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Journal Article

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Publication date:
2023-04

Permanent link:
https://doi.org/10.3929/ethz-b-000587883

Originally published in:
Landscape and Urban Planning 232, https://doi.org/10.1016/j.landurbplan.2022.104650

Funding acknowledgement:
757565 - Enabling transformation: Linking design and land system science to foster place-making in peri-urban landscapes under increasing globalization (EC)

Landscape and Urban Planning 232 (2023) 104650

Contents lists available at ScienceDirect

Landscape and Urban Planning

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

Greater place attachment to urban parks enhances relaxation: Examining affective and cognitive responses of locals and bi-cultural migrants to virtual park visits

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HIGHLIGHTS

- Place attachment is related to the physiological responses of participants during a virtual visit in urban parks.
- Greater place attachment increases the level of relaxation.
- Familiarity with the cultural background of a park increases relaxation.
- Place attachment has measurably started to form in bi-cultural migrants in their host country.

ARTICLE INFO

Keywords:
Place attachment
Migrants
Urban parks
Electrodermal activity
Virtual reality

ABSTRACT

This work is an experimental contribution to assessing the relationship between place attachment and well-being in urban parks in a mobility and migratory context. Using virtual park visits, we aimed at finding out whether place attachment and familiarity with parks are related to physiological responses, i.e. relaxation/arousal. The experimental study involved bi-cultural residents and locals who were invited to experience two comparable urban parks in an audio-visual laboratory. The virtual visit included a Persian Garden in Iran and a historic park in Switzerland. During the session, subjects' affective responses were measured via skin conductance activity and a questionnaire was used to collect information on aspects of place attachment/identity and perceptual properties. Statistical analyses show that place attachment and familiarity with the cultural background of a park have a significant influence on the affective responses, particularly relaxation. In addition, we find some experimental evidence that measurable place attachment has developed among bi-cultural migrants in their new place of residence. Results fit well to theories of place attachment that are compiled in the article.

1. Introduction

Over the past few decades, numerous studies have highlighted the role of urban green space for enhancing the well-being of residents, e.g., via stress recovery (Thompson et al., 2012) or health benefits through physical exercise (Penedo & Dahn, 2005). In addition to these well-known recreational qualities, urban parks can play an important role for inclusion and integration of increasingly mobile people, e.g., as shown by Di Masso et al. (2019), Main (2013), Rishbeth & Powell (2013) and Bazrafshan et al. (2021). The latter authors present compelling research showing that urban green space provides multiple opportunities for migrating communities to form a bond with their places of relocation, either by enjoying the practical use of parks, appreciating their visual properties and possibilities for social interaction and gathering, or recalling memories and meanings. For example, Bazrafshan et al. (2021) were able to confirm the place-referent continuity theory (Twigger-Ross & Uzzell, 1996) via interviews with refugees and locals in urban parks. They showed that elements that were physically different

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https://doi.org/10.1016/j.landurbplan.2022.104650
Received 11 May 2022; Received in revised form 13 November 2022; Accepted 23 November 2022
Available online 17 December 2022

from but had similar meanings and functions to the participants' area of origin, facilitated place attachment, mainly through childhood memories. Consequently, place of origin and place of relocation become interconnected, offering different, yet compatible, experiences. This could help reduce the disruption caused by moving to a new place.

1.1. Research gap and aim of the study

It is clear from the above literature and relevant theory (see section 2) that urban green spaces facilitate place attachment in increasingly mobile societies. There is also broad evidence that place attachment has implications on *reported* well-being. (e.g., Scannell and Gifford, 2017; Liu et al., 2021; Ulrich et al, 1991). However, there have been very few *experimental* studies besides Zhang (2022) linking self-reported place attachment in park environments to physiologically detectable emotional well-being and stress reduction, the latter being an important recreational quality of urban parks. Moreover, it is unclear how the connotations of park elements and the familiarity with cultural values attributed to places may alter these emotional characteristics (see Liu et al. (2021) for a review of this aspect).

To address these research gaps, we aimed at designing an experiment consisting of virtual visits to urban parks to examine the influences of place attachment and cultural background on physiological responses. We were motivated to use physiological experiments because of (1) the possibility to obtain rather unbiased measurements of emotions, (2) the possibility to quantify potential impacts of changing place attachment on physiological properties, and (3) to showcase a comprehensive assessment of the perceived recreational qualities of parks that may not be consciously accessible (Scott et al., 2009; Diener et al., 2018).

1.2. Research design and research questions

The experimental study involves bi-cultural residents (Persians who migrated to Switzerland) and locals (Central Europeans living in Switzerland). Both groups were invited to a session in an audio-visual laboratory to watch and evaluate two comparable urban park scenes, a Persian garden and a Swiss/Central European Park. During the session, individuals' affective responses (arousal/relaxation) were measured through their skin conductance activity and a questionnaire was used to gather information on cognitive and perceptual properties. By correlating people's cognitive judgments with their affective reactions, we sought to answer the following two main questions:

1. How does the participants' self-reported place attachment to the shown parks influence their affective response during the virtual park visit?
2. How does the participants' familiarity[1] with the cultural background of the park contribute to their affective response during the virtual park visit?

2. Theoretical position

The design of the experiment and the interpretation of the results is aligned with broadly supported theoretical concepts and empirical data from the literature, briefly summarized below. Since our questionnaire is based on previous qualitative work by Bazrafshan et al. (2021), their framework to categorize self-reported statements of place attachment is also briefly summarized.

[1] According to our definition, a participant is 'familiar' with a park if he/she spent their childhood in the cultural environment of that same park, i.e., those with a European cultural background viewing the European park and those with a Persian cultural background viewing the Persian garden. Europeans viewing the Persian garden and Persians viewing the European park would be classified as 'not familiar'.

Landscape appraisal: To understand the processes that the participants in our experiment underwent, we refer to the recent article of Wartmann et al. (2021) for an overview of theories of landscape appraisal that have shaped the field and are still broadly accepted. These include the evolutionary theory of Appleton (1975), emphasizing evolutionary traits of human perception of landscape for survival, the information processing theory of Kaplan & Kaplan (1989), emphasizing how humans extract information from the environment and make sense of it, and cultural preference theories (e.g., Tveit et al., 2018), explaining preferences as a result of social and cultural norms, individual characteristics, memories and experiences. Cultural preference theories fit well with perception theories, claiming that top-down visual processes transform simple patches into meaningful objects by the use of cognitive, semantic information to make sense of the scene (Ware, 2008). This top-down visual process is driven by the demands, needs and goals of the observer (Gross and John, 2003). A recent review by Jacques (2021) sheds new light on the above theories with results from neurological experiments. Of particular relevance to our work are the findings from many experiments regarding the cascade of processes in the brain, which follow information coming from the eyes (Chatterjee, 2014). Chatterjee (2014, p.30) summarizes, 'This information is processed in different parts of the occipital lobe, which interact with our emotions in the limbic areas. When we like what we see, the pleasure or reward centers of our limbic areas are turned on. When we think about the meaning of what we are looking at, the temporal lobes are engaged. When we draw on our personal memories and experiences in aesthetic encounters, the inside of the temporal lobe comes online'.

Place attachment as cognitive judgements and affective reactions: Attachment to a place is considered as a factor that helps people call a place home (Cresswell, 2004/Cresswell, 2014). However, feeling attached is a subjective emotion that cannot be assessed objectively (Diener et al., 2018), as it requires participants who have experienced both cognitive and affective responses (Davern et al., 2007). Diener et al. (2003) stated the collective physiological reaction is an overall picture someone can have about their life, which is defined by three main factors: (a) affective and cognitive level; (b) emotional reactivity; (c) cognitive processing of emotional information. Previous findings show that cognition determines perceived emotions (Mee & Wright, 2009). The latter are shaped by past experiences and are considered an ongoing process (Schachter & Singer, 1962). To assess cognitive judgements, self-reported methods are the most appropriate (Diener et al., 2003), while affective reactions become evident when the person is exposed to a specific event that generates a link to a prior experience (Schimmack et al., 2008; Diener, 2009).

Mobility and place attachment: Mobility and relocation are known to impact place attachment (Di Masso et al., 2019). Relocation frequently disrupts personal bonds and social networks (Rishbeth & Powell, 2013; Main, 2013). Understanding how people make these residential migration decisions is complex (Greenwood, 1985; Oishi, 2010) and people have developed a range of strategies to deal with disruptions to their location. The 'fixity-flow' framework (Di Masso et al., 2019) describes many forms of place attachment that exist alongside each other. For the present study, their 'fixity FROM flow' subconcept is particularly important. It stems from theoretical work of Twigger-Ross & Uzzell (1996) known as 'place-referent' and 'place-congruent' continuity. It describes how places become interconnected and can contribute to self-continuity if the physical and social characteristics of two or more places fit the value systems of a person or group.

A place is considered to be a location with tangible properties associated with values and meanings given by inhabitants or social groups (Martorell Carreño, 2003). These are the so-called 'intangible values'. For social groups, these values may differ depending on the shared values of society and the cultural context (Devine-Wright & Howes, 2010). The kind of meaning that transforms a location into a place has been best described in the space-place theory of Hunziker et al. (2007) and the person-process-place framework of Scannell and Gifford

(2010).

Framework to categorize self-reported statements of place attachment: In line with the theoretical literature on place attachment, Bazrafshan et al. (2021) developed a theory-based framework of categories to classify self-reported statements of place attachment by visitors to urban parks (Fig. 1). The framework builds on the three concepts, Place dependency, Place attachment ('sensu stricto'), and Place identity, and consists of 10 categories. For our virtual experiment, eight of the 10 categories were appropriate, since the other two categories are only relevant when visiting a place physically.

3. Methods

3.1. Study sites

We selected two types of public urban parks (Fig. 2) that are typical examples of culture-rich parks for both the Persian and the Central-European culture. The first park (the Eram Garden in Shiraz, Iran) is a century-old Persian garden. It represents a successful approach to dealing with an extreme climate, offering a diverse set of plants, beautifully arranged structures and a sense of relaxation, all of which aim to improve the well-being of visitors (Rostami et al., 2015). As Rostami et al. (2015) highlight, this formerly private, rich historic structure of gardening is now used by residents as a public place for recreation and social activity. The second park (the Rieterpark in Zurich, Switzerland) was laid out in 1855, surrounding a former mansion and today remains the largest original 19th century public landscape park in Zurich (Moll, 2019). Similar to the Persian garden, it has a villa (that of the former merchant Wesendonck). For each of the urban parks, we developed audio-visual stimuli to be perceived and judged by the participants.

3.2. Data collection

3.2.1. Audio-visual stimuli

We generated audio-visual stimuli using 360-degree photos taken by a GoPro camera (Insta360 ONE X) and environmental sounds recorded at the respective photo locations with an ambisonic sound-field microphone (AMBEO VR MIC, Microphone 3D AUDIO). In each park, we captured one spot per park that is characteristic of the park, which includes a historical building, several trails, larger trees, water, sky and benches (Fig. 2). The recordings were taken during spring 2019 at 8.00 am and include typical park sounds such as birdsong and subtle urban background noise to indicate that this is an urban setting. Research has shown that sounds have a significant influence on the mood state and stress recovery of people while they are exposed to virtual urban green scenes (e.g., Jiang et al., 2021; Shu & Ma, 2020).

3.2.2. Participants

A total of 60 bi-cultural participants (27 women, mean age = 33.84 years, SD = 5.23, range = 25–51, of Persian origin and currently living in Switzerland) and 60 locals (34 women, mean age = 32.05 years, SD = 10.69, range = 20–54, of Central European origin and currently living in Switzerland) were recruited using University registration centres for study participants (https://www.uast.uzh.ch; https://faps.ch) and by promoting the experiment within the migrant communities. The main inclusion criteria were appropriate cultural background and Swiss residency of more than five years. All participants had tertiary education (many held an academic diploma). The participants of Persian origin had never visited the Swiss park and the Swiss participants had never visited the Persian garden. The study was approved by the ethics committee of ETH Zurich (EK 2020-N-39). Participants were compensated 30 CHF for approximately 60 min of participation. We collected participants' socio-demographic characteristics during the recruiting phase.

3.2.3. Exposure procedure

The experiment was conducted in an audio-visual laboratory; for a detailed description, see Manyoky et al. (2016). In order to ensure constant light and sound conditions, the stimuli were projected with a head-mounted display (HMD), the HTC VIVE Pro Eye VR Headset. The corresponding landscape sounds were replayed using a 5.0 surround sound system, mounted according to the ITU-R BS.775 standard. Participants sat 2.5 m in front of the centre screen with their non-dominant hand resting on an armrest in order to reduce movement artifacts in EDA data (Benedek, 2010). The surrounding screens were used to project the scene while participants answered the questionnaire. Participants wore skin conductance electrodes (E4 Empatica wristband; https://www.empatica.com/en-gb/) on their non-dominant hand. Data were collected with each participant individually in a laboratory session that lasted around 60 min. All participants could understand and speak either German or Farsi, were physically and psychologically healthy, and had

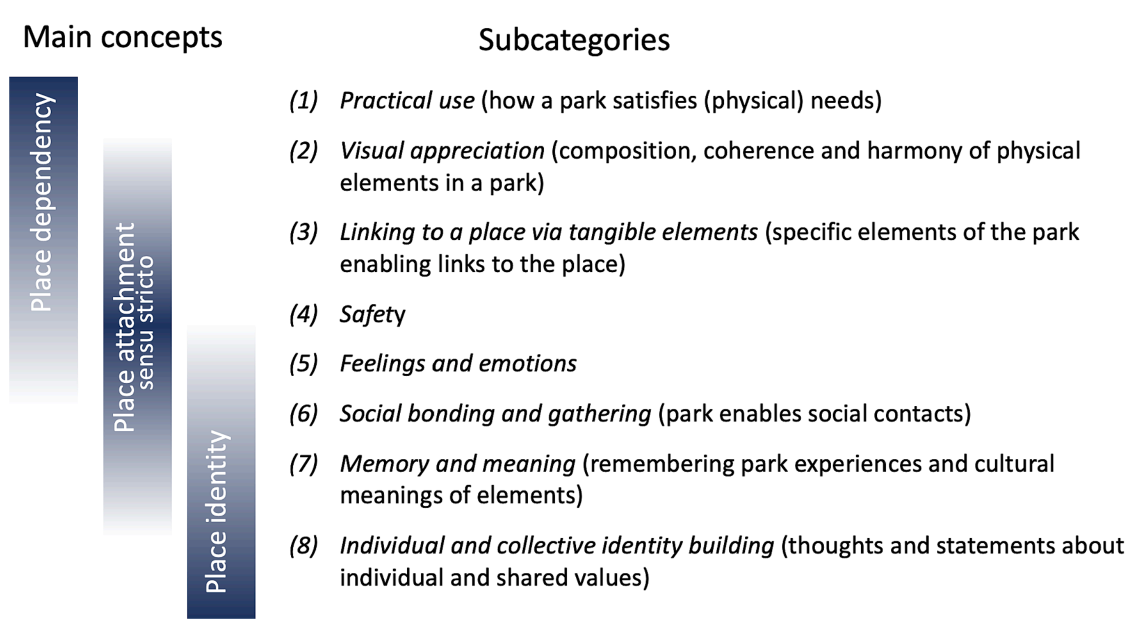

Fig. 1. Framework to categorize self-reported statements of place attachment in urban parks (Bazrafshan et al., 2021). Each main concept (left) is broken down to specific subcategories (right).

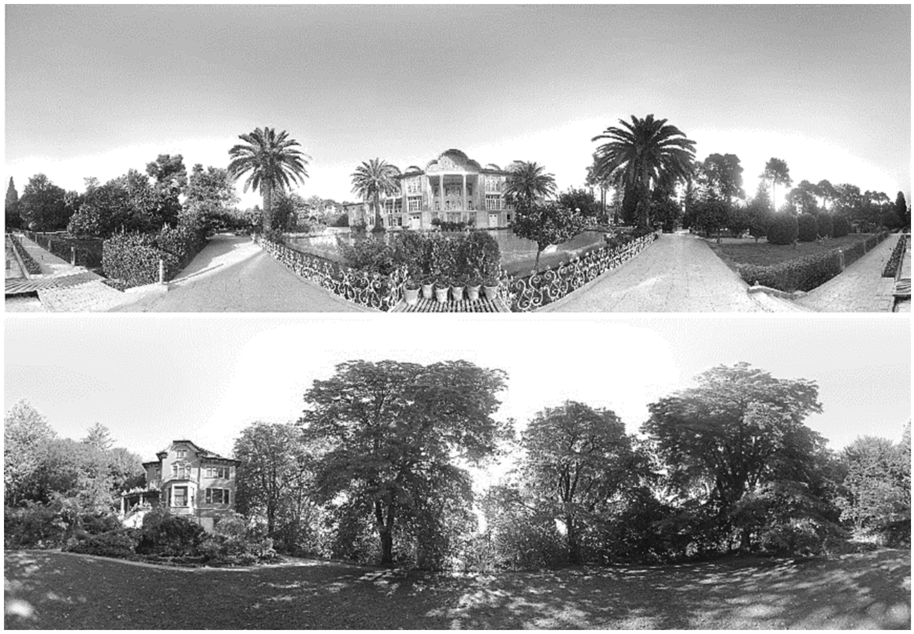

Fig. 2. Characteristic panoramic views of the Persian garden (top) and the Swiss park (bottom) used in the experiment. In the experiment the scenes were shown in color.

normal or corrected-to-normal vision and hearing.

After being informed about the procedure of the experiment and providing written consent, the participants sat in a chair in the centre of the laboratory. The experiment was divided into two parts that proceeded in the same order (Table 1). It started with the Self-Assessment Manikin (SAM) questionnaire (Bradley & Lang, 1994), which has three dimensions: arousal, valence and dominance. Arousal and valence were used to assess participants' reported emotional states (Spielhofer et al., 2021). We did not consider dominance as the participants could not walk around, and there was no disturbing element, such as traffic, in the scene. States of each dimension (ranging from excited to relaxed concerning arousal, and from happy to unhappy representing valence) were represented by images on a five-point scale.

The SAM was followed by a stressor task with white noise in the background. Participants were given high cognitive loads to increase the stress level. The stressor tasks were presented on the centre screen. After completing another SAM, participants were exposed to the first park scene wearing the HMD for 10 min. Participants were able to freely look around by moving their head from a still spot and explore all the details of the scenes according to personal preference. The order of the scenes and stressor tasks were randomized across participants. At the end of each scene, the HMD was removed, and another SAM was conducted. Participants were then asked to complete the questionnaire on place attachment to the seen park (Table 2 and section 3.3.1). This questionnaire captured perceived place attachment, place dependency and place identity with the shown park, as well as judgements of perceived visual characteristics and perception properties (e.g., beauty) of the parks. The procedure was then repeated for the second park.

3.3. *Data and statistical analysis*

3.3.1. *Explanatory variables*

The questionnaire (Table 2) had 25 items with responses on five-point Likert scales, corresponding to Bazrafshan et al.'s (2021) framework for categorizing self-reported statements of place attachment (Fig. 1). The statements were evaluated and tested in a small pilot study and cross-checked with statements from a national survey (Salak et al., 2021). For the main study, we used Cronbach's alpha to check the consistency of the questionnaire. To reduce the 25 dimensions of the questionnaire to a small number of uncorrelated variables, we applied multiple correspondence analysis (MCA). We are aware that many papers treat Likert scales as interval data and therefore perform principal component analysis (PCA). However, we decided to take the more robust approach of MCA, albeit recognizing that independent dimensions explain less of the variance than PCA.

Further explanatory variables were gender, age, and cultural familiarity with the park. According to our definition, a participant is 'familiar' with a park if they spent their childhood in the cultural environment of that same park, i.e., those with a European cultural background viewing the European park and those with a Persian cultural background viewing the Persian garden. Europeans viewing the Persian garden and Persians viewing the European park were classified as 'not familiar'.

3.3.2. *Dependent variables derived from EDA*

The use of EDA measurements to study emotions has been widely studied and discussed (e.g., Caruelle, et al., 2019; Li et al., 2022). Multi-signal analysis (e.g., Stuldreher et al., 2020) of EDA, electroencephalogram (EEG), or heart rate have shown that EDA is a very robust measure to collect the continuous emotional reaction (Dawson et al., 2017). Skin conductance (SC) data were first exported from E4 Empatica using R

Table 1
Sequence of the study procedure representing different stages. Participants were assigned randomly to the starting scene.

Sequence	SAM	Stressor task 1	SAM	Virtual visit of Park 1	SAM	Questionnaire 1	SAM	Stressor task 2	SAM	Virtual visit of Park 2	SAM	Questionnaire 2
Allocated time (min)	1	3	1	10	1	10	1	3	1	10	1	10

Table 2
Questionnaire used to capture participants' place attachment to the parks. Each question belongs to one of the theoretically grounded and empirically supported subcategories of place attachment highlighted in Fig. 1 (Bazrafshan et al., 2021).

Questions	Question number	Subcategories of place attachment (Bazrafshan et al., 2021)
This park meets all my practical, concrete needs.	1	Practical use
In this park, I can do anything I want.	2	
In this park, there are elements that help me to orient myself.	6	
This park is beautiful.	4	Visual appreciation
For me, this park symbolizes the beauty of nature.	5	
The individual things or parts of this park fit together.	7	
In this park I experience nature and can connect with it.	3	Linking to nature via tangible elements
To me, this park symbolizes the coexistence of people and nature.	8	
I feel safe in this park.	12	Safety
Here, I could stay alone for a long time.	13	
In this park, my nationality doesn't matter, it doesn't bother anyone.	18	
In this park, I have a positive feeling.	9	Feelings and emotions
In this park, I can experience myself.	10	
In this park, I can let my soul dangle.	11	
I feel comfortable in this park.	25	
I would like to be here with my friends/family.	16	Social bonding and gathering
In this park, I am encouraged to meet people.	17	
It would be a shame if I never knew about this park.	14	Memory and meaning
This park means a lot to me.	15	
I am used to this kind of park.	20	
My childhood is reflected in this park.	19	Individual identity building
This park is a part of me.	22	
This park symbolizes for me a typical park in Switzerland/Iran.	21	Collective identity building
This park design is unique in the Swiss/Iranian culture	23	
In this park, I feel connected to the region, its people, its nature and its history.	24	

Responses were given on a five-point Likert scale (1 = strongly disagree; 2 = disagree; 3 = neither disagree nor agree; 4 = agree; 5 = strongly agree).

studio and converted to readable format in Ledalab using Matlab. SC signals (microSiemens) have two main components, (1) a relatively fast variation (i.e., the phasic component, PC) and (2) the slow variation (i.e., the tonic component, TC), which indicate general arousal or relaxation (Amin & Faghih, 2019). We decided to use only TC as we were interested in longer term emotional responses rather than sudden physiological reactions (Martinez et al., 2019). Subsequently, continuous decomposition analysis was used to sample TC from each participant's SC data. From the resulting TC series, we selected the data from the stressor task (3 min) and the scene (10 min) and sliced them into 10-, 20- and 30-second (*sec*) segments between 1 *sec* after stimulus onset and 4 *sec* before stimulus end, in order to capture all of the activity related to the stimulus (Benedek, 2010). The resulting time series of stressor task and scene (10-, 20- and 30-*sec* segment means collapsed to a data point) were concatenated and unit-based normalized (0;1). To illustrate the method, Fig. 3 shows an example of a time series for stressor task and scene in 10-*sec* segments (means of 10 *sec*) for one participant and one scene. We did not consider a general baseline of EDA (e.g., Huang et al., 2020); instead, each participant's individual maximum level of arousal achieved with maximum cognitive load was used as the reference level (Martinez et al., 2019).

To calculate the TC measures, we followed Anderson et al. (2017) and calculated the mean TC during the 3-min stressor task (meanS), the mean TC during the first 3 min of the scene, named 'beginning' of the scene (meanB), the mean TC during the 4th to 6th min of the scene, named the 'middle' of the scene (meanM), and the mean TC during the 7th to 9th min of the scene, named the 'end' of the scene (meanE) (Fig. 3). We then calculated the increase or decrease in the TC of each 3-min period of the scene relative to the stressor task by calculating meanB/meanS, meanM/meanS and meanE/meanS. In addition, meanE/meanB was calculated to give the arousal or relaxation between the first and the last 3-min period. In a test study, the 3-min means did not show any significant responses to people's place attachment. Therefore, we searched for alternatives to subdivide the tonic signals (10-, 20- and 30-*sec* segments) into individual arousal and relaxation phases. The 'features' package in R proved to be a suitable tool for deriving critical turning points of the TC values featuring the scene (red symbols, Fig. 3) (features_2015.12–1). In addition, absolute maximum and start and end values of the scene were recorded (yellow symbols, Fig. 3). After having calculated all necessary points in the curves, we derived the difference between two consecutive points to determine whether this phase was an arousal or a relaxation phase (Fig. 3). We then selected the phases with (1) the highest positive difference of TC, to represent maximum arousal (MA), (2) the highest negative difference of the TC, to represent maximum relaxation (MR), (3) the sum of all positive differences of the TC, to represent accumulated arousal (AA) and (4) the sum of all

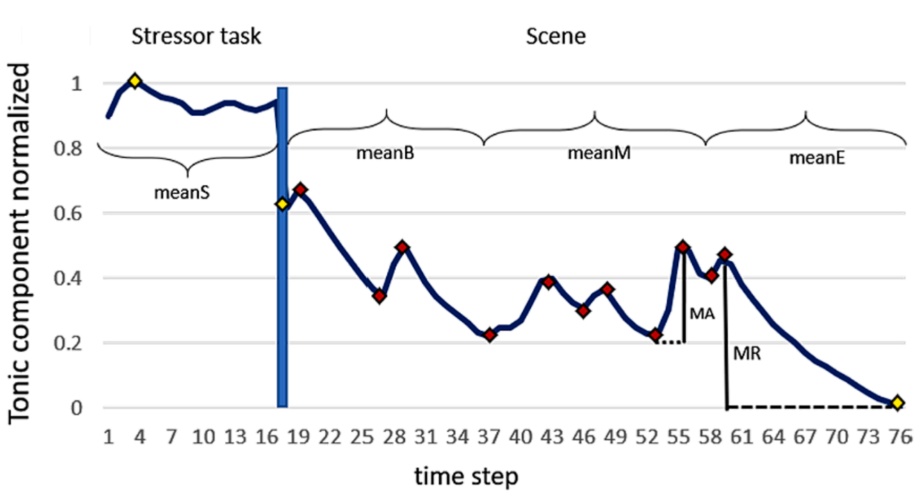

Fig. 3. Unit-based normalized tonic signal (0:1) of a participant in 10-*sec* segments (means of 10 *sec*) for stressor task and scene. The blue bar indicates where the SAM was completed and the HMD was mounted. Physiological measurements were taken during SAM completion and HMD mounting but omitted in the analysis. Red symbols in the scene are the critical points of the series derived with the R package 'features'. Yellow symbols indicate maximum TC (10-*sec* mean) in the stressor phase and the TC value at the beginning and the end of the scene (10-*sec* means). The measures derived from the curve are highlighted in the graph and described in the text.

negative differences of the TC, to represent accumulated relaxation (AR).

3.3.3. Regression modelling

To test the effects of the independent variables on individuals' physiological response, we applied linear mixed effect (LME) models, using the lme4 package (Bates et al., 2014) in R. With LME models, we were able to account for the following three possible random effects of our experiment: (1) subject number—the fact that each subject was exposed to both levels of the urban green scenarios; (2) order of stressor—the fact that there were two different stressor tasks that might have had different influences on people's physiological reactions; (3) order of scene—the stimulus order within the experiment to account for possible overall habituation effects of the stimuli.

We considered the uncorrelated dimensions of the MCA of the questionnaire as the fixed factors (explanatory variables). These refer to the main categories of place attachment, place identity and place dependency. Further fixed factors were the cultural familiarity with the urban park, gender and age. Table 3 shows the dependent variables, the fixed factors and the random factors that were combined in various LME models.

Table 3
Summary of variables used in the LME models.

Dependent variables	Fixed factors (explanatory variables)		Random factors

• Maximum relaxation (MR)[1]
• Maximum arousal (MA)[2]
• Accumulated relaxation (AR)[3]
• Accumulated arousal (AA)[4]
	3-fixed-factor model to answer research question one	• Place attachment (questionnaire)
		  • Dimension 1 of MCA
		  • Dimension 2 of MCA
		  • Dimension 3 of MCA
			• Subject number
			• Order of scene
			• Order of stressor task

• 3-minute means of the tonic component (TC)
  • meanB[5]/meanS[8] (beginning/stressor)
  • meanM[6]/meanS[8] (middle/stressor)
  • meanE[7]/meanS[8] (end/stressor)
  • meanE[7]/meanB[5] (end/beginning)
	3-fixed-factor model to answer research question two	• Cultural familiarity with urban park[9]
		• Gender
		• Age	

[1] phase (see Fig. 3) with highest negative difference of the tonic component (TC).
[2] phase (see Fig. 3) with highest positive difference of the tonic component (TC).
[3] sum of all phases (see Fig. 3) with negative differences of the tonic component (TC).
[4] sum of all phases (see Fig. 3) with positive differences of the tonic component (TC).
[5] mean of the TC during the first 3 min of the scene (in 10 *sec*. intervals) (see Fig. 3).
[6] mean of the TC during the 4th to 6th minute of the scene (in 10 *sec*. intervals) (see Fig. 3).
[7] mean of the TC during the 7th to 9th minute of the scene (in 10 *sec*. intervals) (see Fig. 3).
[8] mean of the TC during the 3-minute stressor test (in 10 *sec*. intervals) (see Fig. 3).
[9] "familiar" = Central Europeans viewing Swiss Park & Persians viewing Persian garden; "not familiar" = Central Europeans viewing Persian Garden & Persians viewing Swiss/European park.

4. Results

4.1. Quality assessment of the experiment

4.1.1. Reported emotional states of participants during the experiment

Over the course of the experiment, participants completed six iterations of the SAM. The mean, median and standard deviation of arousal and valence were very even across the different events during the experiment. Therefore, we conclude that there was no unwanted interference with the EDA measurements, e.g., fear, discomfort, or an unclear experimental set-up.

4.1.2. Consistency of the questionnaire

Following DiStefano et al. (2021), the five-point Likert scale was transformed into three categories to achieve a more accurate estimation of parameters (categories 1 & 2 –> new category 1; category 3 –> new category 2; categories 4 & 5 –> new category 3). Cronbach's alpha for the survey with three-point Likert scales was $\alpha = 0.86$. Kendall's correlation coefficient between the questions ranged from 0 to 0.6. To reduce redundant information, highly correlated questions were eliminated prior to MCA. This is the case for questions 25 and 11 (Table 2) that were highly correlated with question 9, which was retained. Question 23 was removed as it was highly correlated with question 21. Questions 1 and 2 ask about practical uses of the park and are therefore inappropriate in a virtual setting. Questions 16 and 17 are also critical when asked in a virtual environment. In addition, they were correlated with each other as well as with questions 9 and 15. We decided to keep questions 9 and 15 and drop questions 16 and 17. The final set of questions retained in the the MCA is given in Appendix 1.

4.2. Place attachment towards the parks (questionnaire)

Information on cognitive aspects of participant's place attachment was taken from the questionnaire. To reduce the dimensionality of the questionnaire, an MCA was performed. The first three dimensions of the MCA explained 29.8 % of the total variance. To interpret the dimensions, we calculated the Kendall correlation coefficients between the original questions and the dimensions (Appendix 1).

Dimension 1 (horizontal) showed the strongest (negative) correlations with questions 4, 9, 10, 14, 15, 19 and 22, 24; hence this dimension can be interpreted as the general place attachment dimension or indicator containing all facets of place attachment and place identity. This interpretation can be translated into Fig. 4 as follows: the more negative dimension 1 is (i.e., the more to the left in Fig. 4), the stronger participants express place attachment and place identity when viewing the park; the more positive dimension 1 is (i.e., the more to the right in Fig. 4), the lower the self-reported place attachment and place identity when viewing the park.

Dimension 2 (vertical) is more specific: questions dealing with individual identity building and memory and meaning (questions 15, 19, 20 and 22) and safety (questions 12 and 13) showed the strongest correlates with dimension 2. This can be translated into Fig. 4 as follows: the more positive dimension 2 is (i.e., the higher it is in Fig. 4), the more participants confirm that the park supports individual identity building and the more they recall memories and meanings when viewing the parks. The more negative dimension 2 is (i.e., the lower it is in Fig. 4), the weaker participants express individual identity building and memories, but the stronger they respond to questions about safety.

We plotted the responses of all participants along the first and second axes of the MCA and labelled them by cultural group and park seen (Fig. 4). This revealed a clear pattern. The upper-left quadrant (characterized by strong expressions of place attachment, memories and meanings) contains many participants with a Persian cultural background viewing the park of their own culture. The upper-right quadrant (characterized by expressions of individual identity building and memories) contains many participants with a Persian cultural

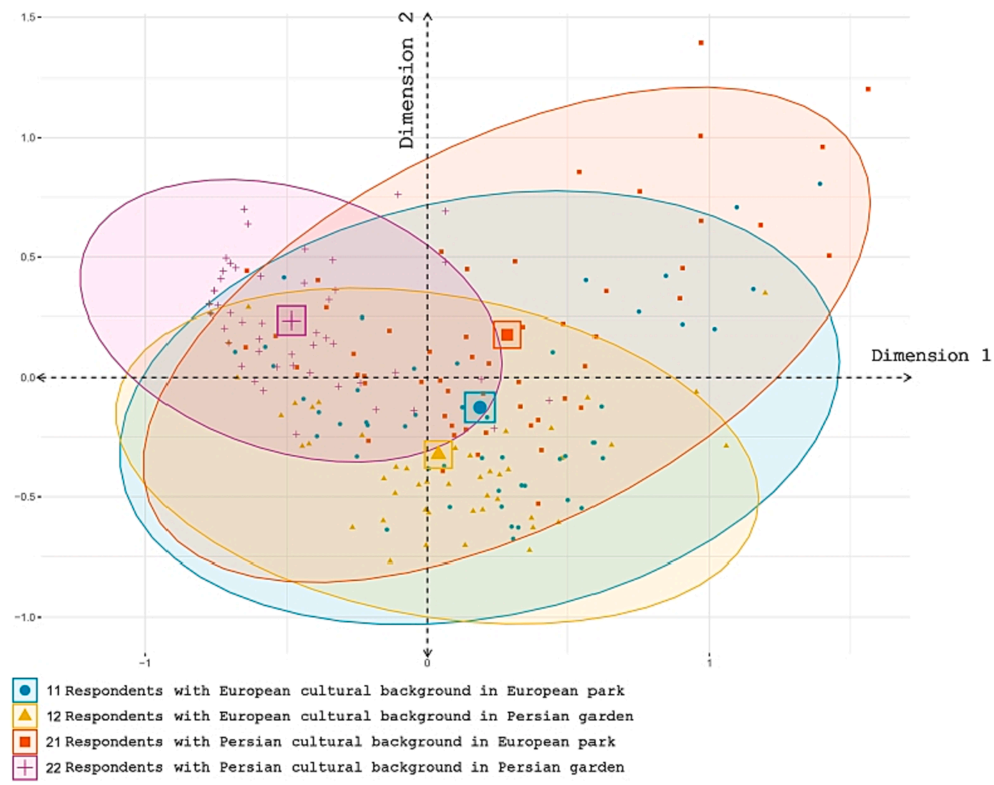

Fig. 4. The first (horizontal) and second (vertical) dimension of the MCA reducing the dimensionality of the questionnaire data. The explained variance is 14.4% and 7.9%, respectively. Meanings of the axes are described in the text. Point clouds represent the locations of individual participants along the two dimensions. Participants are grouped according to cultural background and park seen.

background viewing the European park. The lower-right quadrant (characterized by low self-reported place attachment, place identity and memory but higher reported safety aspects) contains participants with a European cultural background in the park of their own culture and in the Persian garden.

4.3. Influence of place attachment on affective responses

The well-known, relaxing influence of urban green space on the emotional state of participants (Haung et al., 2020) was also found and confirmed for all participants in both parks. This result can be seen in the decline in TC while viewing the park scenes; the average minimum TC (raw values, 10-*sec* resolution) during the scene was significantly lower (36 %) than the average maximum TC during the stressor phase, independent of cultural background, park and reported place attachment ($p < 0.001$, *t*-test, two-tailed, paired). However, while this general finding is interesting in itself, and confirms previous studies and the validity of the current experiment, our research questions do not focus on the general effect of urban green on emotions. Rather, they focus specifically on the influence of place attachment on affective responses. To answer the corresponding research questions, two three-fixed-factor LMEs were calculated (Tables 4 and 5, overview of variables Table 3). The significance of each fixed factor was tested using an analysis of variance (ANOVA) between the full model with all fixed factors and the model in which the factor under test was omitted. Out of these models, only the dependent variable maximum relaxation (MR) showed a consistent and statistically significant relationship with the independent variables for the 10-, 20- and 30-*sec* resolutions (Table 4). In a small number of cases, the accumulated relaxation (AR) was also significantly correlated with the independent variables. None of the dependent variables involving means of TC over longer time intervals showed a significant relationship with independent variables.

For research question one, we wanted to assess the influence of place attachment on affective properties of the participants while viewing the two parks. The three-fixed-factor models displayed in Table 4 clearly show that dimensions 1 and 2, which were obtained from the questionnaires by MCA, best explain the maximum relaxation (MR) of the participants, regardless of whether 10-, 20- or 30-*sec* segments were used. The direction of influence is consistently positive for dimension 1 and negative for dimension 2. This means that MR—a variable with a negative sign—is highest when the participants expressed strong belonging and identity, e.g., a high visual appreciation of the parks, recall of childhood memories and knowledge of the meanings of the places.

For research question two, we wanted to assess the influence of cultural background on affective responses during the virtual park visit. The three-fixed-factor models in Table 5 exhibit that participants who are familiar with a place showed significantly higher MR. While the overall physiological response to the dimension of place attachment (Table 4) was common to both genders, male participants showed significantly higher maximum relaxation and lower arousal when exposed to the parks than female participants (Table 5). There was no significant response of age to any of the dependent factors.

This result is corroborated with data shown in Fig. 5. When participants experienced the park of their own culture (categories 11 and 22), their maximum relaxation (negative sign) was 20–30 % higher compared to experiencing an unfamiliar park (categories 12 or 21). Although the effect was only significant for European participants viewing the Persian garden (category 12) when compared to Persian participants viewing the Persian garden (category 22), the trend is clear. Although not significant, it is evident from Fig. 5 that the Persian participants showed rather high levels of relaxation when viewing the European park. It seems as they have already started to develop an individual bonding (positive axis of dimension 2, Fig. 4), which results

Table 4
Linear mixed models (LMEs) with three fixed factors of place attachment (dimensions 1–3) to answer research question one. All models have subject number, order of scene and order or stressor as random factors. Significant variables are highlighted in bold.

Dependent factors	Independent fixed factors of place attachment (questionnaire)								
	Dimension 1			Dimension 2			Dimension 3		
	Chi-square	p	Direction of influence	Chi-square	p	Direction of influence	Chi-square	p	Direction of influence
10 sec. resolution									
Maximum relaxation (MR)	4.7908	**0.02861***	+	10.51	**0.001187****	–	1.9294	0.1648	–
Maximum arousal (MA)	4e-04	0.9849	+	0.9473	0.3304	+	0.5884	0.4431	+
Accumulated relaxation (AR)	3.2214	**0.07268.**	+	1.3894	0.2385	–	1.4464	0.2291	–
Accumulated arousal (AA)	0.2276	0.6333	–	0.2496	0.6173	–	0.1134	0.7363	–
20 sec. resolution									
Maximum relaxation (MR)	4.8872	**0.02706***	+	5.6172	**0.01778***	–	2.2695	0.1319	–
Maximum arousal (MA)	0.1261	0.7225	+	3.3867	**0.06572.**	+	0.0121	0.9124	–
Accumulated relaxation (AR)	2.6486	0.1036	+	2.6991	0.1004	–	3.2284	**0.0724.**	–
Accumulated arousal (AA)	0.2306	0.6311	+	0.0179	0.8935	–	0.1136	0.7361	–
30 sec. resolution									
Maximum relaxation (MR)	7.0872	**0.0078****	+	4.1371	**0.04195***	–	2.349	0.1254	–
Maximum arousal (MA)	0.9726	0.324	+	2.3382	0.1262	+	0.0077	0.9302	–
Accumulated relaxation (AR)	2.4583	0.1169	+	2.6622	0.1028	–	3.8486	**0.0498***	–
Accumulated arousal (AA)	0.3035	0.5817	+	0.0102	0.9194	+	0.4652	0.4952	–
3-minute means of the tonic component (TC) from 10sec. resolution									
meanB/meanS (beginning/stressor)	1.1589	0.2817	+	2.0233	0.1549	–	0.1178	0.7314	–
meanM/meanS (middle/stressor)	0.1615	0.6878	+	1.9147	0.1664	–	0.7282	0.3935	–
meanE/meanS (end/stressor)	0.0817	0.775	+	1.7155	0.1903	–	1.8299	0.1761	–
meanE/meanB (end/beginning)	1.2293	0.2675	–	0.1133	0.7364	+	0.2714	0.6024	–

The significance of each fixed factor was tested using an ANOVA between the full model with all fixed factors and the model in which the factor under test was omitted. Note that MR and AR have by definition a negative sign: the more negative, the higher the relaxation of the individuals. (Significance levels of t-tests: <0.001: ***; 0.001–0.01: **; 0.01–0.05: *; 0.05–0.1: ".").

in increased relaxation while viewing the park of their host country. This process of establishing a bond with a new place is described by Bazrafshan et al. (2021) and discussed in more detail later in the present paper against the theoretical background.

5. Discussion

This paper makes important contributions to the knowledge about place attachment and recreational qualities of urban parks in a mobility and migratory context. The following discussion examines the results (a) methodologically and (b) via the theoretical framework of place attachment, mobility and migration outlined in section 2.

5.1. Methodological discussion

5.1.1. Technical aspects of the experiment

The use of wearable devices to assess emotional state is becoming more common, but their reliability has been questioned, leading to some comparative experimental tests of reliability (Borrego et al., 2019; Konstantinou et al., 2020). Based on the results and recommendations of these studies, we designed our E4 Empatica wristband experiment with a fixed armrest and continuous monitoring of the live data stream recording. On two occasions, the experiment had to be stopped when the signals dropped to zero. In our case, this resulted in a technical failure rate of about 1 % measured across all participants. A limitation of the experiment is that we showed participants a fixed image position in the park. Although they could freely choose viewing directions and times in a 360-degree window, they did not have the opportunity to walk virtually throughout the parks and explore them according to their preferred direction. This is a technical limitation of our experiment (and of virtual reality experiments in general), but it was necessary to ensure standardization of some of the park aspects. Further, the experiment was conducted with more highly educated participants, as we did not have access to participants from all segments of the migrant population. This may influence perceptions and expectations of an urban park.

5.1.2. Extraction of measures from normalized TC profiles

Generating variables from tonic or phasic profiles for statistical comparison with treatment data is either done by averaging the signal over certain temporal windows, e.g., beginning, middle or end (Anderson et al., 2017), or over a certain time period after a stimulus exposure (Spielhofer et al., 2021; Benedek & Kaernbach, 2010). We also followed this procedure by calculating means in fixed windows for the stressor task, and for the beginning, middle and end of the scene (meanS, meanB, meanM, meanE; see Fig. 3). With these fixed window measures, there is, however, much less flexibility to account for the individual physiological processes of the participants. This could be one reason why we did not find any statistically significant results with the fixed windows. As a novelty and an alternative to current data treatments (e.g., Li et al., 2022; Tronstad et al., 2022), we subdivided the TC profiles into critical turning points and critical sections using objective methods (via the 'features' package in R) to find sections where individual participants showed relaxation or arousal. Sections with the highest relaxation yielded significant statistical relationships with cognitive variables such as place attachment, familiarity, etc., which was not the case with fixed window means.

Table 5
Linear mixed models (LMEs) with the three fixed categorical factors cultural familiarity, gender and age of the participants to answer research question two. All models have subject number, order of scene and order or stressor as random factors. Significant variables are highlighted in bold.

Dependent factors	Independent factors								
	Cultural familiarity*			Gender*			Age		
	Chi-square	p	p	Chi-square	p	Direction of influence	Chi-square	p	Direction of influence
10 sec. resolution									
Maximum relaxation (MR)	2.8784	**0.08978.**	+	6.3105	**0.0120***	–	0.078	0.7858	–
Maximum arousal (MA)	0.0839	0.7720	–	1.0871	0.2971	–	0.1407	0.7076	+
Accumulated relaxation (AR)	0.4505	0.5021	+	0.0943	0.7588	–	1.8138	0.178	+
Accumulated arousal (AA)	0.0231	0.8793	–	9.3002	**0.002291****	–	0.1323	0.7161	–
20 sec. resolution									
Maximum relaxation (MR)	2.7175	**0.0993.**	+	8.6482	**0.003274****	–	0.2209	0.6383	+
Maximum arousal (MA)	0.3659	0.5453	–	1.1181	0.2903	–	0.8572	0.3545	+
Accumulated relaxation (AR)	0.181	0.6705	+	7.6088	**0.005808****	–	1.1663	0.2802	+
Accumulated arousal (AA)	0.0034	0.9538	–	7.142	**0.00753****	–	0.0616	0.804	+
30 sec. resolution									
Maximum relaxation (MR)	4.7083	**0.03002***	+	12.344	**0.0004424*****	–	0.0959	0.7568	+
Maximum arousal (MA)	0.3885	0.5331	–	3.0853	**0.079.**	–	0.7573	0.3842	+
Accumulated relaxation (AR)	0.2685	0.6044	+	9.3548	**0.002224****	–	0.5561	0.4558	+
Accumulated arousal (AA)	0.0686	0.7934	–	6.9296	**0.008478****	–	0.3922	0.5311	+
3-minute means of the tonic component (TC) from 10sec. resolution									
meanB/meanS (beginning/ stressor)	0.1374	0.7109	–	0.0433	0.8352	+	3.238	**0.072.**	+
meanM/meanS (middle/stressor)	0.1177	0.7316	–	0.1251	0.7236	–	2.5312	0.1116	+
meanE/meanS (end/stressor)	0.1356	0.7127	–	1.0672	0.3016	–	1.025	0.3113	+
meanE/meanB (end/beginning)	2.7812	**0.09538.**	–	1.3742	0.2411	–	0.3454	0.5567	+

The significance of each fixed factor was tested using an ANOVA between the full model with all fixed factors and the model in which the factor under test was omitted. Note that MR and AR have by definition a negative sign: the more negative, the higher the relaxation of the individuals. (Significance levels of t-tests: <0.001: ***; 0.001–0.01: **; 0.01–0.05: *; 0.05–0.1: “.”). *Cultural familiarity and gender are categorical variables; the effect of cultural familiarity is expressed with the category ‘NOTFAMILIAR’, the effect of gender is expressed with the category ‘MALE’.

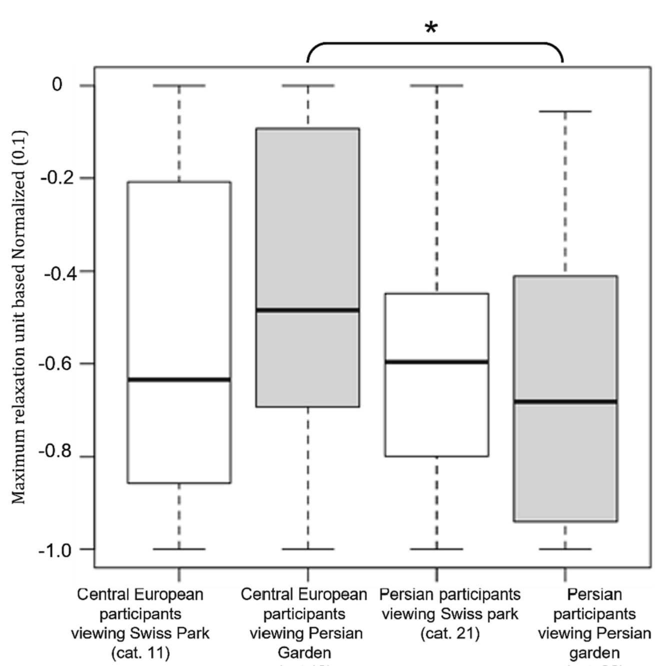

Fig. 5. Boxplot showing maximum relaxation (MR) of participants as a function of cultural background and park. MR was extracted from normalized TC profiles sampled and averaged in 30-*sec* intervals. MR has a negative sign, i.e., the more negative, the higher the relaxation. Distributions with (*) are significant at $p < 0.05$.

5.2. Theoretical-conceptual discussion

Our successful experimental linking of affective data with cognitive information on place attachment from the questionnaire confirms previous studies that establish this link with *reported* well-being (e.g., Scannell & Gifford, 2017). Our results are further supported by neurophysiological studies, in particular Chatterjee's (2014) cascade model (see section 2), which describes the processing of information such as meaning, memories and visual appreciation in different parts of the lobe, and its interaction with emotions in the limbic areas. Meaning, memories and visual appreciation are indeed considered key drivers of place attachment and place identity (Devine-Wright & Howes, 2010; Rishbeth & Powell, 2013). Our experimental results further support the widely described claim that affective reactions towards built and natural environments can be modified by cultural background or other cognitive aspects (Kaplan & Kaplan, 1989; Siegrist & Sütterlin, 2017; Zajonc, 1980; Chatterjee, 2014). This aligns well with cultural preference theories (see section 2, in particular Tveit et al. (2018)) emphasizing that landscape perception is a result of social and cultural norms, individual characteristics, memories and experiences.

Additionally, we can experimentally confirm studies (for a review, see Liu et al. (2021)) demonstrating that familiarity with the cultural background of places affects emotions towards those places. Indeed, we show that relaxation is highest in the park of a person's own culture where the park elements fit the value systems of a person or group (Devine-Wright & Howes (2010). From a migratory perspective, however, it is noteworthy that the bi-cultural migrants who had been living in Switzerland for over five years show increased relaxation when viewing the park of their host country. This indicates that a sense of place attachment had already started to form in such people, confirming previous studies (e.g. Lewicka, 2011) that have shown length of residence as one of the best predictors of place attachment. It seems that for this group, place of origin and destination exist with place attachments directed towards multiple places as hypothesized in the 'fixity FROM flow' sub-concept of Di Masso et al. (2019). In other words, we suspect that the the bi-cultural background of our migrant participants facilitates their linking to multiple places, more so than for European participants with a single cultural background.

It is not clear why European participants show less relaxation in the park of their own culture than Persian participants perceiving a Persian garden. It may be that underlying the Persians' strong reaction to the sight of a Persian garden is a nostalgic affinity (possibly homesickness) (Rishbeth & Powell, 2013), a desire or wish for a place romanticized by their situation as migrants with no real hope or expectation of visiting it again in the near future. While all these differences are in place, it is important to remember that none of the participants with a European cultural background had ever lived in a Persian environment for an extended period of time, while the bi-cultural migrants (Persians) had been physically immersed in European culture. This leads to the unanswered question of how much such a physical experience (or the lack of one) influences responses in the audio-visual laboratory experiment.

Concerning the observed gender response in our experiment, the literature is inconclusive. Shu and Ma (2020) found a gender difference in physiological restoration (measured with EDA) while exposed to urban park soundscapes, but Momin et al. (2020) reported no such effect. More research is needed to understand gender effects in immersive setups.

6. Conclusion

Our study, besides Zhang (2022), is one of the few *experimental* studies to link self-reported place attachment to park environments to physiologically detectable emotional well-being and stress reduction. First, higher place attachment and place identity to parks increases relaxation levels in visitors and thus improves the recreational qualities of the visited places. Second, it can be shown that familiarity with the cultural background of a park increases relaxation, most likely via place attachment. Third, place attachment has measurably started to form in bi-cultural migrants at their new location. Together with the findings from Bazrafshan et al. (2021) and Di Masso et al. (2019), we confirm the 'fixity FROM flow' sub-concept, which holds that place attachments are not exclusively limited to one place and irretrievably disrupted by migration, but can develop toward multiple places. As suggested in the place-referent continuity theory (Twigger-Ross & Uzzell, 1996), place of origin and place of relocation can become interconnected, offering different, yet compatible, experiences.

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Urban green administrators can benefit from our research in two ways. First, our study strengthens the argument (often) proposed by practitioners that place attachment to urban parks is key for stress reduction and thus recreational quality. Consequently, parks should be designed and operated in a way that multicultural communities can readily become familiar with the place and its underlying culture, e.g., by emphasizing legibility and coherence, improving accessibility, or using plants or architectural elements that have similar functions in a global context (for details, see Bazrafshan et al. (2021)). Second, park visitation should be considered a comprehensive cognitive-emotional experience, especially for migrating communities. Consequently it can be argued that emotion measurements should be routinely included in park monitorings as this would allow to capture affective processes of landscape perception that may not be consciously accessible (Scott et al., 2009; Diener et al., 2018).

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

All data preparation, modelling and analysis was conducted in RStudio 1.4.1717, MATLAB R2021b v9.11 (LicenseNo: 40519558) and Ledalab V3.4.9 and the processed data and scripts to replicate the results of this research have been made available alongside this publication (https://doi.org/10.16904/envidat.356).

Acknowledgements

This manuscript is part of a PhD thesis supported by the State Secretariat for Education, Research and Innovation SERI (ESKAS-NR: 2017.1113), the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL) and the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (grant agreement no. 757565). The authors would like to thank Mr Saeed Mehrafsar for administration support in the Persian garden, Ms Laura Endres for her wholehearted technical support in AVLAB, and Mr Matteo Riva and Mr Timos Papidas for their great help during the experiment. We are grateful for the insightful support of Dr Marcelo Galleguillos Torres and Dr Victor Schinazi during the post- experiment analysis.

Appendix 1. Final set of questions (statements) retained in the multiple correspondence analysis (MCA). To interpret the dimensions of the MCA, Kendall's correlation coefficient was calculated between each question and the dimensions.

Statement	Question number	Kendall correlation coefficient to dimensions 1 and 2 of the MCA		Subcategories of place attachment (Bazrafshan et al., 2021)
		Dimension 1	Dimension 2	
In this park, there are elements that help me to orient myself.	6	−0.103	−0.215	Practical use
This park is beautiful.	4	−0.533	−0.124	Visual appreciation
For me, this park symbolizes the beauty of nature.	5	−0.404	0.265	
The individual things or parts of this park fit together.	7	−0.413	−0.169	
In this park I experience nature and can connect with it.	3	−0.336	0.237	Linking to nature via tangible elements
To me, this park symbolizes the coexistence of people and nature.	8	−0.454	0.172	
I feel safe in this park.	12	−0.150	−0.367	Safety
Here, I could stay alone for a long time.	13	−0.253	−0.304	
In this park, my nationality doesn't matter, it doesn't bother anyone.	18	−0.013	−0.206	
In this park, I have a positive feeling.	9	−0.455	−0.269	Feelings and emotions
In this park, I can experience myself.	10	−0.494	0.148	
It would be a shame if I never knew about this park.	14	−0.557	0.007	Memory and meaning
This park means a lot to me.	15	−0.659	0.302	
I am used to this kind of park.	20	−0.218	0.334	
My childhood is reflected in this park.	19	−0.460	0.404	Individual identity building
This park is a part of me.	22	−0.630	0.376	
This park symbolizes for me a typical park in Switzerland/Iran.	21	−0.348	−0.056	Collective identity building
In this park, I feel connected to the region, its people, its nature and its history.	24	−0.499	0.059	

Responses were given on a five-point Likert scale (1 = strongly disagree; 2 = disagree; 3 = neither disagree nor agree; 4 = agree; 5 = strongly agree).

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