.

The preferred urban planning outcome concerning the future of the Puhos mall was studied by giving the respondents five options, formulated to imply the following attitudes: (1) preserving, (2) moderate renewing, (3) radical renewing, (4) other ideas, and (5) no opinion. The respondents could also give voluntary explanations for their choices.

All participants used the same set up to carry out the experiments. Participants were first asked to open the survey link and read the short introduction to the study, including how to use the 3D geovisualization with a mouse and a keyboard. The survey started by asking them whether they know anything about the Puhos mall. If the respondent had any prior knowledge of Puhos mall (i.e., was familiar with the mall or had visited it), a new question followed in which the respondent was asked to specify whether he/she had visited the mall or not. Subsequently, respondents familiar with it were asked to choose from a list of adjectives the ones that best fit their own idea about the Puhos mall before continuing to Puhos 3D. If the respondent did not know anything about the Puhos mall, the survey led the respondent immediately to Puhos 3D. At Puhos 3D, the respondents were asked to take a four-minute virtual tour and select and watch preferably four videos. Afterwards, the respondent was instructed to go back to the survey and continue responding.

Survey parts 5, 6, 10–14, and 24 (Appendix A) asked respondents questions about their sense of presence. Parts 8, 17, and 19 asked them about their sense of place. Survey parts 20–21 asked them to provide planning-related information on the use of digital 3D environments and their ideas on the future use of 3D models. The rest of the survey questions asked for additional information and background variables, such as familiarity with the Puhos mall, gender, and personal interests. Considering the respondents' young age and their abilities as respondents, we did not require information on socio-economic parameters, but instead aimed to gain an understanding of a respondent's profile by asking about their personal leisure time interests. One primary school teacher, two adolescents, and five researchers tested the survey before the data collection phase.

2.5. Respondent recruitment

Respondents were recruited using two methods. First, three primary schools in southern Finland, in the cities of Helsinki, Hämeenlinna, and Raisio, expressed an interest in cooperating and invited the study group to join eight distinct classes. The attending classes consisted of ninth graders (15–16 years old), except for one class, which consisted of eighth graders (14–15 years old). All the students received invitation letters to join the research study 3–4 weeks in advance. The letter included basic information on the study and information on respondents' privacy protection. Only those students willing to join and having their guardians' signed permission were allowed to join the study.

Each student attended the study individually using a computer with a monitor, keyboard, mouse, and web browser. In the beginning, the students received oral and written instructions on how to use Puhos 3D and how to respond to the survey questions. The whole process took 45–60 min.

Since the number of respondents familiar with the Puhos mall (including those having any prior knowledge, not only those who had visited) was relatively few, we supplemented the sample by inviting respondents to the Itis shopping mall located near the Puhos mall. At the Itis mall, young adults and adolescents aged 15 and over were informed about the study and asked to take part in the test and survey. The research team had two computers with a monitor, keyboard, mouse, and web browser. Recruitment started by asking if the person was 15 years old or older and whether he or she had ever heard about or visited the Puhos mall. The participants were given oral and written instructions before the test and survey, as at the schools.

Data collection took place during a total of four school visits (two days in Helsinki, one day both in Raisio and Hämeenlinna) in May 2018 and one day at the Itis mall in June 2018. Altogether, the final data used for the analysis included 122 respondents. Some of the respondents replied to the open-ended questions with answers that had nothing to do with the question or the topic. On the other hand, some respondents stated their age to be something else that it should have been in order them to join the survey (conflicting with the information we had). For these reasons, we needed to exclude eight respondents.

2.6. Analysis

Quantitative survey responses were analyzed in SPSS 24 via descriptive statistics and cross-tabulation. As the variables' level of measurement was nominal and ordinal, we used non-parametrical tests in the cross-tabulation. Pearson's Chi square tests were applied to identify significant associations between those unfamiliar and familiar with the Puhos mall in the nominal scale questions (multiple choice) and Mann-Whitney U tests in the ordinal scale questions, that is, the Likert Scale questions (De Winter & Dodou, 2010). Fisher's exact test was applied for the nominal scale questions when the cell size was small and required an alternative test method. In the reporting of the test results, * denotes significance level at $P \leq 0.05$, ** denotes significance level at $P \leq 0.01$, and *** denotes significance level at $P \leq 0.001$.

Responses to the open-ended questions (Q19, Q21, and Q24, Appendix A) were manually coded through inductive content analysis in an MS Excel table to identify different topics described by the respondents. No cross-tabulation was used in the analysis of the open-ended questions.

In addition, control cross-tabulation tests were applied using the following background variables instead of familiarity: (1) gender and those having an interest in (2) games and gaming, (3) new technologies and devices, (4) urban culture, such as shopping and going to cafes, and (5) traveling and getting to know new cultures.

3. Results

3.1. Profile of respondents

Our study comprised a total of 122 respondents. The profile of the respondents is presented in Table 1, which shows that 28.7% were familiar with the mall ($n = 35$), that 6.5% ($n = 8$) of the respondents had some knowledge about or image of the mall prior to the virtual visit, and that 22.1% ($n = 27$) had visited the mall prior to the visit.

3.2. Perceived sense of presence

The respondents familiar with the Puhos mall expressed a more positive sense of presence than those unfamiliar with it in all the Likert scale statements dealing with a perceived sense of presence (Fig. 3,

Table 1
Respondent profile in terms of familiarity, control variables, and site of recruitment (groups compared in the analysis denoted with *, and in the control analysis with **).

Type	Respondents	n	%
Familiarity	Familiar, all*	35	28.6%
	Familiar: had visited the mall prior to the virtual visit	27	22.1%
	Familiar: had some knowledge or image of the mall prior to the virtual visit	8	6,5%
	Unfamiliar*	87	71.3%
Control variable	Female**	62	50.8%
	Male**	60	49.2%
	Interest in games and gaming**	61	50%
	Interest in new technologies and devices**	56	45.9%
	Interest in urban culture, such as shopping and going to cafes**	53	43.4%
	Interest in traveling and getting to know new cultures**	79	64.7%
Site of recruitment	Student in Hämeenlinna	29	23.8%
	Student in Helsinki	39	32%
	Student in Raisio	35	28.7%
	Visitor at Itis shopping mall, Helsinki	19	15.6%
	All	122	100%

Appendix B). Similarly, those unfamiliar with the mall expressed a more negative sense of presence than those familiar with it in all statements.

Most respondents (61.5%) fully or slightly agreed with the statement that *the environment of Puhos 3D was easy to understand* (Fig. 3, S1), while 45.1% of the respondents fully or slightly agreed with the statement *I could navigate in the real Puhos mall based on the virtual visit* (Fig. 3, S2). Regarding the second statement, the groups exhibited statistically significant differences in their responses: only 11.5% of unfamiliar respondents fully agreed with the statement compared to 34.3% in the familiar group. Half (50.2%) of the respondents fully agreed or slightly agreed that *the environment of Puhos 3D felt real* (Fig. 3, S3), and similarly about half of the respondents (51.6%) fully or slightly agreed that *the*

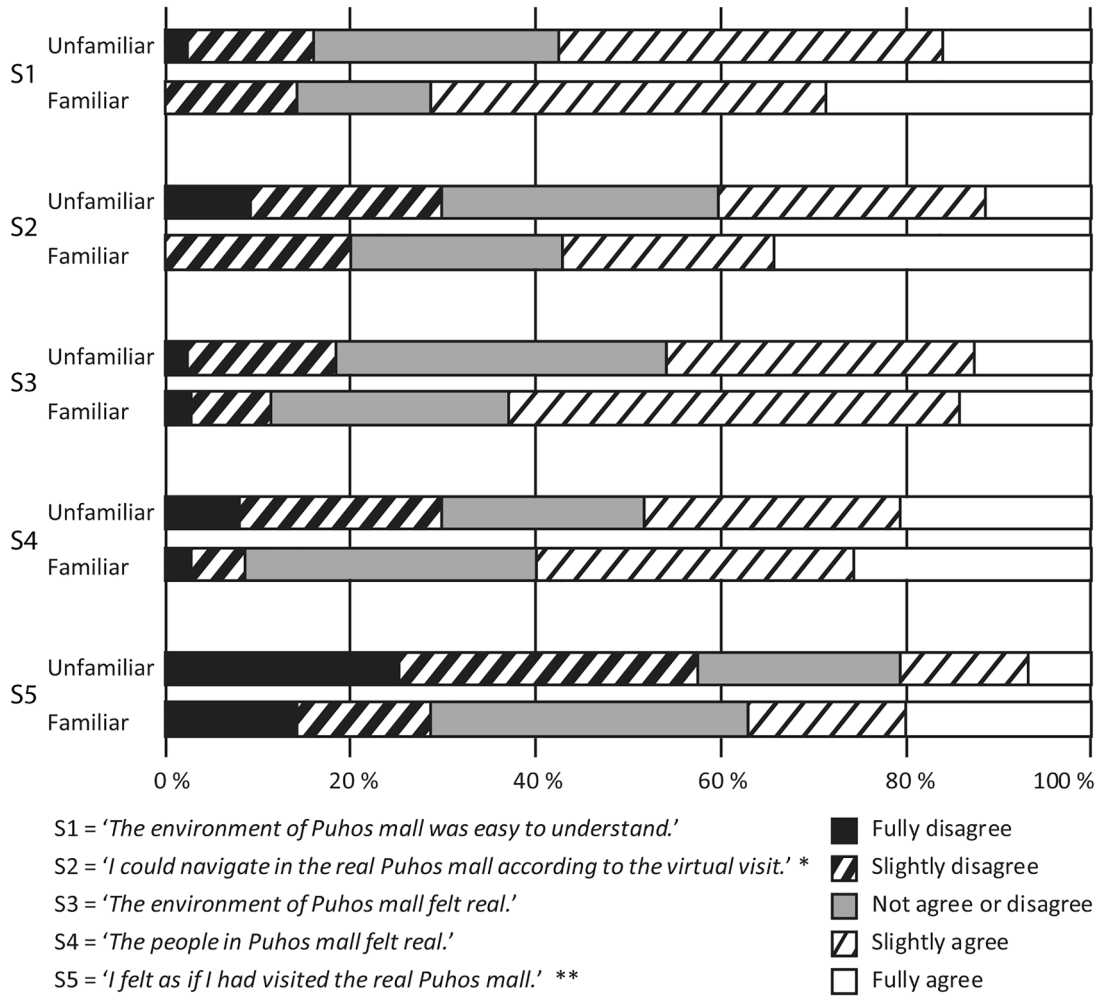

Fig. 3. Distribution of responses related to statements evaluating the perceived sense of presence in Puhos 3D, with a distinction between the unfamiliar (n = 87) and familiar (n = 35) respondents. The statistically significant differences between the groups denoted with * and with **.

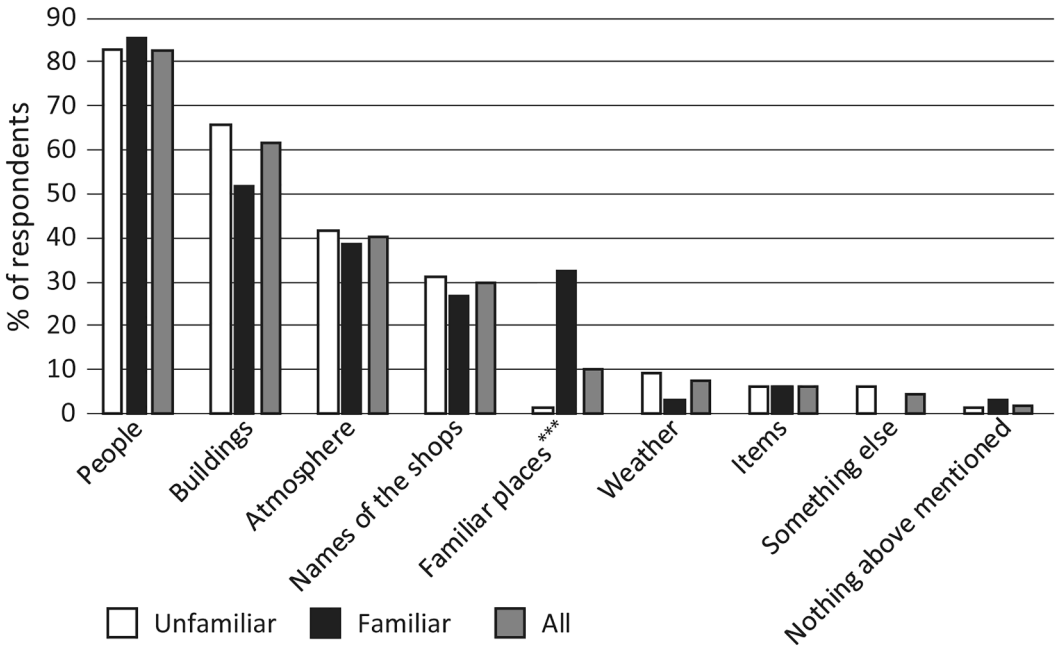

Fig. 4. Frequency of details that respondents paid attention to in Puhos 3D, with a distinction between unfamiliar (n = 87) and familiar (n = 35) respondents. The statistically significant difference between the groups denoted with ***.

people in Puhos 3D felt real (Fig. 3, S4).

One-quarter of the respondents (25.4%) fully or slightly agreed with the statement that Puhos 3D generated a *feeling like having visited the real Puhos mall* (Fig. 3, S5). With this statement, the groups show statistically significant differences in their responses (Fig. 3, S5). Unfamiliar respondents disagreed with the statement more than those familiar with the mall: 57.5% of those unfamiliar with it and 28.6% of those familiar with it either fully or slightly disagreed, and vice versa; 20.7% of the

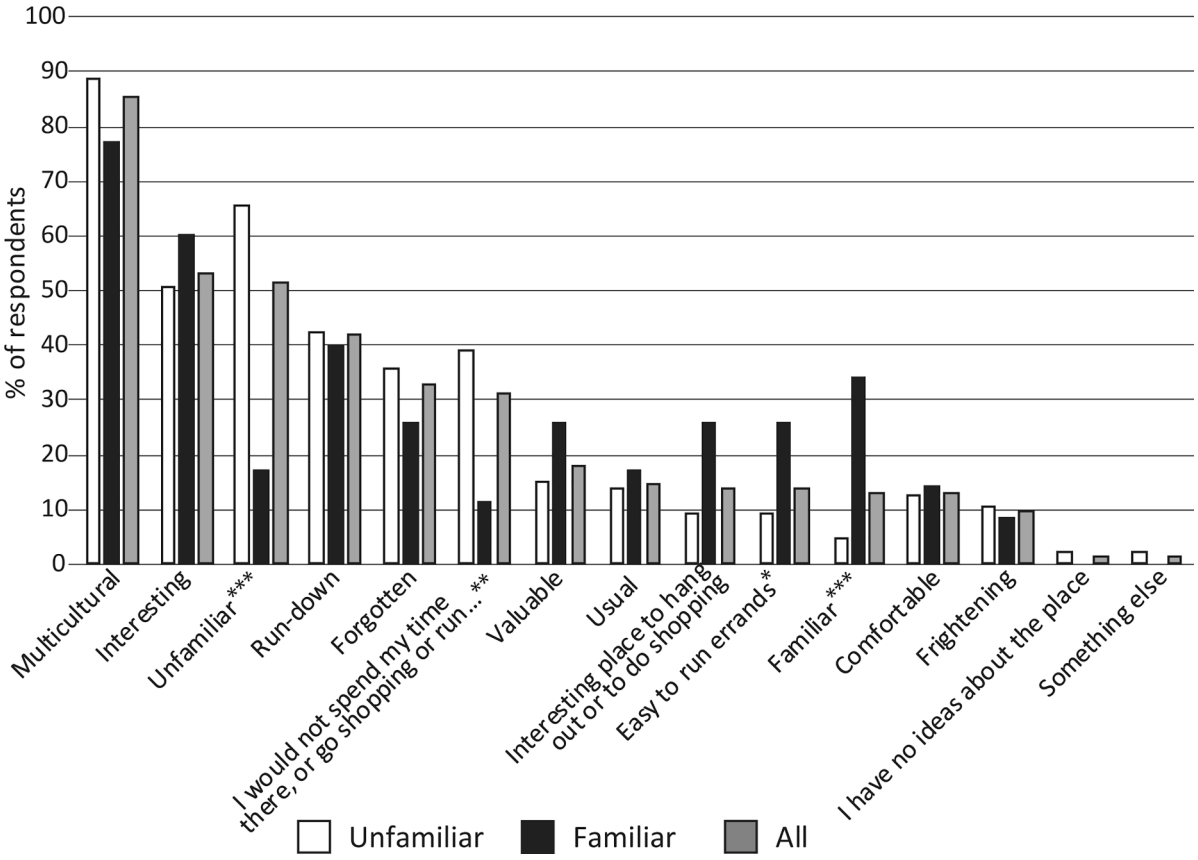

Fig. 5. Distribution of terms equivalent to respondent's perception of sense of place in the Puhos mall, with a distinction between unfamiliar (n = 87) and familiar (n = 35) respondents. The statistically significant differences between the groups denoted with *, with ** and with ***.

unfamiliar and 37.1% of the familiar fully or slightly agreed.

We asked the respondents to indicate what details they paid attention to the most in Puhos 3D (Fig. 4, Appendix B). The vast majority (82.8%) noted *people* in the 3D environment, and the trend was quite similar within the two groups. The share of respondents who noticed *buildings* varied a bit between the groups (65.5% of those unfamiliar, 51.4% of those familiar) but did not show statistical significance. Familiar respondents chose *familiar places* statistically significantly more often than unfamiliar ones. Respondents who paid attention to *other details* mentioned, for instance, *birds on the inner yard of Puhos 3D*.

Of all the respondents, 53.7% (n = 66) made suggestions in the open-ended question on how to improve the virtual visit to Puhos 3D. What was considered to increase the sense of presence the most was the *ability to move around* in Puhos 3D. Forty-five percent of respondents to this question pointed out *it was not easy to move around* in the 3D environment. When respondents were asked about their preferred mode of moving around in Puhos 3D, 53.3% specified *walking*, 32.8% specified *flying*, and 13.9% did not specify. Other often-mentioned topics for improving a sense of presence included *presenting people as 3D objects* (10.6%), *better image quality* (10.6%), and *a more realistic presentation* (9.1%). Some respondents also suggested including *the possibility to go inside the shops* (4.5%) or *adding ambient sounds*, such as *people's talk, footsteps, or remote car sounds* (3.0%), and *the possibility to discuss with the people in the 3D environment* (3.0%) as well as *the possibility to test it with 3D glasses* (3.0%).

3.3. Perceived sense of place

The most suitable term equivalent to respondents' perception of Puhos was multicultural, identified by 85.2% of respondents (Fig. 5, Appendix C). Statistically significant differences between the groups were observed for the terms *familiar* and *easy to run errands*, which familiar respondents chose more often than the unfamiliar ones, and for the *unfamiliar* and *I would not spend my time there or go shopping or run errands there*, which unfamiliar respondents chose more often than the familiar ones.

Respondents were asked to evaluate whether they got interested in the Puhos mall and whether they would visit it more often after the virtual visit (Fig. 6, Appendix C). The most chosen option (51.4% among the unfamiliar and 39.1% among the familiar respondents) was that respondent's interest or attitude did not change, or that respondent could not say whether his/her interest changed. Those expressing a positive interest did not vary significantly between the familiar and unfamiliar groups. However, the unfamiliar respondents expressed a negative interest statistically significantly more often (33.3%) than the familiar respondents (14.3%).

Respondents were asked to describe Puhos as a place in an open-ended question based on their experience in Puhos 3D and on their possible previous experiences (Fig. 7). The responses were analyzed through inductive content analysis (without cross-tabulation). The identified topics were almost equally split between positive (10 topics, 51% of all descriptions) and negative (9 topics, 49% of descriptions) place descriptions. In the positive descriptions, respondents highlighted the *multicultural character* of Puhos (40% of familiar and 47% of unfamiliar respondents), while the negative descriptions identified Puhos as *a place for immigrants and foreigners* (38% of unfamiliar and 29% of familiar respondents). Both groups (35% of all respondents) described Puhos as a *rundown* and *old* place.

A difference between the unfamiliar respondents compared to the familiar ones is seen in the more frequent positive descriptions related *to diverse and ethnic shops, businesses, and services* (21% of unfamiliar and 12% of familiar respondents) and negative descriptions related to seeing Puhos as a *gloomy*, *unattractive*, or *dirty* place (20% of unfamiliar and 3% of familiar respondents) and as a *small* or *cramped* place (6% of unfamiliar and 0% of familiar respondents).

Then again, a higher share of respondents in the familiar group compared to the unfamiliar group described Puhos as a *comfortable*, *friendly*, or *nice* place (6% of unfamiliar and 15% of familiar respondents) and also more frequently added other positive descriptions, such as *valuable* or *important*, *approving*, and *ordinary* (1–2% of unfamiliar and 6–9% of familiar respondents).

The actual responses highlight, on the one hand, the duality between the positive and negative place descriptions:

I think the Puhos mall seems to be an interesting and multicultural place. There seems to be some interesting shops, and I think I'll visit the place in the future. (male, unfamiliar with Puhos mall)

Puhos is multicultural and it is a good thing. The things people look for that you can't find in normal stores, people find in Puhos. Puhos should stay and not to be torn down because it is really important for most people. (male, familiar with Puhos mall)

I got the impression that it is meant for immigrants and people from abroad. It seems like a gloomy place and the atmosphere was not very homely. (female, unfamiliar with Puhos mall)

I think the Puhos mall is an old, run-down, and dirty place. I wouldn't want to go there. The services there were interesting and multicultural, but I didn't like the place. (female, unfamiliar with Puhos mall)

On the other hand, the following description calls attention to the uniqueness and strangeness of the mall as well as an interest in the place:

The Puhos mall was in a really bad condition but an interesting place. I would like to see the place. (male, unfamiliar with Puhos mall)

Respondents also described the place as a community, including notions of exclusive community:

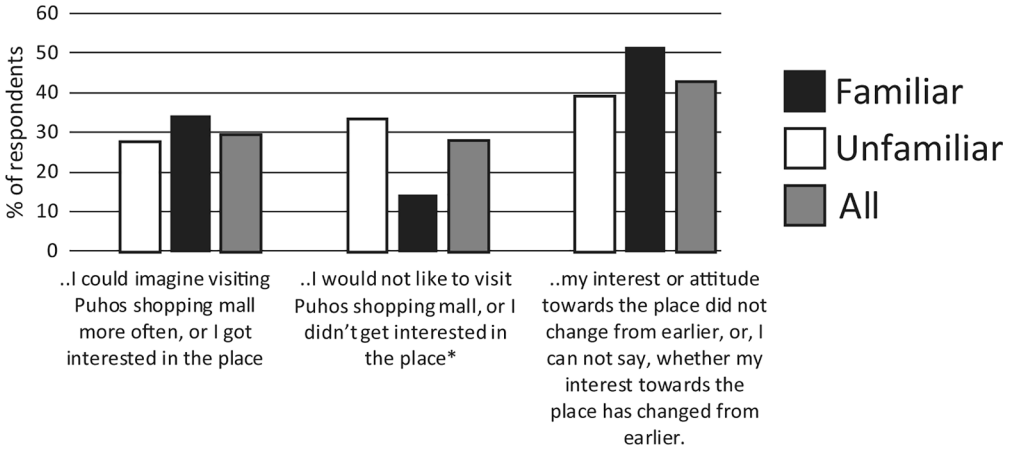

Fig. 6. Distribution of interest in the Puhos mall after the virtual visit, with a distinction between unfamiliar (n = 87) and familiar (n = 35) respondents. The statistically significant difference between the groups denoted with *.

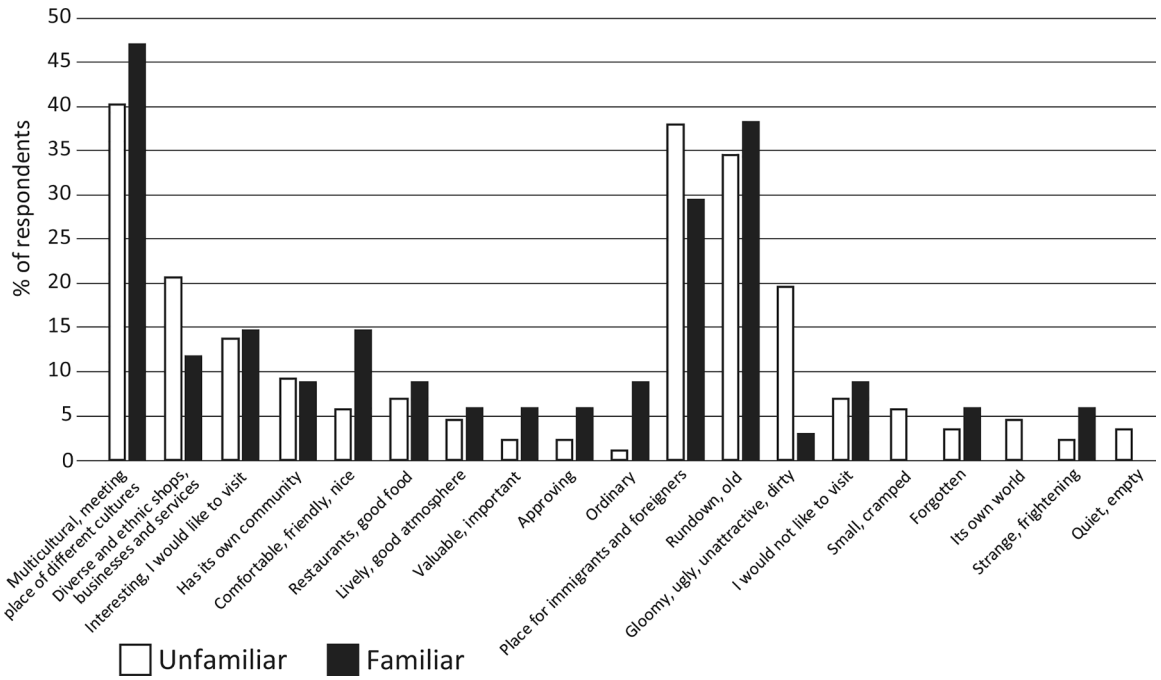

Fig. 7. Positive and negative descriptions related to Puhos as a place after the virtual visit, with a distinction between the unfamiliar (n = 87) and familiar (n = 35) respondents.

I think Puhos is a multicultural place, and there are many shops selling different products than normal Finnish stores. I myself would probably not go there because it seems different and I would not feel like belonging to the crowd. Puhos doesn't seem to be located in Finland but in some other country, like an Arabic country. (female, unfamiliar with Puhos mall)

Puhos is a place for multicultural people because there they feel at home and see many acquaintances. Puhos is a nice place in my opinion. (female, familiar with Puhos mall)

3.4. Opinions on the future of the Puhos mall

Almost half of respondents (47.5%) supported a moderate renewing of the mall (Fig. 8, Appendix D). That option was the most popular one among the unfamiliar respondents, however, comparison between the groups did not show any statistical significance. We could find a statistically significant difference in the statement concerning preserving the Puhos mall. While 25.7% of the familiar respondents supported preserving the mall, only 10.3% of the unfamiliar respondents found preserving the most suitable option for future. There was no statistical significance in the differences concerning the radical renewal attitude; 24.1% of those unfamiliar with the mall preferred *demolition of the place, construction of new houses and complete renewal of the mall.* However, it is notable that 25.7% of the familiar respondents chose this option, which is exactly the same percentage as of those who preferred preservation of the mall.

The respondents had a chance to explain their preferred choice in an open-ended question. As in the questions considering the sense of place, multiculturality proved to be a central issue in the responses (n = 26). Many of the respondents who chose preserving or moderate renewing of the mall noted that the multicultural character of Puhos is worth supporting and that urban planning should be targeted to maintain Puhos mall as a place for multicultural society and their services.

The place looked like it needs refurbishment. (Moderate renewing, unfamiliar with Puhos mall)

Ideally, I think the shopping center could be renovated to remain multicultural. (Moderate renewing, unfamiliar with Puhos mall)

A respondent familiar with the Puhos mall chose the preserving option due to the historical aspect of the mall:

The place is somewhat rundown, but I personally like those kinds places because they always remind me that history was created by people and should

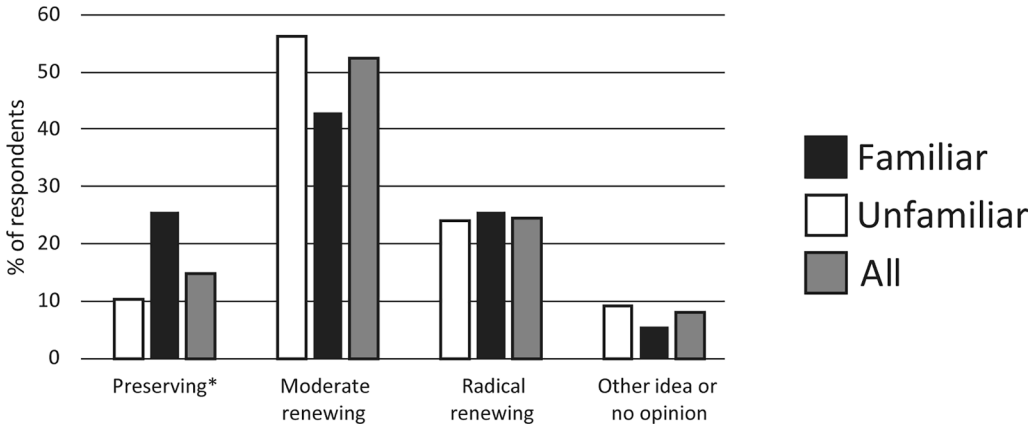

Fig. 8. Distribution of respondents' opinions on preferred urban planning outcome for the future of Puhos mall, with a distinction between the unfamiliar (n = 87) and familiar (n = 35) respondents. The statistically significant difference between the groups denoted with *.

not be forgotten. (Preserving, familiar with Puhos mall)

The multiculturality of the mall was contested in some of the responses considering radical renewing. One respondent described that also the Finnish culture could be visible at Puhos:

The mall could remain multicultural but there could be even more different cultures than there are now. In addition, even basic Finns could be attracted to the shopping center. (Radical renewing, unfamiliar with Puhos mall)

In addition, the bad shape of Puhos mall was given as explanation.

The place looked pretty rundown for our modern world, and it may be that it will be demolished. (Radical renewing, unfamiliar with Puhos mall)

3.5. Tests with control variables

The sense of presence and sense of place together with the preferred urban planning outcome were further statistically tested with control variables using the same tests as with familiarity. The cross-tabulation results are presented in the Appendix E. Gender did not show any statistical significance in the tests.

The control variable 'interest in travelling and getting to know new cultures' resulted in five statistically significant results: Only 16.5% of the group were skeptical, that is, fully or slightly disagreed with the statement, *the people in Puhos mall felt real(*)*, while the respective share was 37.2% among other respondents. Thirty-three percent of the group fully or slightly agreed with the statement, *I felt like I would have visited the real Puhos mall(*)*, while 11.7% of other respondents fully or slightly agreed with it. Some half of the group (46.8%) chose *atmosphere(*)* as a detail they paid attention to, while the respective share was 27.9% among other respondents. Nineteen percent of the group chose *comfortable(*)* as an equivalent term for the Puhos mall, while the respective share was 2.3% among other respondents. The group chose *moderate renewing(*)* statistically significantly more often (60.2%), than the other respondents (39.2%).

The control variable 'interest in urban culture, such as shopping and going to cafés', resulted in five statistically significant results, as well: 60.4% of the group fully or slightly agreed that *the environment of Puhos felt real(*)*, while the respective share was 43.4% among other respondents. Also, 66% of the group fully or slightly agreed that *the people in Puhos mall felt real(**)*, while 40.5% of other respondents fully or slightly agreed with it. The group fully or slightly agreed with the statement *I felt like I would have visited the real Puhos mall(*)* up to 35.8%, while the respective share was 17.3% among other respondents. *Interesting(*)* was chosen as equivalent term for Puhos 3D by 64.2% of the group, while the respective share was 44.9% among other respondents. Additionally, 98.1% of the group chose *multicultural(***)*, while the respective share was 75.4% among other respondents.

The control variable 'interest in new technologies and devices' resulted in two statistically significant results: 53.6% of the group paid attention to *atmosphere(**)*, while the respective share was 28.8% among other respondents. Also, 19.6% of the group chose *comfortable(*)* as an equivalent term for the Puhos mall, while the respective share was 7.6% among other respondents. Finally, respondents interested in games and gaming were more likely to choose *other opinion or no opinion(**)* (14.8%) for the future of Puhos mall than other respondents (1.6%).

4. Discussion

4.1. The connection of familiarity, sense of presence, and sense of place in perceiving Puhos 3D

The results indicate that prior familiarity with the real environment affects the sense of presence and sense of place of a 3D geovisualization. This outcome underlines the findings of previous studies, where a user's prior experiences and information with a place alter perception of a 3D geovisualization (Bishop & Rohrmann, 2003; Newell, 2017; Pouke et al., 2019) and that the users of 3D geovisualizations are a diverse group with varying knowledge, affections, and needs (e.g., Falconer, 2017; Voinov et al., 2018; Pouke et al., 2019; Ugwitz et al., 2019).

The comparison of a sense of presence between the studied groups shows that the respondents familiar with the Puhos mall were more optimistic about their ability to navigate in the real mall with the support of a virtual visit. While we did not actually test their ability to do so, this indicates a stronger confidence towards Puhos 3D by the respondents who were familiar with the place. The same respondents also more likely agreed that they felt like they would have visited the actual mall during the virtual visit compared to those who had never visited the place and had any prior knowledge of it. In fact, it turned out that respondents familiar with the Puhos mall were generally more optimistic regarding all the tested statements concerning sense of presence, while unfamiliar respondents were more skeptical with them.

In terms of sense of place, open-ended responses describing Puhos as a place yielded rich qualitative data. Further, comparison of the sense of place between the studied groups generally shows that terms associated with positive ideas (e.g., an interesting place to hang out or to go shopping) were favored more by the respondents who were already familiar with the Puhos mall. Similarly, terms associated with negative ideas (e.g., forgotten or unattractive place) were favored more by the respondents who were unfamiliar with the mall. Further, unfamiliar respondents were more likely to express negative interest towards the mall. This indicates that familiar respondents received, remembered, and/or maintained a more positive sense of place regarding the Puhos mall than the unfamiliar respondents. Due to the study limitations, we cannot say for sure whether the positive sense of place among familiar respondents is mainly, or only, connected to their previous experiences. However, in the context of our study field, this notion is useful; our results highlight that a virtual visit to Puhos 3D does not substitute for a real visit. Thus, 3D geovisualizations such as Puhos 3D are best used as supportive tools in communication in urban planning and secondary to a real visit, as reality exceeds our ability to simulate it (Ervin, 2001; Appleton & Lovett, 2003; Newell & Canessa, 2015). The virtual visit can, however, at least reinforce the already existing sense of place, that is to say, it can support the viewer by resembling it and causing the viewer to pay attention to it.

As an important outcome of our study, sense of presence seems to be, apart from the familiarity, connected to the sense of place (Newell & Canessa, 2015; Newell, 2017). In the light of our results, a weaker sense of presence might hinder the experience and perception of a place. Vice versa, previous familiarity, or even the positive sense of place, might increase the sense of presence. Hence, it is impossible to give a straightforward answer to which one is the dominant explanatory factor or whether it is eventually a matter of co-construction. In any case, our results demonstrate the existing interplay between sense of presence and sense of place in the perception of a photorealistic 3D geovisualization.

4.2. Notions on the deployment of photorealistic 3D geovisualizations for communication in urban planning

The results regarding sense of place and sense presence resonate with the results concerning the preferred urban planning outcome. Interestingly, familiarity was connected to more polarized opinions on urban planning. The preserving attitude was statistically significantly more common among the familiar respondents, and less among the unfamiliar ones. Thus, respondent's familiarity with the place not only affects the perception of the 3D geovisualization but also the attitude towards urban planning. From previous studies, we know that sense of place can motivate place-protective behavior and engagement among residents as well as visitors (Lukacs & Ardoin, 2014). However, surprisingly the option to radically renew the mall was similarly and even slightly more common among those familiar with the mall as those unfamiliar with it, even if not statistically significantly. Unfamiliar respondents most often chose the moderate renewing option. One way to elaborate on this finding is that the participants' familiarity and/or maybe even the

stronger sense of presence and sense of place can explain the greater level of confidence in the information received. This assumption would need more evidence, and thus, it should be considered in future studies.

A 3D geovisualization or any geovisualization, as stated in critical GIS research since 1990 s (e.g., Kwan, 2002; Schuurman, 2006), is not neutral or value free as a medium. Nonetheless, for this very reason, they can offer possibilities for social transformation and empowering practices, e.g. by visualizing marginalized spaces (Pavlovskaya, 2018). The previous research has introduced connection with memories, remembrance, and deeper understanding of the place when evoked as part of participatory planning (Fenster & Misgav, 2014). Similarly, familiarity, and possibly remembrance, seem to play an important role for the perception of a photorealistic digital 3D representation; the study results indicate that familiarity affects not only the perception while experience of using the tool, but also the opinions of urban planning related visions. Indeed, perception of Puhos 3D was linked to mostly positive impressions among the familiar viewers. Stronger emotional bonds to the place have been associated with higher landscape evaluations in the previous studies (Soini, Vaarala, & Pouta, 2012), which could be linked to the more positive results with the sense of presence and sense of place of the digital representation of a place, too. A study addressing the connection of not only familiarity, but in-depth emotional bonds of a place, with the sense of presence and sense of place in perception of a 3D geovisualization could further explain this.

Our study could not address whether the 3D geovisualizion-based sense of place is comparable with the inquiries based on in situ experiments, that is to say, how a fast type of sense of place generated by photorealistic 3D geovisualizations differs from those generated in situ, within the same timeframe. In essence, the sense of place generated by a 3D geovisualization can hardly be comparable to be anything other than a fast type of sense of place emphasizing passive perception, especially as the Puhos 3D lacks a birectional interplay with the physical environment, meaning it is not a digital twin of the environment (Qi et al., 2019; Batty, 2018). However, it is possible that the multimodal character of Puhos 3D played a role. It remains open as to how much the videos and stories about the local people affected the respondents' sense of place and the meanings they assigned to the place. Presumably, the videos and stories must have been important in building the perceptions because Puhos 3D merely offered the physical setting for the stories. However, this is the case with any tools providing spatial information in communicative and participatory planning; 3D geovisualizations are not usually deployed without a context. Generally, they are used in association with at least some additional information and formulation of the task (Hayek, 2011; Lovett et al., 2015). In this way, even if not deployed in real participatory planning, the Puhos 3D simulates a realistic case for communication purposes and was indeed used in the news story (Yle, 2017). The results indicate that the Puhos 3D was able to bring forth the main functions of 3D visualization aided participatory planning, namely individual information processing, discussion and information transfer (Hayek, 2011). A real planning-related study setting would promote further communicative goals of enhancing collaboration and mediation.

As the effectiveness of the tools, that is, the ability to deliver sense of presence increases, the issues of sense of place become more meaningful. That is, as the connection between sense of place and sense of presence becomes more evident in perceiving 3D geovisualizations (Bishop & Rohrmann, 2003; Newell & Canessa, 2015; Falconer, 2017; Newell, 2017; Pouke et al., 2019), the question of digitally delivered sense of place becomes more relevant in communicative urban planning deploying these tools, too. Thus, studying individual's relationship to the respective place prior to participation seems to offer a fruitful way to understand how the outcomes of 3D geovisualization assisted communication process are determined, and possibly, limited.

4.3. Technical considerations and limitations of the study

In terms of transmitting information, the respondents observed details related both to the tangible aspects (such as people and buildings) and intangible aspects (such as atmosphere) of the mall. The suggestions made to improve the virtual visit indicate that a better ability to move around, preferably by foot, is a crucial aspect that could increase the capacity of users to engage with a 3D geovisualization and their sense of presence. Suggestions for improving the virtual visit, such as presenting people as 3D objects or adding a soundscape of the place, point to spatial presence (Saunders et al., 2011; Wirth et al., 2007; Cummings & Bailenson, 2016). Generally, all the adolescent respondents could comprehend both the spatial (3D) and narrative (video interview content) dimensions of the Puhos shopping mall. The results also show that those who did not possess any information about, or had not visited the mall for real, could describe the place spatially, detect meanings, and assess its potential (Raymond et al., 2017; Kyttä, 2004). Virtual, mobile and gamified proposals have been shown facilitate learning and motivation (Zhang & Clear, 2014; Chang et al., 2015; Bowser et al., 2013; Fonseca et al., 2016) and similarly, the use of Puhos 3D with adolescents shows to stimulate informal learning of multiculturality in an urban context. In participatory urban planning, these place-based values can only be captured by consulting the public, and our study highlights 3D geovisualization as a powerful platform for provoking such values.

The adolescent participants for the most part considered Puhos 3D easy to use and straightforward. However, differences in digital skills should be taken into account when targeting wider public participation (Van Dijk, 2017). The original purpose of the Puhos mall news article was to discuss a topical urban planning issue and offer the audience a local point of view. In a similar manner, Puhos 3D is the product of its creators, given the fact that a journalist designed the original article, its narrative and ambiance and chose the interviewees appearing in the videos. This should be taken into consideration when evaluating the results. In addition, user responses to 3D geovisualizations are often complex and personal (e.g., Falconer, 2017; Pouke et al., 2019). As we studied the respondents' subjective perceptions of a 3D geovisualization, the reliability of the results is altered by the fact that these perceptions might vary within the same person on two separate occasions (Lessiter et al., 2001). Also, everyone had a slightly different virtual visit depending on the triggered stimuli, such as how they moved around and what interviews they decided to watch. Such issues should be considered when evaluating the results.

Besides familiarity with the place in question, users' educational background, gender, and familiarity with digital technology have been shown to affect the use of 3D geovisualizations (Koh et al., 2010). Our results indicate that personal interests may also be significant, while *gender* did not show any statistical significance in our study. The tests with control variables showed that especially *an interest in traveling and getting to know new cultures*, and *an interest in urban culture such as shopping and going to cafés* were in some cases statistically significant with respect to sense of presence, while somewhat surprisingly *an interest in games and gaming* did not prove statistically significant with it. Sense of place proved somewhat statistically significant with the control variables, but it was not possible to form a systematic conclusion regarding the results. Based on these results, personal interests (e.g., openness to new cultures) may affect the way a person perceives a 3D geovisualization presenting a mall in connection with ethnic minorities. This should be further explored in future studies, as our focus was merely on prior familiarity with the real physical place.

5. Conclusions

We can conclude that both the sense of presence and sense of place are useful concepts for understanding perceptions related to 3D geovisualizations to support communication in urban planning, and that these two concepts work in interplay with each other. Moreover, we demonstrated how previous familiarity with, that is, prior knowledge of and/or a prior visit to the respective place, alters perceptions in terms of sense of presence and sense of place. The difference in the respondents' familiarity is also somewhat connected to the differing opinions on the preferred urban planning outcome. Sense of presence offers information on how informative and effective the medium was in gaining insights about the place and its characteristics. Sense of place, whether generated quickly or mirrored based on prior experiences, leads to a deeper understanding of what kinds of meanings the 3D geovisualization stimulates, namely the affordances, attitudes, and idea about Puhos as a place, and the possible differences in them. Our study demonstrates that perception is not only dependent on the realism that the 3D geovisualization is able to transmit, but also on the individual knowledge, prior experiences and differing characteristics of the audience. However, a 3D geovisualization can deliver information, affordances and even meanings of a place while reinforcing the possible existing ones. According to our results photorealistic 3D geovisualizations are best used as supportive tools in communication for urban planning and secondary to a real visit.

Acknowledgements

This work was supported by the Academy of Finland under grants 272195, 307362, 293389, and 321555, by the City of Helsinki Innovation fund, and by the Aalto Doctoral Programme in Engineering. We warmly thank Henrik Gullmets, Johan Gullmets, the Finnish Broadcasting Company YLE, and the schoolteachers and students for their cooperation.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.landurbplan.2020.103996.

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