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Contemporary versus traditional styles in architecture and public space: A virtual reality study with 360-degree videos

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ABSTRACT

Visual appearance of the built environment contributes to psychological affect and influences subjective well-being. However, little is known on how residents perceive and experience the visual appearance of global contemporary trends in architecture and urban design. This paper evaluates environmental perceptions and affective appraisal of contemporary versus traditional styles in architecture and public space. A recently-developed research method in this field of study is employed: panel evaluations of 360-degree videos of real environments, viewed with mobile-based virtual reality platform. The examined urban spaces are streetscapes and public squares. Results suggest that contemporary architectural styles – inspired by postmodernism and characterized by asymmetry, lack of ornamentation, and industrial appearance – are evaluated less positively than traditional styles – characterized by symmetry and ornamentation. Contemporary architecture scores lower in environmental perception than traditional architecture. This finding poses critical questions on current trends in architectural styles and subsequently on the livability of new built environments. Further research is necessary to obtain a more in-depth understanding of how the detailed physical characteristics of architecture contribute to perceptions and emotional well-being.

1. Introduction

The visual appearance of the built environment contributes to emotional responses and psychological affect (Hanyu, 1997, 2000; Zhang & Lin, 2011), and can thereby influence happiness and life satisfaction (Mouratidis, 2018, 2019a; Negami, Mazumder, Reardon, & Ellard, 2019; Seresinhe, Preis, MacKerron, & Moat, 2019). Emotional response to the visual appearance of the built environment is one of the key responses induced by such environment (Nasar, 1987), since humans actively interact with their immediate environment in their everyday lives (Nasar, 1994). Considering these everyday interactions along with the increasing evidence linking visual appearance of the built environment to subjective well-being (Seresinhe et al., 2019), it becomes clear that understanding how the visual appearance of buildings and public spaces affects perceptions and emotions becomes key to successful urban development (Nasar, 1994; Zhang & Lin, 2011).

However, little is known on how the visual appearance of global contemporary trends in architecture and urban design is perceived and experienced by residents. Worldwide, contemporary architectural styles are rapidly spreading and overtaking the traditional (McNeill, 2009). Asymmetry, minimalism and lack of ornamentation, and industrial appearance now form the standard style in architecture and urban design. Traditional design styles with symmetry, ornamentation, and links to local history are being abandoned. Although there are strong theoretical debates over contemporary versus traditional architectural styles (Curl, 2018), empirical research on perceptions and experience of these styles is missing. Such research is necessary to inform urban planning decisions on the visual appearance of current and future development and provide critical insights for citizens willing to participate in local urban governance.

Perceptions and affective appraisals of the urban environment are often assessed with panel evaluations of photographs in existing literature (Hanyu, 2000; Nasar, 2008; Zhang & Lin, 2011). New technology, however, now offers new opportunities to researchers conducting this type of research. A new method that can be used for panel evaluations of perceptions and experiences in the environment is the 360-degree videos viewed with a mobile-based virtual reality (VR) platform. The 360-degree videos, also called immersive videos or spherical videos, allow the user to look in every direction (Elmezeny, Edenhofer, & Wimmer, 2018). When 360-degree videos are viewed with a VR platform, the user immerses himself/herself in the displayed environment and does not interact with the real world (Baños et al.,

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2004; Portman, Natapov, & Fisher-Gewirtzman, 2015). This allows an experience of the displayed environment that is closer to reality compared to that of photographic presentation. With current advancements in technology, this research method is becoming more and more reliable and accessible, providing new opportunities for research in environmental psychology, architecture, landscape architecture, and urban design and planning (Portman et al., 2015).

The present study applies this recently-developed research method to investigations of perceptions and emotions related to the visual appearance of contemporary architectural and urban design styles. This is the first study, as far as we are aware, to compare contemporary versus traditional styles in architecture and public space by evaluating environmental perceptions and affective appraisal. The paper has two major objectives: (1) to evaluate environmental perceptions and affective appraisal of contemporary versus traditional architecture and public space and (2) to test a recently-developed research method in this field of study based on 360-degree videos and VR presentation. The paper relies on quantitative data on environmental perceptions and affective appraisals of contemporary and traditional public spaces in Oslo, Norway. Public spaces were captured with 360-degree video technology and presented to participants using a mobile-based VR platform. Each public space was assessed by participants using a questionnaire. Data were analyzed with pairwise comparisons of public spaces. Pairs have similar characteristics but differ in design style: contemporary versus traditional.

2. Literature review

2.1. Contemporary versus traditional architecture

Contemporary architecture, mostly inspired by postmodernism and high-tech architecture, is constantly spreading all over the world (McNeill, 2009). Global urbanization and urban densification, combined with globalization, result in a universal style of architecture that is taking over traditional styles linked to the history and traditions of each place. This global contemporary style of architecture is usually the style embraced by architecture schools worldwide. The effect of global "star architects", who are a source of admiration and inspiration for many young architects, is also contributing to the embracement of contemporary architecture as the prevalent architectural style (Ponzini & Nastasi, 2016). Eventually, cities across the globe are looking more and more alike. For example, the cityscapes of downtown Lagos, New York, or Shanghai are looking more and more similar, despite belonging to very different cultures. The spread of contemporary architecture seems unstoppable.

Contemporary architecture has been both praised and criticized heavily. Notable works of contemporary architecture by "star architects" have been glorified as contemporary city landmarks and symbols of the art of architecture. Such landmarks are often employed by national and local governments to attract tourism, businesses, investment, and capital (Orueta & Fainstein, 2008). These strategies, however, have been heavily debated for their social sustainability. There are several levels of criticism. They are criticized for being undemocratic and for favoring certain economic gains over providing social equity and covering the needs of local residents (Andersen & Røe, 2017; Ponzini, 2011; Tarazona Vento, 2017). Contemporary architecture and its developers and architects are criticized for being motivated by individualistic purposes inspired by the phenomenon of "star architecture". They are criticized for prioritizing individual glory and success through design rather than seeking to create livable built environments and cities. Moreover, contemporary designs are criticized by some for not being in harmony with the rest of the city, for being disruptive to local history, and for causing cities to lose their local identity (Curl, 2018).

The most obvious question on the debate between contemporary and traditional architectural styles is aesthetics. The asymmetry, lack of ornamentation, and industrial appearance in contemporary architecture are endorsed by some for being groundbreaking, interesting, impressive, while others consider it a barbaric process which spreads dystopias around the world (Curl, 2018). Nevertheless, what do residents think? Do they find global contemporary architecture aesthetically pleasant? What emotions does it generate for city residents? Is it more pleasant than the more traditional styles that are being abandoned?

Aesthetics and environmental perception are not just matters of opinion however (Nasar, 1992). They have been found to significantly contribute to subjective well-being. Recent studies suggest that aesthetically pleasing built environments can increase happiness (Negami et al., 2019; Seresinhe et al., 2019) and that positive emotional response to the built environment is associated with greater life satisfaction (Mouratidis, 2019b). Despite the importance of aesthetics for well-being, empirical research on perceptions of contemporary versus traditional architecture and urban design is almost nonexistent. Such research can inform urban planning decisions on building development and provide insights for citizen participation in local urban governance.

2.2. Perceptions of urban space and affective appraisal

Perceptions of urban aesthetics and emotional response to urban aesthetics are evaluated using measures of environmental perception and affective appraisal (Hanyu, 2000; Johansson, Sternudd, & Kärrholm, 2016; Russel & Pratt, 1980; Schindler et al., 2017; Weber, Schnier, & Jacobsen, 2008). Measures of environmental perception may evaluate a wide range of attributes of urban spaces such as architecture, public space design, safety, vegetation, sociality, complexity, and familiarity (Hanyu, 1997; Nasar, 1994; Rapoport, 2013; Schindler et al., 2017). Affective appraisal aims to measure the emotions experienced within urban space such as pleasant versus unpleasant, exciting versus boring, and relaxing versus stressful (Hanyu, 2000; Posner, Russell, & Peterson, 2005). Environmental perception and affective appraisal of urban spaces are found to be associated (Hanyu, 1997, 2000; Zhang & Lin, 2011), suggesting that perceptions of urban spaces generate emotional responses and thereby contribute to subjective well-being (Mouratidis, 2018, 2019a; Seresinhe et al., 2019). Well-maintained vegetation, upkeep and order, and openness of space are qualities that have been found to be positively linked to psychological affect (Johansson et al., 2016; Zhang & Lin, 2011). As mentioned above, comparisons of environmental perception and affective appraisal between contemporary and traditional urban spaces are currently missing in existing literature.

There are several modes that can be used to present urban spaces to participants who in turn evaluate environmental perception and affective appraisal. In a literature review, Nasar (2008) lists all the possible modes of presentation: photos, models, VR walk-through, color video or file, and on-site exposure. These modes offer both advantages and disadvantages as they differ in degrees of realism and in the extent of experimental control that they allow. Due to the latest advancements in VR technology, recent experimental studies related to urban design and planning have been assessing environmental perceptions with VR tools (Echevarria Sanchez, Van Renterghem, Sun, De Coensel, & Botteldooren, 2017; Liu & Kang, 2018; Maffei, Masullo, Pascale, Ruggiero, & Romero, 2016; Ruotolo et al., 2013).

To Nasar's (2008) list, we can now add another mode of presentation: 360-degree videos of real environments viewed with mobile-based VR platform (Table 1). This method presents urban spaces as close to reality as possible since participants can view real environments with videos covering all directions, whilst immersed in the displayed environment (see also Sun et al., 2019). The method allows researchers to invite panels of participants to evaluate a series of places from one location. They are more realistic than the commonly used one-dimensional photographs or virtual representations, equally easy to use, but are more difficult to manipulate by changing selected features of the examined environment.

Table 1
Different modes of presentation for assessment of environmental perception and affective appraisal.
Adapted from Nasar (2008).

Mode of presentation	Similarity to on-site experience	Experimental control	Ease of use
On-site experience	Most realistic	Less control	Difficult to take panel to site
360-degree videos viewed with mobile-based VR platform	More realistic	Hard to control	Easy to have panel evaluate places
Videos	Realistic	Hard to control	Easy
VR simulations	Realistic	Allows control	Easy
Photos	Realistic	Allows control	Easy

2.3. VR technology and 360-degree videos

According to Kirner and Kirner (2011), VR is defined as a human-computer interface that allows the user to interact in a three-dimensional space, exploring aspects of this space through vision, hearing and touch in real time, through special devices. Considerable studies have indicated four factors to reach a VR experience, namely: virtual world, immersion, presence and interaction (Baños et al., 2004; Estupiñán, Rebelo, Noriega, Ferreira, & Duarte, 2014; Gutierrez, Vexo, & Thalmann, 2008; Sanchez-Vives & Slater, 2005). Immersion refers to the extent to which a user is isolated from the real world. In an immersive VR, the user is completely encompassed by the virtual environment and does not interact with the real world. Presence in VR has been defined as "the sense of being in a virtual environment rather than the place in which the participant's body is actually located". The level of immersion offered by a VR system is one factor that may influence a user's feelings of presence. The concept of interaction is essential in a virtual world. It facilitates possibilities for navigations and extraction of embedded information in the virtual environment.

Latest developments in VR technology have enabled a major leap forward for research focusing on assessing people's perceptions and communicative responses to built environments. Two major technological innovations have made this possible. First, the availability of technologies for capturing VR content of real surroundings by using consumer level 360-degree cameras and freely available and customizable applications. Second, the innovation of affordable VR technology for mobile-based Head-Mounted Displays (HMD) with motion sensor that allows a 360-degree vision of a virtual world, while eliminating the visual contact with external reality. By applying a high level of realism (presence) through 360-degree videos or panoramas, VR provides a much higher environmental legitimacy in comparison to traditional environment representation methods (e.g. drawings, maps, renderings and videos). In addition, VR based visuals benefit from the strength of lab-based research by allowing control over the experimental condition. Moreover, low-cost and mobile-based VR platforms, such as Google cardboards with smart mobile phones, have expanded VR application beyond lab environment to enhance community-engagement and participatory design research. Such technology can make visual studies in fields such as architecture, landscape architecture, and environmental planning more interdisciplinary (Portman et al., 2015).

3. Data and methods

3.1. Public spaces of the study

This study compares eight public spaces within the city of Oslo (Figs. 1 and 2). Fig. 1 presents photos of the eight public spaces from Google Street View as well as from the authors' collection. Fig. 2 presents 360-degree photos of the eight public spaces taken with the 360-degree camera during the video capturing of the study.

Four streets (two traditional and two contemporary) and four public squares (two traditional and two contemporary) are examined. Naturally, there are numerous traditional design styles that are largely distinct, and numerous contemporary design styles that are also distinct. In this study, we differentiate between the traditional and the contemporary design style based on rough but key differences: symmetry versus asymmetry, ornamentation versus lack of ornamentation, and differences in construction materials. Traditional public spaces are classified in the study as those where the surrounding architecture is mostly traditional. By traditional architecture, we refer to architectural styles that were prominent in Oslo, and Norway in general, approximately until the 1930s. The common characteristics of such traditional architecture are styles with symmetry, some degree of ornamentation, possible presence of natural materials, and possible links to local history. On the other hand, contemporary public spaces are classified in the study as the ones where surrounding architecture is mostly contemporary. Contemporary architecture is characterized by minimalism, lack of ornamentation, asymmetry, and often by materials such as fair-faced concrete, glass, and steel. Such styles are relevant to post-modernism and high-tech architecture that were mostly developed from the 1960s onwards. As seen in Fig. 1, buildings surrounding the traditional public spaces A1-A4 are all characterized by symmetry and some degree of ornamentation, whereas buildings surrounding the contemporary public spaces B1-B4 are characterized by asymmetry, minimalistic forms, lack of ornamentation, and some presence of glass or steel.

Public space design follows the style of the surrounding architecture except for A1 and B1, which are different parts of the same street and differ only in surrounding architecture. For the rest of the public spaces in the study, traditional surrounding architecture is combined with more traditional public space design, whereas contemporary surrounding architecture is combined with more contemporary public space design. Traditional street A2 is paved with a more traditional-looking sett pavement, while contemporary street B2 is paved in a more minimalistic way with concrete blocks. Similar pavement differences exist for the public squares of the study. In addition to these differences, traditional squares A3 and A4 contain centrally placed fountains, resembling the traditional European piazza, while on the other hand, contemporary squares B3 and B4 are designed in a more minimalistic way and do not contain any fountains. Moreover, the circular garden in B4 is not centrally placed, adding to the sense of asymmetry in this contemporary public square.

The comparisons in the study are conducted in pairs: a traditional public space is compared to a contemporary public space of similar size, orientation, and height of surrounding buildings. Naturally, since the study examines real cases and not virtual ones, it was not possible to find identical public spaces that only differ in architectural styles and public space design. There are slight deviations in public space size, building heights, vegetation, and the presence of shops on ground floor level. The eight public spaces in the study were selected so that such deviations within each pair are as small as possible in order to reduce biases. As a result, the public spaces of each pair are as similar as possible except for their architectural styles and public space design.

3.2. Technology used and recording of 360-degree videos

The VR visuals were constructed as 360-degree videos reproducing each of the public spaces. Videos were captured with a 360-degree Ricoh Theta V, with resolution of 3840 × 1920 pixels at 29.97 fps. The 360-degree videos captured the surroundings in every direction at the

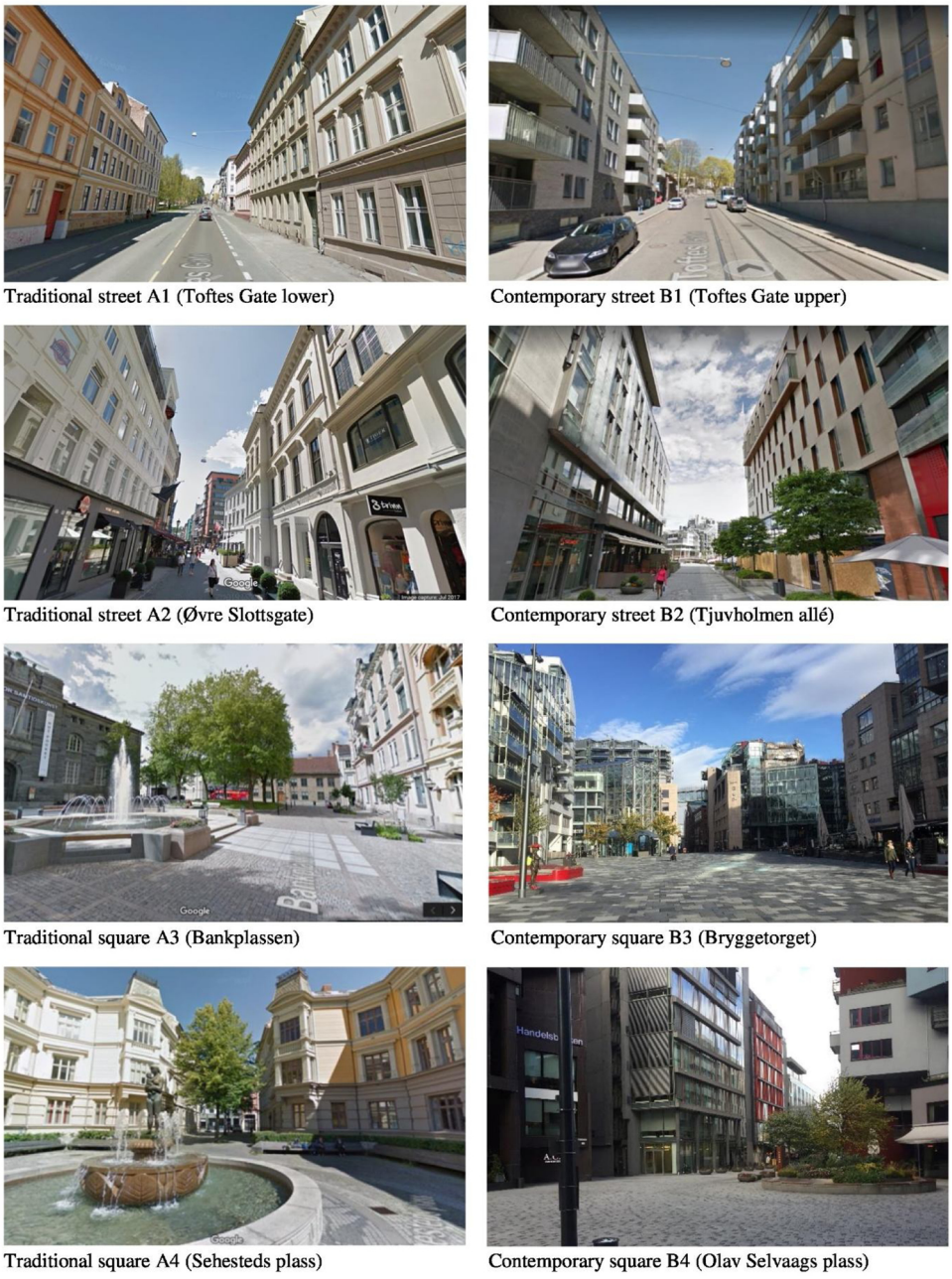

Fig. 1. The eight public spaces of the study (sources: Google Street View and authors' collection).

same time, along with sound. The videos were all recorded on Tuesday 2 October 2018. The weather was partly cloudy and the weather conditions in the videos are similar. The videos were edited with Camtasia Studio video editor so that each final video clip-time was cut to 45 s and included similar amounts of moving objects such as people, cars, and trams in the two videos of each pair. In general, since the recording was conducted during work hours, moving objects were minimal in all videos, as seen in Fig. 2. As a result, the sound from moving objects was low in the videos. Since the weather conditions in the videos are similar, relevant sound/noise exposure does not differ substantially between pairs. However, even slight deviations in sound/noise exposure may have affected the results to some extent (Echevarria Sanchez, Van Renterghem, Thomas, & Botteldooren, 2016; Kang, 2000; Preis, Kociński, Hafke-Dys, & Wrzosek, 2015).

The tripod of the camera was placed at 90 cm height to provide a view from a sitting height, similar to the one in the video presentation that followed. The camera was placed in similar locations at the public spaces of each pair. For streets with vehicle access, A1 and B1, the camera was placed on the sidewalk from the same side. For streets with controlled vehicle access, A2 and B2, the camera was placed in the middle of each street. For public squares, A3, B3, A4, and B4, the camera was placed approximately in the centroid of each square.

The 360-degree videos were presented to participants through a mobile-based VR platform: a View-Master deluxe HMD with Motorola G4 smartphones with 1080 × 1920 pixels screen resolution. The playback was made with Android VR Media Play application. To reproduce the sounds and minimize external noises, during the experimentation participants wore a headset together with the HMD. The audio used was not spherical (i.e. audio field rotates accordingly with the participant's head movement) as it was not captured with a 3D microphone. The headsets used for the video presentation were KOSS KPH5 stereo headphones with foam ear cushions.

Fig. 2. The eight public spaces of the study (views from 360-degree camera).

3.3. Participants

Twenty-eight students from the Norwegian University of Life Sciences served as study participants. The participants included 13 males and 15 females, aged 18–27, while the mean age was 21.5 years. They were first-year students from a variety of disciplines such as real estate, biotechnology, forestry, landscape architecture, urban and regional planning, biology, animal science, environmental science, and physics. The majority of the students lived near the university campus located at Ås, a town in the periphery of Oslo, Norway. The study was conducted as part of a university course. To recruit the participants, the research study was presented in different lectures offered to first-year students at the university. They were informed that the participation in this research was a voluntary act. Interested participants provided their emails in sign-up sheets. An invitation email was then sent to participants informing them of the time and location of the study.

3.4. Measures

A questionnaire was prepared to obtain participants' evaluations of public spaces. This included questions on affective appraisal and environmental perception. Affective appraisal questions were placed first to reduce possible biases from environmental perceptions influencing responses to affective appraisal. The questionnaire was written in English and then translated to Norwegian. Data collection was anonymous. Sociodemographic questions in the questionnaire included only age, sex, field of study, and postal code.

To assess emotional responses to the built environment, affective appraisal scales by Hanyu (1997, 2000) were used. These scales are based on the theories on affective quality by Russel and Pratt (1980). Responses covered the following bipolar emotions: pleasant-unpleasant, exciting-boring, relaxing-distressing, unsafe-safe, interesting-uninteresting, and active-inactive. These scales range from (1) "very", (2) "a little", (3) "neutral", (4) "a little" and (5) "very." For variables

where an increase in value indicates a less positive emotion, data were later recoded so that increasing values translate into positive emotions.

Environmental perceptions were assessed using Likert-scale questions. These questions were assessed in the following order. Overall perception of the public space was evaluated with the statement "I really like this street/square" using a Likert scale ranging from (1) strongly disagree to (5) strongly agree. Perception of architecture was evaluated with the statement "I really like the buildings/architecture in this street/square" using the same scale. Perception of public space design was evaluated with the statement "I really like the design of this street/square" using the same scale.

The degree of familiarity with the area to which the public space belongs was assessed with the question "To what extent do you know the area?" on a scale of (1) "not at all", (2) "a little" (3) "somewhat", (4) "much" and (5) "to a great extent." After all the videos were presented, the participants were asked to evaluate possible experience of cyberickness (VR sickness). They were specifically asked "Did you feel dizzy or nauseous?" on a scale of (1) "not at all", (2) "a little" (3) "somewhat", (4) "much" and (5) "to a great extent."

3.5. Procedure

The 360-degree video presentation was conducted on 31 October 2018. The presentation took place in a room with 10 tables and 10 swivel chairs that rotate 360 degrees to both left and right. For the presentation of the videos, each participant was given a set of mobile-based VR platform and headset. The videos were presented with individual HMD devices and with assistance from the research team. Since each participant required individual assistance, the videos were not displayed simultaneously for all participants. Participants attended the video presentation in four separate groups. Before the video presentation, each group was informed of the procedure. The questions of the questionnaire were also explained to prevent confusion. To avoid biases, participants were not informed about the objectives of the study and the traditional versus contemporary comparisons. They were simply informed that they would view eight different public spaces. Participants watched eight videos of the eight public spaces and completed a questionnaire after each video presentation. The questionnaire was the same for each video. Each 360-degree video lasted 45 s. Participants were able to view the video freely in every direction during these 45 s. Using the swivel chair, they could rotate 360 degrees. After completing all video presentations, they also completed a short questionnaire with age, gender, study program, place of residence, and evaluation of possible cybersickness. The eight videos were presented in pairs. To increase the validity of the study, two groups watched videos with the traditional part of the pair first, while the other two groups started with the contemporary part of the pair. In total 13 participants followed the sequence: A1, B1, A2, B2, A3, B3, A4, B4, and 15 participants followed the sequence: B1, A1, B2, A2, B3, A3, B4, A4.

4. Results

Tables 2–5 present pairwise comparisons between traditional and contemporary public spaces, while Table 6 presents overall comparisons. T-tests are used to assess whether the differences in means are statistically significant. The level of familiarity with the public space yields significantly positive associations with all variables of environmental perception and affective appraisal (except for safety which is nonsignificant), according to bivariate correlation analysis conducted by the present study. Therefore, significant differences in familiarity could potentially affect the results.

4.1. Streets A1-B1

Table 2 suggests that both environmental perceptions and affective appraisals are in general significantly more positive for traditional street A1 than for contemporary street B1. A1 and B1 are different parts of the same street and only differ in surrounding architecture. Thus, environmental perception and affective appraisal are not influenced by potential factors such as neighborhood location, street size, and street orientation. The most important difference between A1 and B1 is in architecture: the traditional architectural style of A1 is clearly perceived more positively compared to the contemporary B1. Probably influenced by the architectural style, public space design and overall perception of public space are significantly more positive for A1. A1 is experienced as more pleasant, exciting, relaxing, and interesting than B1. Since the main difference between A1 and B1 is the architectural style, the more positive emotional responses to A1 can be mostly attributed to traditional architecture. As expected, the level of activity is similar for A1 and B1 since the videos were captured with minimal moving objects. The level of familiarity is almost identical for A1 and B1 since they are part of the same street.

Table 2
Comparison of means between traditional (A1) and contemporary (B1) streets.

Variable	Traditional street A1 (N = 28)		Contemporary street B1 (N = 28)		t-test
	Mean	s.d.	Mean	s.d.	
Environmental perception					
Architecture	3.82	(0.77)	2.43	(1.03)	***
Public space design	3.11	(0.83)	2.68	(0.98)	*
Overall perception	3.29	(0.71)	2.86	(0.97)	*
Affective appraisal					
Pleasant	3.50	(0.79)	3.04	(0.96)	*
Exciting	2.86	(0.93)	2.39	(1.10)	*
Relaxing	3.50	(0.84)	3.07	(0.90)	*
Safe	3.86	(0.80)	3.61	(0.96)	
Interesting	2.93	(1.09)	2.36	(1.22)	*
Active	2.75	(1.14)	2.79	(1.03)	
Level of familiarity with area					
Familiarity	2.14	(1.30)	2.11	(1.34)	

T-tests of difference in mean show significant differences at: *p < 0.10, **p < 0.05, ***p < 0.001.

4.2. Streets A2-B2

Table 3 suggests that certain environmental perceptions and affective appraisals are significantly more positive for contemporary street B2 than traditional street A2. Perceptions of architecture do not differ significantly for the two streets. Public space design and overall perception of public space are significantly more positive for B2. B2 is perceived as more pleasant, relaxing, and safe compared to A2. Perhaps because A2 is located in a busy area of downtown Oslo, next to the city's main commercial streets, it induces less positive emotions compared to the more quiet B2 which is located in the high-end residential area of Tjuvholmen. The slightly higher degree of vegetation, slightly greater street width, and less complexity in the distal end of the street (openness of space) in B2 also possibly contribute to positive perceptions and affective appraisals of public space (Kaplan & Kaplan, 1989;

Table 3
Comparison of means between traditional (A2) and contemporary (B2) streets.

Variable	Traditional street A2 (N = 28)		Contemporary street B2 (N = 28)		t-test
	Mean	s.d.	Mean	s.d.	
Environmental perception					
Architecture	3.61	(0.83)	3.68	(1.16)	
Public space design	3.57	(0.88)	4.29	(0.71)	**
Overall perception	3.46	(0.92)	4.04	(0.84)	**
Affective appraisal					
Pleasant	3.61	(0.83)	4.11	(0.83)	**
Exciting	3.29	(0.71)	3.64	(0.95)	
Relaxing	3.36	(0.91)	3.89	(0.69)	**
Safe	3.89	(0.88)	4.36	(0.73)	**
Interesting	3.50	(0.74)	3.64	(0.95)	
Active	3.50	(0.96)	3.14	(0.76)	
Level of familiarity with area					
Familiarity	2.29	(1.58)	2.21	(1.34)	

T-tests of difference in mean show significant differences at: *p < 0.10, **p < 0.05, ***p < 0.001.

Liu & Kang, 2018; Mouratidis, 2019a; Zhang & Lin, 2011). The levels of activity and familiarity do not significantly differ for the two streets.

4.3. Public squares A3-B3

Table 4 suggests that environmental perceptions and some affective appraisals are significantly more positive for traditional square A3 than contemporary square B3. Perceptions of architecture and public space design as well as overall perception of public space are significantly more positive for A3. A3 is also perceived as more pleasant and relaxing compared to B3. Traditional square A3 yields the most positive environmental perceptions among all public spaces of the study. The traditional architecture of A3 is the most positively perceived architecture in the study and is substantially more positive than the contemporary architecture of B3. The influence of architecture along with the presence of the large fountain and the stronger presence of vegetation could be potential reasons for the more positive evaluations of public space design and public space overall as well as the more pleasant and relaxing emotional responses to A3. The levels of activity and familiarity do not significantly differ for the two squares.

Table 4
Comparison of means between traditional (A3) and contemporary (B3) public squares.

Variable	Traditional square A3 (N = 28)		Contemporary square B3 (N = 28)		t-test
	Mean	s.d.	Mean	s.d.	
Environmental perception					
Architecture	4.25	(0.84)	3.46	(1.14)	**
Public space design	4.39	(0.88)	3.79	(1.26)	**
Overall perception	4.36	(0.78)	3.64	(1.16)	**
Affective appraisal					
Pleasant	4.21	(0.96)	3.75	(0.84)	*
Exciting	3.46	(1.07)	3.25	(1.08)	
Relaxing	4.29	(0.90)	3.36	(0.91)	***
Safe	4.14	(1.01)	3.93	(0.98)	
Interesting	3.89	(1.03)	3.46	(1.23)	
Active	3.07	(0.94)	3.11	(1.03)	
Level of familiarity with area					
Familiarity	2.50	(1.32)	2.50	(1.53)	

T-tests of difference in mean show significant differences at: *p < 0.10, **p < 0.05, ***p < 0.001.

4.4. Public squares A4-B4

Table 5 suggests that the architecture of traditional square A4 is perceived as significantly more positive than that of contemporary square B4. A4 is also experienced as more relaxing compared to B4. The other environmental perceptions and affective appraisals do not significantly differ for the two squares. Familiarity, however, is significantly higher for B4. Since familiarity is found to be significantly correlated with environmental perception and affective appraisal in this study, it could be assumed that responses for A4 would have been even more positive with equal levels of familiarity.

Table 5
Comparison of means between traditional (A4) and contemporary (B4) public squares.

Variable	Traditional square A4 (N = 28)		Contemporary square B4 (N = 28)		t-test
	Mean	s.d.	Mean	s.d.	
Environmental perception					
Architecture	4.04	(0.84)	3.64	(0.91)	*
Public space design	3.75	(1.08)	3.36	(1.16)	
Overall perception	3.57	(1.07)	3.39	(0.99)	
Affective appraisal					
Pleasant	3.71	(1.01)	3.54	(0.79)	
Exciting	2.96	(0.96)	2.79	(1.03)	
Relaxing	3.75	(1.08)	3.21	(0.69)	**
Safe	4.04	(0.88)	3.86	(0.89)	
Interesting	3.21	(1.10)	3.11	(0.99)	
Active	2.29	(0.76)	2.68	(0.98)	
Level of familiarity with area					
Familiarity	1.50	(1.00)	2.29	(1.51)	**

T-tests of difference in mean show significant differences at: *p < 0.10, **p < 0.05, ***p < 0.001.

4.5. Overall comparisons

Table 6 presents overall comparisons of means between the four traditional public spaces and the four contemporary public spaces. Results suggest that contemporary architecture is generally perceived less positively than traditional architecture, as well as that contemporary public spaces are generally less relaxing than traditional public spaces. The other environmental perceptions and affective appraisals do not differ significantly for the two groups.

4.6. Evaluation of the order of video presentation

To examine the potential effect of the order in which the videos were displayed to participants, t-tests of difference in means were conducted comparing the evaluations of participants who followed the sequence A1, B1, A2, B2, A3, B3, A4, B4, and those followed the sequence B1, A1, B2, A2, B3, A3, B4, A4. It should be mentioned that, due to the relatively small sample size, the interpretation of such comparisons should be cautious. The overall evaluations of participants who watched the videos of traditional public spaces first (for each pair) do not differ significantly from those who watched the videos of contemporary public spaces first (for each pair), with the exception of safety of traditional public spaces which is evaluated less positively

Table 6
Overall comparison of means between traditional and contemporary public spaces.

Variable	Traditional public spaces (N = 112)		Contemporary public spaces (N = 112)		t-test
	Mean	s.d.	Mean	s.d.	
Environmental perception					
Architecture	3.93	(0.85)	3.30	(1.17)	***
Public space design	3.71	(1.02)	3.53	(1.19)	
Overall perception	3.67	(0.96)	3.48	(1.07)	
Affective appraisal					
Pleasant	3.76	(0.93)	3.61	(0.93)	
Exciting	3.14	(0.95)	3.02	(1.13)	
Relaxing	3.72	(0.99)	3.38	(0.85)	**
Safe	3.98	(0.89)	3.94	(0.92)	
Interesting	3.38	(1.05)	3.14	(1.20)	
Active	2.90	(1.05)	2.93	(0.97)	
Level of familiarity with area					
Familiarity	2.11	(1.35)	2.28	(1.42)	

T-tests of difference in mean show significant differences at: *p < 0.10, **p < 0.05, ***p < 0.001.

(marginally significant, p < 0.10) for those who watched videos of contemporary public spaces first. There are certain differences (p < 0.10) in the evaluations of specific public spaces related to the order in which the videos were displayed. A1 is perceived as more exciting and active for those who watched B1 before A1 than for those who watched A1 first. B1 is perceived as less pleasant, exciting, relaxing, and interesting for those who watched A1 first. The overall perception of public space for B1 is also lower for those who watched A1 first. A2 is perceived as less pleasant, exciting, and interesting for those who watched B2 first. B3 is perceived as more pleasant and exciting for those who watched A3 first. The perception of architecture for B3 is also higher for those who watched A3 first. A4 is perceived as less safe for those who watched B4 first.

4.7. Evaluation of cybersickness (VR sickness)

Table 7 presents the participants' evaluations of feelings of dizziness or nausea during the VR presentation of the 360-degree videos. The mean feeling of dizziness is 2.59. Seven participants did not feel dizzy or nauseous at all, four felt a little dizzy or nauseous, twelve felt somewhat dizzy or nauseous, one felt highly dizzy or nauseous, while three felt dizzy or nauseous to a great extent. Although not very high overall, there is some degree of feelings of dizziness associated with the 360-degree video presentation, while for certain individuals these feelings are strong. Correlations between cybersickness and environmental perceptions/affective appraisals were also examined. All correlations are nonsignificant, except for perceived safety which is found to be positively correlated with cybersickness (p = 0.026). The finding of such correlation seems to be coincidental.

Table 7
Evaluation of cybersickness.

Variables	N	Min/Max	Mean	s.d.
Feeling dizzy or nauseous during 360-degree video presentation	28	1/5	2.59	(1.25)

5. Discussion

5.1. Contemporary versus traditional architecture and public space

This paper has provided, as far as we are aware, the first empirical study that compares environmental perceptions and affective appraisals of contemporary versus traditional styles in architecture and public space. The study captured videos from eight public spaces using 360-degree video technology, presented them to participants with mobile-based VR platform, and obtained quantitative evaluations of environmental perceptions and affective appraisal. The analysis performed pairwise comparisons between public spaces with similar characteristics, although differing in design style: contemporary versus traditional.

Findings from this study suggest that traditional architectural styles for buildings – characterized by symmetry and ornamentation – are evaluated more positively than contemporary architectural styles – characterized by asymmetry, lack of ornamentation, and industrial appearance. For three out of four pairs in the study, traditional architecture scores significantly higher than contemporary architecture, while for one pair the scores are similar. The highest score in perceptions of architecture (mean = 4.25) is reported for the traditional square Bankplassen (A3), while the lowest score (mean = 2.43) is reported for the contemporary part of the street Toftes Gate (B1). The more robust comparisons in perceptions of architecture are those comparing the traditional versus contemporary parts of the same street, Toftes Gate (A1 versus B1). This is because these two spaces differ in architecture while their other features (e.g. street size, pavement, street trees) are very similar or mostly identical since they constitute different parts of the same street. Therefore, the significantly more positive score of traditional architecture compared to contemporary in Toftes Gates (3.82 versus 2.43) provides probably the most reliable evidence of the more positive evaluations of traditional architecture found in the study.

Although findings on perceptions of architectural styles are relatively straightforward, findings on perceptions of public space design, overall perceptions of public space, and affective appraisals of public space suggest that these depend on a variety of factors and not only on specific design styles. Although the study's data do not allow for sophisticated inferential analysis, pairwise comparisons and qualitative evaluations provide indications that elements such as architecture, vegetation, upkeep, car restrictions, public seating places, and urban fountains may contribute to positive perceptions and affective appraisals of urban spaces. Vegetation and upkeep appear to be important qualities of environmental perception and affective appraisal in line with previous studies (Johansson et al., 2016; Zhang & Lin, 2011). How perceptions and emotions in public space are shaped is a complex issue. Several other factors related to form and functions of public spaces may play important roles in that. Such factors may be relevant to physical attributes such as design complexity, building uses and presence of third places, presence of seating places, and presence of public art, as well as perceived attributes such as the link to history, safety and fear of crime, inclusiveness or exclusiveness, segregation and inequality, and the degree of publicness of space (see e.g. Carmona, 2010, 2015; Lynch & Carr, 1979; Madanipour, 2003; Rapoport, 2013; Varna & Tiesdell, 2010).

The results from this study shed light on a crucial issue for the present and future of cities: the evaluation of visual appearance of contemporary versus traditional design styles in architecture and urban design. The visual appearance of cities is not only a matter of aesthetic preference, but is also linked to emotional responses induced by the built environment (Hanyu, 1997, 2000; Zhang & Lin, 2011), and thereby contributes to human well-being (Mouratidis, 2018, 2019a;

Seresinhe et al., 2019). The study's outcomes suggest that contemporary designs in building architecture are perceived less positively than traditional ones. This finding poses critical questions on current trends in contemporary architecture and subsequently on the livability of newly-developed built environments. Architecture differs from many other art forms in that residents cannot choose whether they will experience it or not, as they can do for example with music, theater, or painting. On the contrary, residents experience architecture in their neighborhoods and cities every day and are affected by it (Nasar, 1994). Therefore, both practitioners and policymakers need to base their decisions on architectural styles on residential needs and preferences. To achieve a more democratic urban life, citizen participation is key in shaping the aesthetics of buildings and public spaces. At the same time, decisions on architectural as well as urban design styles should also be driven by scientific research: they should be more informed by behavioral, environmental, and social research findings.

5.2. VR technology and 360-degree videos

The paper employed a recently-developed research method for visual evaluations of urban spaces based on commercially available VR technologies used under laboratory conditions. More specifically, the study focused on utilization of 360-degree video capturing of urban surroundings combined with use of smart mobile phones VR platform with HMD.

One of the well-known documented complications associated with using VR is cybersickness. Cybersickness is an affliction common to users of virtual environments. Similar in symptoms to motion sickness, cybersickness can result in nausea, headaches, and dizziness (Rebenitsch & Owen, 2016). While a recent study reported high level of cybersickness among subjects when using similar experimental setup "360-degree videos with HMD" for studying environmental perception during a simulated walk (Calogiuri et al., 2018), this study shows a lower level of cybersickness among subjects. The mean for feeling dizzy and nauseous was 2.59, which indicates a feeling between "a little" (2) and "somewhat" (3). Seven of the respondents did not get dizzy or nauseous at all. This study shows that 360-degree videos can achieve less cybersickness if the videos are captured in a fixed position and in synergy with the position of subjects under the VR experiment when used for visual evaluation studies. This study assumes that exposing subjects in a sitting or standing position to a moving 360-degree video through HMD will increase cybersickness.

The reason some of the participants got cybersickness in our study is probably the low resolution of the smart mobile phones display. Even though the videos were captured in 4 K resolution, the screen of the smart mobile phones reduced the resolution to 1080 × 1920 pixels. The quality of the video shown to the participants was therefore much lower than what was captured in advance. What could have improved the experience is phones with better screen resolution. However, resolution would still not be substantially improved because mobile based VR or other commercially available standalone VR units (e.g. Oculus Rift, GO, Quest, HTC Vive) are not yet able to display 4 K resolution. We assume that even though the resolution was not optimal, the results would not have been any different with a higher resolution. The only difference would have been the user experience, in which we can reasonably expect improvements within the near future as technology is developing rapidly.

5.3. Future research

The study has a few limitations that could be addressed by future research. More research is necessary to obtain an in-depth understanding of perceptions and affective appraisal of architecture and urban design. More cases comparing contemporary versus traditional styles are needed to reach strong conclusions. Future studies could explore other architectural styles and other types of public spaces. As the number of participants in the VR experiment is relatively limited and the participants are young and come from a specific cultural background, future research should examine this topic using larger samples and samples from other sociodemographic and cultural backgrounds. Some pairs examined in the study slightly differ in certain physical elements, such as vegetation, potentially influencing perceptions and affective appraisal (Kaplan & Kaplan, 1989). Experimental studies that manipulate the physical elements of urban space to perform comparisons of different design styles can provide stronger internal validity and stronger support for causality. In addition, future studies should focus on a detailed examination of specific physical attributes of architecture and urban design and how these are perceived and experienced by residents. They should investigate which of these attributes are positively perceived and experienced and which ones are negatively perceived and experienced. They should provide understanding of what it is in contemporary architecture that could be negatively perceived: is it the asymmetry, the lack of ornamentation, the materials used? To what degree does each attribute contribute to perceptions and experiences? Finally, to offer a more realistic and immersive audio experience during experiments, future VR studies could use spatial audio, noise cancelling headsets, and soundproof rooms, as done for example by Sun et al. (2019).

6. Conclusions

The study has provided new empirical insights into users' evaluations of visual appearance of contemporary versus traditional design styles in architecture and urban design. Users' perceptions and affective appraisals of contemporary versus traditional design styles have been compared. Findings from the study suggest that users prefer the visual appearance of traditional architectural styles compared to that of contemporary architectural styles. Statistical comparisons of environmental perception between the two styles indicate significantly higher values for traditional architectural styles. These findings pose preliminary questions on current architectural trends and highlight the need for practitioners and policymakers to pay closer attention to residential needs and preferences when deciding on architectural styles of future urban development. Perceptions and affective appraisals of public space are complex and appear to be influenced by a variety of physical elements including architectural design, vegetation, upkeep, car restrictions, public seating places, and urban fountains. Further research is needed to deeply understand the impact of specific physical attributes of architecture and urban design on human perceptions and emotions.

A recently-developed research method for panel evaluations of perceptions and experiences in the environment has been applied in the study: panel evaluations of 360-degree videos of real environments viewed with smart mobile phone VR platform with HMD. This method allows panel evaluations in controlled conditions while at the same time offers a presentation of the displayed environment that is as close to reality as possible. Combining 360-degree videos with VR presentation immerses participants in the displayed environment, while minimizing interaction with the real world. Thereby, evaluation of perceptions and affective appraisals of the examined environment using this method are expected to be more reliable than those with commonly used photographs. Evaluations of cybersickness in the study reveal that participants experience, on average, low to moderate levels of dizziness or nausea. Rapid technological advancements are expected to further improve user experience and further address the problem of cybersickness. Another aspect of this research method that could be further explored is facilitating the ability to manipulate the 360-degree videos by changing selected features of the displayed environment. Such an option would increase the internal validity of empirical investigations, as it would allow researchers to modify specific physical elements of space and evaluate their subsequent impact on perceptions and experiences.

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