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RESEARCH ARTICLE

The impact of urban street green transformation on subjective well-being and evaluation of the location: A case study in Vienna, Austria

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ABSTRACT

Urban green landscapes, such as street- and ground-level greenery, are essential for urban populations, enabling frequent and spontaneous interactions with nature in cities. While many cities have increased their green infrastructure and landscapes, their impact on well-being and environmental evaluations needs to be studied more. In the present study, we conducted a field experiment that directly addressed this aspect. Specifically, on two urban streets in Vienna (Austria), we conducted the same structured field experiment during two different periods, during March and May/June in 2022, resulting in different levels of greenery in two urban streets. We aimed to study if and how varying quantities of greenery in urban street landscapes influence subjective well-being in terms of subjective feelings of stress and affective mood, as well as the restorative potential of the locations. Our results showed that, unlike the often-reported positive impact of urban green spaces, the varying amount of greenery on the streets did not positively affect the well-being or the restorative potential of the locations. The results highlight that simply implementing greenery might not be sufficient to induce positive effects. Instead, more intense and dense greenery would be necessary to achieve the desired outcomes.

Keywords: urban greening landscape; field study; biophilia designs; well-being; evaluations; green cities

1. Introduction

1.1. Limited urban green spaces in cities and the potential of urban green landscape

Urban green spaces (UGSs in the following texts) are defined as 'publicly owned and accessible open spaces within urban and peri-urban areas that are wholly or partly covered by considerable amounts of vegetation' (p.3) [1]. They can be 'any vegetation found in the urban environment, including parks, open spaces, residential gardens, or street trees' (p.113) [2]. Interactions with UGSs are vital in maintaining and

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promoting the psychological well-being, physical health, and cognitive functions of the residents [3–7]. For instance, living in natural and green environments decreases stress and increasing health [8–10]. Interacting with biophilic environments enhances cognitive performance [11]. The benefits of UGSs are not limited to human health and well-being but also extend to ecological quality and health in urban environments [12], such as reducing heat island effects [13].

Increasing UGSs is a pivotal societal task. However, in the recent past, we have seen the opposite; together with global warming and rapid urbanization, in many cities, the amount of UGSs has been significantly declining over the past decades [14–16]. Among other things, one of the reasons could be the practical difficulties in implementing them in urban areas. Especially in urban areas with high density, creating UGSs such as urban parks and forests can be quite a challenge as they are resource-intensive in terms of space, maintenance, and building in the first place [17]. Aside from the declining amounts of UGSs, the amount of contact with UGSs is getting less, as urban residents spend most of their time indoors [18].

Past studies have predominantly focused on the effects delivered by urban parks and forests [6]. However, with the background introduced above, there has been a growing interest in exploring the effects of various UGSs beyond parks and forests, such as urban green landscapes (UGLs in the following texts) [19]. UGLs include street-level trees or plants on sidewalks, urban gardens, and greenery on buildings. UGLs require fewer resources than UGSs and offer more frequent and spontaneous contact with nature for a broader proportion of urban residents. In line with this trend, many cities are implementing UGLs to support the health/well-being of their citizens and biodiversity [20].

1.2. Scientific evidence on urban green landscape on well-being

Nevertheless, scientific research on UGLs is relatively scarce. Papastergiou et al. [6], in their scoping review, reported that amongst 136 articles examining the effect of UGSs in urban environments on well-being, only 14 articles (hence about 10% of the articles) investigated the impact of UGLs, including street-level greenery or greenery on the building. Importantly, those studies mainly examined the relationship between UGLs and well-being from correlational evidence, lacking empirical evidence with controlled experiments. For example, We et al. [21] reported the relationship between street-level greenery around residential/work environments and well-being (i.e., life satisfaction). The life satisfaction scores and their residential/work environment information were retrieved from a large data pool, while the street greenness level was calculated from street views. Their results generally suggest a positive relationship between the number of UGLs and life satisfaction. At the same time, there are variations in results due to demographic factors, such as gender, educational background, and income. These methods are effective in exploring the possible impact of UGLs. However, it is important to conduct control experiments to establish the suggested relationship as an empirical fact, e.g., direct comparisons in well-being outcomes in the same environment with different amounts in UGLs. In sum, despite the increase of UGLs, their actual impact must be studied further.

Studying the effects of UGLs, varying the amounts of greenery can also be relevant to the practical implications as past research has reported that the quantity of greenery is an essential factor in delivering effects. In essence, there are suggestions for the minimum amount of greenery in public spaces to successfully deliver positive impacts both physically and mentally. World Health Organization (WHO), for example, recommend urban residents to have access to a minimum of 0.5 to 1ha of public green space within 300m of their home [22]. Recently, the 3-30-300 rule [23,24] has been introduced. This rule stipulates that each individual should be able to see at least three trees from their windows, have 30% of trees canopy in their neighbourhood, and reside within 300m of a high-quality green space. Nonetheless, the European

Environment Agency (EEA), highlights that there is a huge diversity in different green provision guidelines, depending on the locations (see https://www.eea.europa.eu/publications/who-benefits-from-nature-in). Hence, there is no single guideline, which can be applied in general.

Related scientific studies have also shown mixed results. For example, some studies have shown that denser greenery, operationalized by the amount of vegetation, grass, herbs, in the testing environments or in the visual stimuli, often delivers a more significant positive impact [22]. In contrast, other studies have shown that the impact of greenery quantity (or wildness of greenery) varies depending on the contexts, such as in urban parks, on urban streets, and on building rooftops [23,24]. Other studies targeting smaller spaces also suggest similar results. For example, Nordh et al. [25], in their experiment in a laboratory, found that the restorative potential of small parks was related to the quantity and density of the greenery. These findings are relevant for UGL planning, highlighting that not only the greenery implementation but also the extent of implemented greenery could deliver different outcomes. Hence, when planning UGLs, it is also essential to ask: How much green is necessary to deliver positive effects? The answer might lead to different strategies for spatial and material resource planning.

1.3. The present study

In the present study, we directly addressed the effects of UGLs, specifically in urban streets, varying the amounts of greenery. We specifically focused on the effects on subjective well-being (i.e., the feeling of stress and positive/negative affect) and environmental evaluations (i.e., the restorative potential of the locations). Subjective well-being was assessed in previous related studies to evaluate the effects of greenery on residents or users of the studied environments. We acknowledge well-being as a multifaceted concept and note that in the present study, we specifically focus on the state of well-being in the short term, *experienced well-being* [26]. Experienced well-being refers to our emotions or health states in a short time, e.g., how one's affect changes after interacting with specific locations or stimuli. We argue that focusing on short-term aspect of well-being has several advantages. First, everyday interactions with urban streets typically last for short periods. Hence, assessing the effects on experienced well-being has high ecological validity. Second, short term well-being benefits seem vital in leading to long-term well-being benefits. For example, Bratman et al. [27] reported that the frequency of contact with nature was associated with both short-term (i.e., stress, positive/negative affect) and long-term (i.e., life satisfaction, purpose of life) well-being parameters. Such a relationship might stem from frequent short-term well-being experiences accumulating and resulting in long-term well-being benefits. Hence, in the first place, it is crucial to assess whether interactions with urban streets with greenery can lead to short-term effects. Regarding the restoration potential of the locations, previous studies have shown that higher restorative potential is essential to induce a positive impact [28].

Hence, it was also interesting for the present study to assess whether varying the amounts of greenery on streets can change their restorative potential.

We conducted our field study on two different urban streets in two different periods, i.e., March 2022 and May/June 2022. The two periods were chosen for three main reasons. First, they were two periods where the weather was not too extreme for Vienna (see the detailed climate data in Austria from here: https://www.worlddata.info/europe/austria/climate-vienna.php); hence, the participants did not have to struggle from high cold or heat during the testing times. Second, these two periods, by belonging to two different seasons, exhibited two different amounts of greenery as the trees had more or less foliage. Third, some constructions happened in one of the two street tested, which resulted in the implementation of new green parterres for the second period of testing. Overall, one street had more green appearances in May/June than in March, due to the seasonal effects. The other street had more green in May/June than in March, after the implementation of the greenery (for the actual amount of greenery increase in two streets, see Table 1). In sum, this study not only adds new insights into the impact of urban green landscapes but also provides information on whether the extent of greenery matters for the benefits of natural elements in cities to manifest.

The present study primarily investigated the following research questions: (1) Do greener urban landscapes (i.e., amount of greenery) positively impact our well-being? (2) Do greener urban landscapes positively impact the restorative potential of the locations?

For each research question, two distinct hypotheses were tested: (1) The greener the streets, the more significant the improvement in well-being scores observed among participants (2) The greener the streets, the higher the restorative potential of the locations reported.

As a secondary objective, the present study also investigated—in an explorative way—the relationship between well-being improvements, the restorative potential of the locations, and personal traits. Some personal traits, such as the general stress level or nature-relatedness, might change the size of observable effects. For example, a participant who is more stressed in general or is less related to greenery might evaluate greener environments as more restorative. Adding this aspect assessed the inter-individual generalizability of the effects delivered by greenery.

2. Material and Methods

2.1. Participants

This study includes 24 participants (15 female, M_{age} = 27.10, *SD* = 8.70). They were recruited by word of mouth and snowball effect and were over 18 years old with no general health issues. They received 30€ as participation compensation. The study was approved by the local committee of the University of Vienna (Austria) following the Declaration of Helsinki.

We asked participants to visit the test sites two times (see detailed information below). Hence, those who did not come on the second visit (n = 4) were excluded from the analysis below. The final sample includes 20 participants (12 female, M_{age} = 28.10, *SD* = 9.20).

As our recruitment process was uncertain, e.g., it was not clear how many participants signed up for the study period over three months, we could not tell beforehand how many participants would come back for the second visit, we did not perform any priori power analysis. Instead, we performed the sensitivity test, assessing the detectable effect size based on the actual number of the participants. Following our analysis structure (see 2.6. Data Analyses, for more detailed descriptions), the sensitivity test, using G*Power (Faul et al., 2007), suggested that our sample size can detect moderate to strong effect size (Cohen's f = 0.27) assuming power of 80% and significance level at $\alpha = .05$.

2.2. Study design

Three within-subject factors were included: *Testing site* (*Street 1, Street 2*), *Street greenness* (*grey, green*), and *Measurement time* (*pre, post*). Detail information on *Testing site* and *Street greenness* can be found in the following section *2.3. Testing sites and Street Greenness.*

All participants walked for five minutes in both *Testing site* (*Street 1, Street 2*). Each participant joined the first and second data collection, conducted in March and in May/June 2022, respectively. The *Street greenness* of the *Testing site* (*Street 1, Street 2*) changed between the two visits. The first visit in March occurred when the *Street greenness* was *grey*, before the spring growth phase or the landscape transformation, and the second visit occurred when the *Street greenness* was *green.* Within each visit, the subjective feeling of stress as well as the affective mood of the participants were measured before (*pre*) and after (*post*) the walk. As all participants experienced both *Testing sites* (*Street 1, Street 2*) with both levels of *Greenness* of *Testing sites* (*grey, green*), measuring the subjective well-being before (*pre*) and after (*post*) each walk, all three factors were within-subject factors.

Although *Testing sites* was one of the factors in the present study, they had different *Street greenness* treatment. Specifically, Street 1 had undergone a change in greenery due to the seasons (i.e., the trees and gardens that were present during the first period of data collection grew green leaves and green grass), and hence, there was no structural changes in terms of the nature elements on the street. On the other hand, Street 2 had undergone a more significant change in the amount of greenery after the construction of the street, and hence, the structure of the street itself changed. As the way of the changes in greenery appearance was different across the two streets (see section 2.3. Testing sites and Street Greenness, for detailed information), the statistical analysis reported below was conducted separately for each street. A detail description of the statistical analysis can be found in *3.6. Data analysis*.

2.3. Testing sites and street greenness

The data collection took place in two streets in Aspern Seestadt in Vienna (Austria): Trude-Fleischmann-Gasse (Street 1 from hereon) and Simone-de-Beauvoir-Platz (Street 2 from hereon, see **Figure 1**). Aspern Seestadt is located about 10 km northeast of the city centre of Vienna, which is a flagship city for the social challenge project in European Commission and is a showcase project of Smart City Vienna wherein Seestadt acts as an urban laboratory (see the district information here, https://www.aspern-seestadt.at/en). According to Gorgol (2024) [29], the urban development of Seestadt aims and ensures three following points "A high share of publicly accessible spaces (almost half of the district's area is to be parks, squares, and streets) with an emphasis on ensuring a diverse array of public spaces; A diversified functional structure of development (the aim is to achieve a balance between the share of residential development and the number of jobs provided by services, educational functions, etc.); Creation of attractive public green recreational areas" (p.8). Further, their urban developments employ the environmental impact assessment (EIA) to investigate the potential impacts of the projects before implementing changes. With above-mentioned points, it was ideal to conduct a field experiment in Seestadt for the following reasons. First, as the area is distanced from the city centre area, there was less environmental factors, such as dense traffics, intense noises. Second, Aspern Seestadt implements urban changed within a systematic framework, e.g., EIA. Hence, their urban changes present standardized and comparable ways.

Both streets and greenery appearance during the second data collection (May/June 2022) are shown in **Figure 2** and the appearances of the same streets between the two testing seasons from the same angle are presented in **Figure 3**. The chosen section of streets was the same length, 60 meters. The two streets were located close to each other, with an intersection point in between. Those streets were chosen because they are in a relatively newly built area of the city, which is still about to be optimized. Both streets are pedestrian zones, with little to no touristic traffic, and similar in regard to architecture.

A description of the street characteristics as well as precisions about the type and amount of greenery and their changes are presented in Table 1. For Street 1, 147 m^2 of the testing area (24.5% of the whole testing area, 600 m^2) showed the changes in terms of the green appearances. Again, we note that, the present study aims to test the appearance of nature and green elements in an urban street. Hence, even though the bare trees were present in the same amount of the testing areas during the first data collection, we counted the appearance of greenery and nature element as changes in the testing environment. For Street 2, the areas with green and nature elements increased from 30 m^2 to 286 m^2 (29.80% of the whole testing area, 960 m^2).

We note that greenery presented in the precise testing areas, where the participants walked, was slightly less than 30% out of the whole testing areas in both streets, which is the suggested minimum amount of inducing effects[23,24]. Nonetheless, other greeneries were visually present outside of the actual testing areas (see "Background green" marked in blue in **Figure 2**). Hence, we acknowledge that two testing streets showed enough changes in terms of greenery appearances between the two testing periods, which can theoretically induce positive impact on well-being. We also note that both streets had undisturbed traffic environments, e.g., no traffic was allowed for the two streets, and each street had one lane. Hence, participants had high traffic security during the experiment and were not disturbed by external pressure sources.

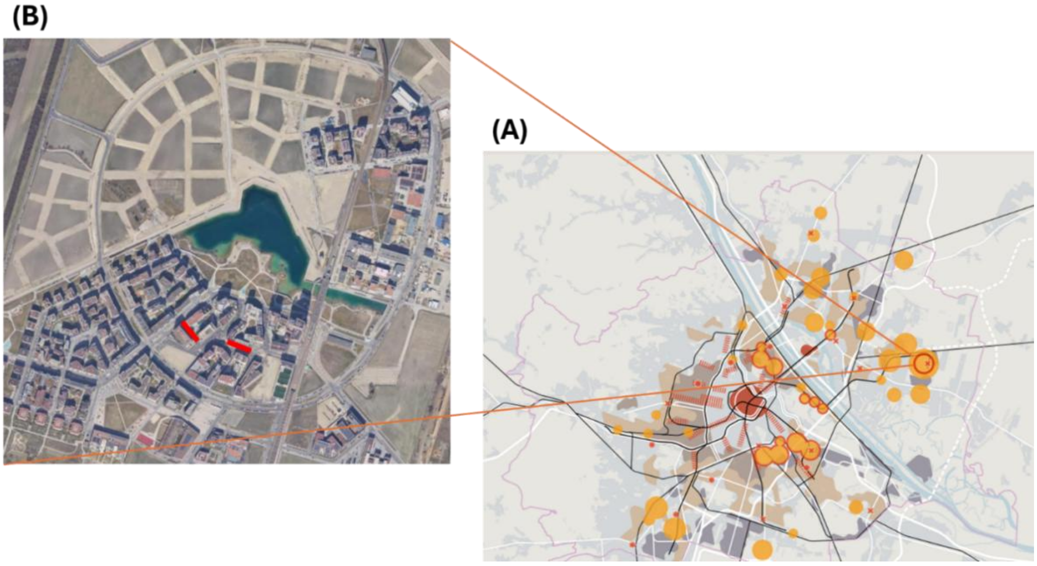

Figure 1. (A) City map of Vienna, showing urban spatial developmental plan. Source: STEP 2025, Stadtentwicklungsplan, Magistrat vom Wiener Gemeinderat, Stadt Wien, 2014, p. 67 (public domain). Orange circles in this figure highlights the areas with development potential. Red circle within the orange circles represents propriety zone for future additions, including Aspern Seestadt. Black square in the figure was added by the authors to indicate the location of Aspern Seestadt. (B) Google map satellite for the locations of the two testing streets, highlighter in red bars.

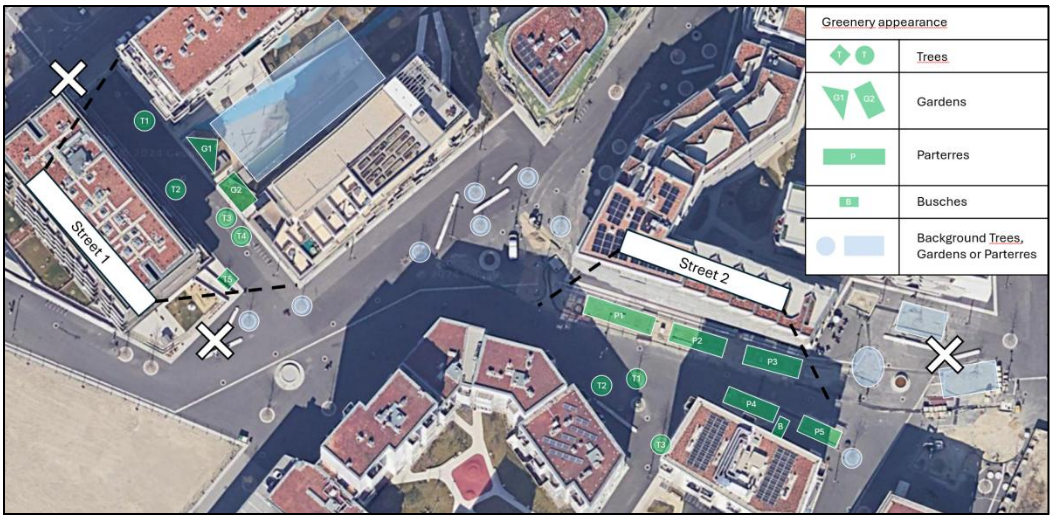

Figure 2. Google map satellite image showing the two streets tested in the present study, showing the greenery appearances during the second data collection. The white crosses represent the areas where the participants answered the questionnaires.

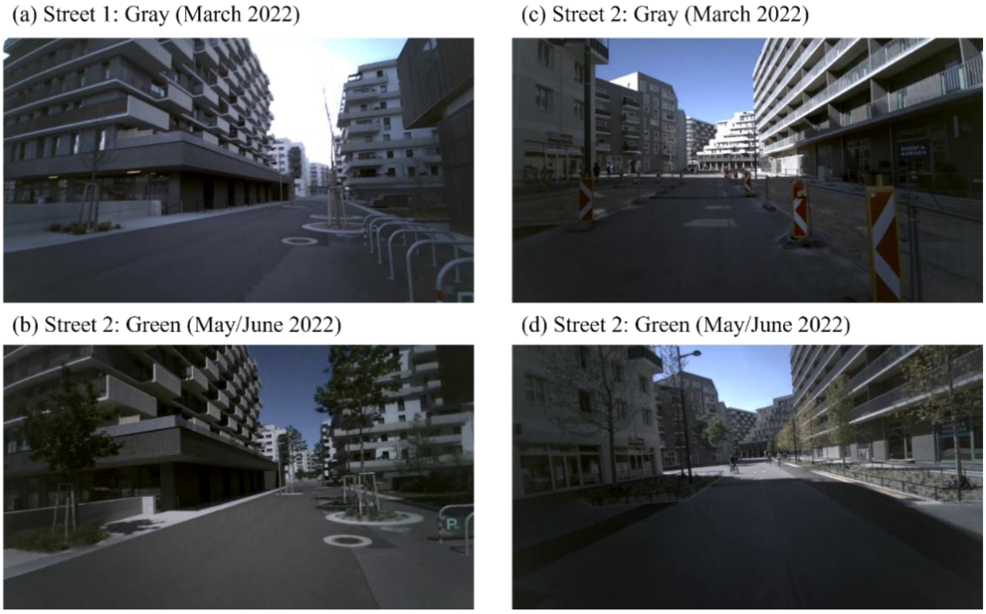

Figure 3. Street 1 during the first period (a) and the second period (b) of data collection, and Street 2 during the first period (c) and the second period (d) of data collection.

Table 1. Summary of the Testing Site and Street Greenness characteristics.

Metrics	**Street 1: Trude-Fleischmann-Gasse**		**Street 2 : Simone-de-Beauvoir-Platz**	
	March 2022	May/June 2022	March 2022	May/June 2022
Daily usage scenario	Pedestrian areas with limited access for deliveries		Pedestrian areas with limited access for deliveries	
Street width	10 m		16 m	
Street length	60 m		60 m	
Plant type and structure	Five street-level trees (no leaves)	Five street-level trees (with green leaves)	Bushes next to two restaurants and three trees	Bushes next to two restaurants and three trees
	Two small urban gardens in the middle of the street (ground structure with soil visible while no greenery)	Two small urban gardens in the middle of the street (grasses on the ground)		Five parterres with grasses and 10 trees
Green space area (in ground m²)	147	147	30	286

2.4. Measurements

We used standard well-being questionnaires, ensuring consistency and comparability of the results with previous studies.

For the subjective well-being measurements, we used three variables: Perceived level of stress, PANAS (German version[29], and POMS-SF[30]. The Perceived level of stress measures subjective feeling of stress with a slider-type scale, ranging from 0 (not at all) to 100 (completely). The PANAS measures affective mood states on two dimensions - positive and negative - with 10 items each, with a five-point Likert-type scale ranging from 1 (not at all) to 5 (extremely). POMS-SF also measures affective mood, divided into five sub-categories, i.e., *Tension*, *Depression*, *Anger*, *Fatigue* and *Vigour*, and the total mood disturbance score combining scores from all sub-categories. Although both PANAS and POMS measure affective mood, POMS provide detailed information, e.g., what aspect of negative mood was influenced. By implementing both questionnaires, they also serve as the validation check and provide complementary information as mentioned above.

For appraisals of the testing sites, Perceived Restorativeness Scale (PRS[31]) was used.

PRS is a commonly used scale to evaluate the level of restorativeness of the location using 26 items on a seven-point Likert-type scale ranging from 1 (not at all) to 7 (completely). The items are divided into sub-groups, i.e., *Being away*, *Coherence*, *Fascination*, and *Compatibility* based on the Attention Restoration Theory[28].

For personal trait measurements, we employed the Perceived Stress Scale (PSS[32]) and Nature Relatedness Scale (NR-6[33]). The personal traits were measured to see if general level of stress or general attitude towards the nature significantly changed between the two visits, as they can influence the results, e.g., people who are more stressed in general, are more likely to show bigger improvement in well-being scores, regardless of the presence of greenery. Furthermore, both measures were used in our exploratory analysis, investigating the relationship between those personal traits and our main variables (i.e., well-being measures, PRS).

2.5. Procedure

The entire testing took around 1.5 hours per person. The testing was conducted only under good weather conditions from 9:30 to 17:00. We made sure that only one participant was present on each street at a time, so the participants did not encounter each other during the testing. Weather conditions remained relatively stable during each testing period. The first round of testing in March was characterized by early spring weather with temperatures ranging from -3°C to 12°C and wind speeds up to 26 km/h. During the second data collection, it was warmer spring weather with temperatures ranging from 12°C to 29°C and wind speeds mainly below 12 km/h.

Figure 4 shows seven steps of the data collection for one visit and the recorded measures in each step. Upon arrival, the participants were informed about the general procedure of the present study and signed the consent form. Before going to the testing locations, they were equipped with mobile physiological sensor devices (E4 wristband and eye-trackers)[1]. A shoulder bag to carry their mobile phone and personal belongings during the experiment was provided. As the experiment was carried out right after the COVID-19 lockdown, participants used their own mobile phones to answer all questionnaires for hygiene reasons.

The order of first contact with the street was counterbalanced across participants (i.e., some participants started the experiment with Street 1, others with Street 2). A short duration of the interaction, i.e., five minutes, was chosen in the present study, as it represents a natural scenario of walking down one street rather than spending a longer time in one place. Before going for a walk, we told the participants that the time would be measured by the researcher, so they did not have to worry about it. They were also asked not to use their mobile phones, not to eat or drink anything, not to smoke, and not to go inside the buildings during the walk. Other than those restrictions, they were instructed to walk in the street as they normally would.

We note that the participants were brought to the starting point of the walk (see **Figure 2**) only when 10 minutes had passed since the start of the questionnaire. This procedure was applied to set the time as similar

[1] Note that physiological data was collected during the testing as a device manipulation practice for other scientific projects. For this reason, the quality of the physiology data was not checked during the data collection, and this aspect is beyond the scope of the present study. Hence physiology data is not reported in the present study.

as possible across participants to control for any possible carry-over effects from the previous walk, e.g., some participants might answer the questionnaires quicker than the others, which might lead to a better transmission of memories from the previous walk to the next one etc.

During both walks, the researcher(s) went to a street next to the testing street. From the side paths of those streets, the experimenters observed whether the participants followed our instructions, e.g., if they stayed in the testing area, not going into shops etc. Nonetheless, the experimenters were not visible from the participants. Hence, the participants did not feel like they were being watched.

After completing the last questionnaires, the participants came back to the preparation room, and all the devices were removed.

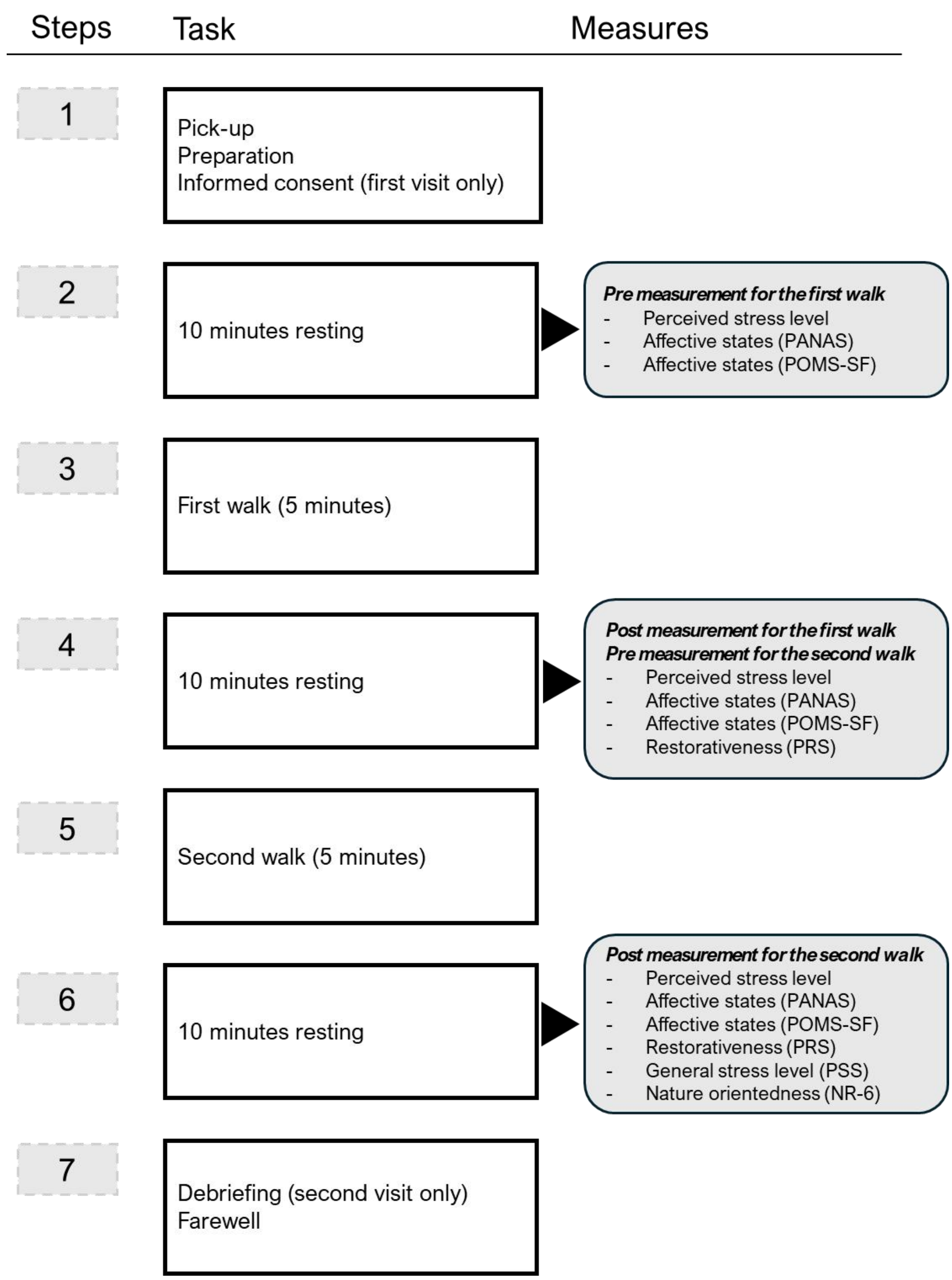

Figure 4. Seven Main steps of the procedure for each participant for both visits.

2.6. Data analyses

Cleaning/merging data and statistical analyses were performed using RStudio [34]. Data and the analysis code for the present study is available from the following link: https://osf.io/gmqb8/?view_only=cc921c903201452aa8f4d88338bab0a6. To answer our two main research questions (1. Do greener urban landscapes (i.e., amount of natural components) positively impact our well-being? 2. Do greener urban landscapes (i.e., amount of natural components) positively impact the restorative potential of the locations?), the following analytical strategies were employed:

To test the differences in well-being scores (i.e., Perceived stress level, PANAS, and POMS-SF) before and after the walk, we ran a series of Linear Mixed Models (LMMs), using each well-being measure as the dependent variables. The statistical modelling reported below was performed using *lmer*() function of the "lme4" package (Version 1.1-13 [35]) with the "lmerTest" package (Version 3.0-1[36]), which applies Satterthwaite approximation for the estimations of p values. In the LMMs, the model structure was fixed across all measures. Specifically, each well-being score was set as dependent variables. As fixed effects, we set a treatment-coded contrast comparing the Measurement Time (pre vs. post, setting pre as the baseline), a treatment-coded contrast comparing the Street greenness (grey vs. green, setting grey as the baseline), and the interaction between the two variables. As random effects, we set the random intercept for individuals to consider for the inter-individual differences in the well-being scores. The model was performed for each street separately. For the interpretation of the results, on top of indexes commonly used in null-model statistical tests, such as p-value or confidence intervals, we also used the Bayes Factors (BFs). The use of BFs was motivated by two reasons. First, BFs provide relative evidence for the null or alternative hypothesis as opposed to the p-value that only implies the rejection of the null hypothesis and acceptance of the alternative hypothesis based on a cutoff value. Second, Bayesian methods have advantages for small sample sizes [37,38]. When the sample size is small, it is often hard to attain statistically significant or meaningful results [39]. In a cumulative series of studies where coefficients fall just below significance, if all results show a trend in the same direction, Bayesian methods would produce a (slowly) increasing confidence regarding the coefficients—more so than frequentist methods. With the two advantages above, we decided to include BFs. We followed the BF classification provided by [40] for our interpretation, where numbers between 0.33 and 3 provide inconclusive evidence, numbers starting from 3 provide evidence for the alternative hypothesis, and the numbers below 0.33 provide evidence for the null hypothesis.

For the second research question, to test the differences in PRS scores for each street between the first and second visits, we ran a series of LMMs, using PRS scores for each street in each visit as the dependent variables. Here, to assess how the greenness in one street can change the restorativeness of the street, we set PRS scores as dependent variables. As a fixed effect, we set a treatment-coded contrast comparing the Street greenness (grey in March vs. green in May/June, setting grey as the baseline). Like the analyses on the well-being scores, we set a random intercept as the random effect in the model. BF was also used for the interpretation of the results.

As an explorative analysis, we investigated the relationship between the appraisals/well-being outcomes and personal traits. For this, we computed a correlation map using all variables. The focal interest in this analysis is, for example, to see if those who evaluated the location as more restorative showed higher improvements in their feelings of stress, positive mood, negative mood, and their evaluations of the location. However, we note that the aim to report this result is to show the correlations between the well-being outcomes, which can be used in the power analysis for the future studies, and to inspire further hypotheses for the future studies by seeing the related variables. Hence, we did not have any specific hypotheses to be tested, hence reporting the correlation map. To compute the correlation scores, well-being scores before and after the walk were integrated into the well-being outcome measure, which was defined as follows. For negative well-being measures, i.e., stress level and negative mood, well-being outcomes were computed by subtracting the scores before the walk from the scores after the walk. As such, when the negative well-being scores decreased after the walk, the value is greater than 0, e.g., 20 (before the walk) – 10 (after the walk) = 10. In contrast, for the positive well-being scores, i.e., positive mood score in PANAS and Vigor scores in POMS, well-being outcomes were computed by subtracting the scores after the walk from the scores before the walk. As such, when the positive well-being scores increased after the walk, the value is also greater than 0, e.g., 30 (after the walk) – 20 (before the walk) = 10. Consequently, for both negative and positive well-being parameters, the well-being outcomes that are greater than 0 can always be interpreted as an improvement in specific well-being scores. For the computations, we used *rcorr()* function of the Hmisc package (version 2.0-4)[45]. We note that this function computes the correlation coefficients using Person's *r* for all possible pairs of the comparisons.

3. Results

Prior to the main analysis, we computed the average scores for the general stress level over the past month (PSS) and nature relatedness (NR-6) using all scores from both first and second visit. Individual scores on the PSS and NR-6 can range from 0 to 40 and 1 to 5 respectively. The average scores on the PSS and NR-6 were 21.58 (*SD* = 6.84, 95% CI [19.40, 23.80]) and 3.28 (*SD* = 1.40, 95% CI [2.83, 3.72]). Hence, not unexpected after covid, our participants could be considered to have a moderate level of general stress over the past month as well as moderate level of nature relatedness. The average PSS scores are 22.45 (*SD* = 6.42, 95% CI [19.40, 25.50]) and 20.70 (*SD* = 7.12, 95% CI [17.40, 24.00]) for the first and second visit. The average scores for NR-6 are 3.30 (*SD* = 1.42, 95% CI [2.64, 3.96]) and 3.25 (*SD* = 1.41, 95% CI [2.59, 3.91]) for the first and second visit. Seeing the range of the 95% confidence intervals, there were no significant differences in PSS and NR-6 scores between first and second visit.

3.1. Pre and post walk comparisons for momentary well-being questionnaire data

Table 2 and 3 show the descriptive statistics for all measures for two streets (**Table 2** for Street 1, **Table 3** for Street 2) on different of Greenness (grey, green) separately for before and after the walk.

Table 2. Mean values for Perceived stress level, PANAS, and POMS-SF scores across pre and post measurement time for Street 1.

Scales	Grey		Green	
	pre	post	pre	post
Perceived stress level				
	20.40 (18.56)	14.83 (14.29)	20.40 (18.56)	15.10 (15.54)
PANAS:negative mood				
	12.46 (2.11)	12.38 (2.32)	12.05 (1.73)	11.15 (1.31)
PANAS: positive mood				
	30.88 (8.84)	28.67 (9.42)	29.55 (8.64)	28.50 (8.86)
POMS-SF; total disturbance				
	-1.75 (11.63)	-2.67 (11.86)	-2.39 (10.12)	-4.79 (9.80)
POMS-SF; tension				
	2.67 (2.32)	2.17 (2.06)	2.15 (1.93)	1.80 (1.79)
POMS-SF; depression				
	1.08 (1.35)	1.25 (1.57)	1.79 (2.02)	0.85 (1.23)

Scales	Grey		Green	
	pre	**post**	**pre**	**post**
POMS-SF; anger				
	1.00 (1.33)	1.00 (1.33)	0.80 (1.36)	0.80 (1.36)
POMS-SF; fatigue				
	3.54 (4.32)	2.29 (2.39)	3.10 (3.82)	2.79 (2.57)
POMS-SF; vigor				
	13.00 (5.96)	11.67 (6.88)	13.20 (5.25)	12.40 (5.92)

Note: *The values in brackets represent the Standard Deviations (SDs)*

Table 3. Mean values for Perceived stress level, PANAS, and POMS-SF scores across pre and post measurement time for Street 2.

Scales	Grey		Green	
	pre	post	pre	post
Perceived stress level				
	20.29 (21.50)	15.21 (18.33)	19.00 (19.39)	14.35 (15.04)
PANAS: negative mood				
	13.38 (3.31)	11.75 (1.75)	12.05 (1.76)	11.45 (1.32)
PANAS: positive mood				
	30.29 (9.25)	28.75 (9.95)	29.60 (9.82)	28.40 (9.51)
POMS-SF; total disturbance				
	2.50 (15.20)	-2.46 (12.37)	-1.60 (12.99)	-4.58 (9.70)
POMS-SF; tension				
	3.46 (3.56)	2.00 (2.15)	2.75 (2.49)	1.95 (1.68)
POMS-SF; depression				
	1.79 (2.65)	1.00 (1.44)	1.90 (2.75)	1.20 (1.58)
POMS-SF; anger				
	1.52 (2.56)	1.17 (1.86)	0.95 (1.19)	0.95 (1.39)
POMS-SF; fatigue				
	3.04 (3.30)	2.62 (3.36)	3.20 (4.36)	2.55 (3.09)
POMS-SF; vigor				
	11.65 (6.78)	11.67 (6.74)	12.45 (6.45)	12.25 (5.91)

Note: *The values in brackets represent the Standard Deviations (SDs)*

3.1.1. Perceived stress level

Figure 5 shows the boxplots and the distribution of perceived stress level for Measurement time (pre vs. post), Street greenness (grey vs. green), separately for the two streets (Street 1 and 2). The fixed effects and results of the LMM using perceived stress level is shown in **Table 4**. The results showed no significant main effect of Measurement time, of the Greenness, nor the interaction between the two variables in both streets. Seeing both models for each street showed the BFs smaller than 1, 0.33 and 0.32 respectively for Street 1 and 2, they also supported the null-hypothesis; there were no differences in well-being scores between Measurement time and Street greenness.

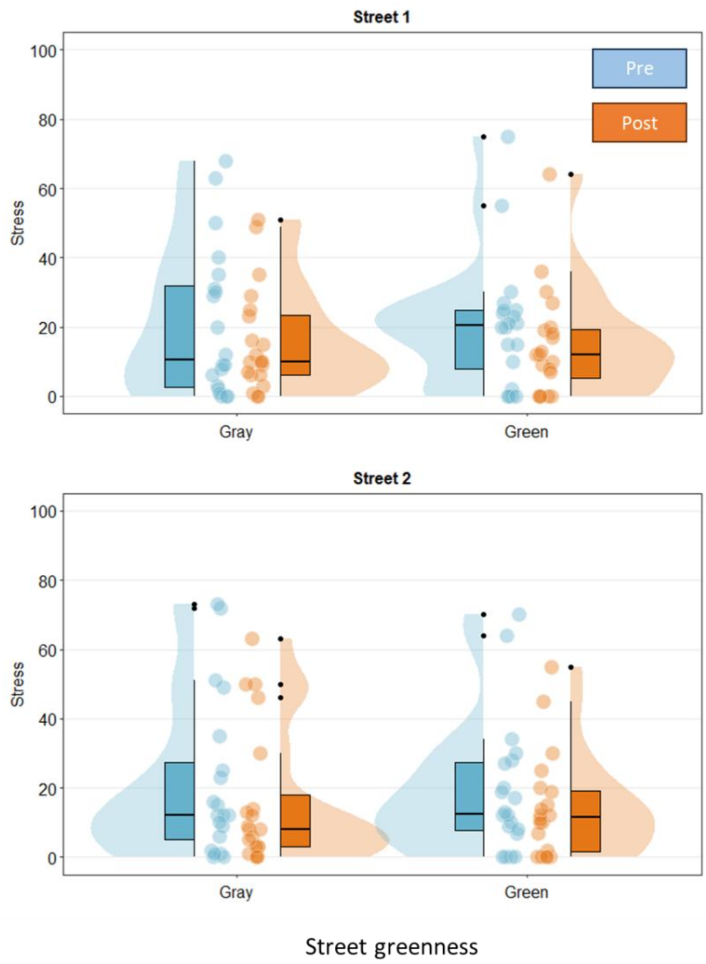

Figure 5. Raincloud plots for Perceived stress level per Measurement time (pre vs. post) and Street type (Grey vs. Green), presented separately for the two test sites (Street 1 and 2). Each dot represents the score from each participant, presented together with box plots. The central lines represent the median values, while the lower lines represent the first quartile of the data, and the higher lines represent the third quartile. Black dots represent the outliers. We note that this interpretation of the figure applies to the following Raincloud plots.

Table 4. Fixed effects and coefficients in the LMMs predicting Perceived stress level for the two testing sites (Street 1 and 2).

Fixed Factors	Estimate	95% CI		t value	Pr(>|t|)	BF
		Lower	Upper			
Street 1						0.33 ±4.11%
(Intercept)	20.80	12.89	28.71	5.21	**<.001**	
Time - post	-4.95	-9.91	0.007	-1.94	0.057	
Greenness – Green	-0.40	-5.36	4.56	-0.16	0.88	
Time * Greenness	-0.35	-7.36	6.66	-0.10	0.92	
Street 2						0.32 ±11.63%
(Intercept)	21.20	12.66	29.74	4.86	**<.001**	
Time - post	-5.00	-13.29	3.29	-1.17	0.25	
Greenness - Green	-2.20	-10.49	6.09	-0.52	0.61	
Time * Greenness	0.35	-11.37	12.07	0.06	0.95	

Note: *The significance level was adjusted to 0.025 (0.05/2) with Bonferroni method.*

3.1.2. PANAS

Figure 6 shows the boxplots and the distribution of Negative mood (A) and Positive mood (B) from PANAS for Measurement time (pre vs. post), Street greenness (grey in March vs. green in May/June), separately for the two streets (Street 1 and 2). The fixed effects and results of the LMMs using both Negative and Positive mood are shown in **Table 5**. The results showed no significant main effect of Measurement time, of the Greenness, nor the interaction between the two variables in both streets in both Negative and Positive mood. Seeing all BFs are smaller than 1 (all BFs < 0.79), all analysis supported the null-hypothesis.

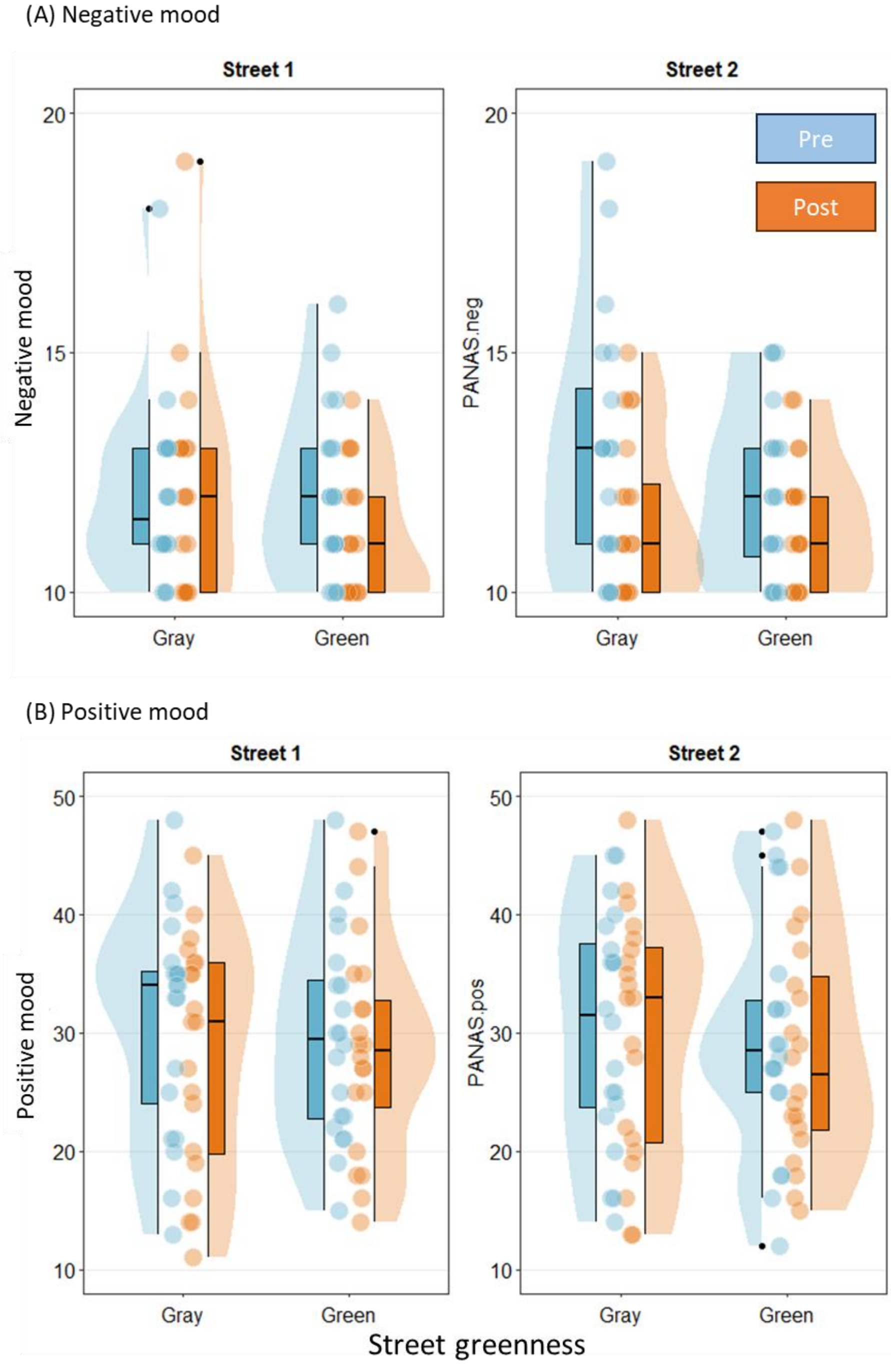

Figure 6. Raincloud plots for (A) Negative mood and (B) Positive mood per Measurement time (pre vs. post) and Street type (Grey vs. Green), presented separately for the two test sites (Street 1 and 2)

Table 5. Fixed effects and coefficients in the LMMs predicting negative (upper) and positive (lower) mood separately for the two testing sites (Street 1 and 2).

Fixed Factors	Estimate	95% CI		t value	Pr(>|t|)	BF
		Lower	Upper			
Negative mood						
Street 1						0.79 ±3.37%
(Intercept)	12.00	11.21	12.79	29.56	**<.001**	
Time - post	0.05	-0.83	0.93	0.11	0.91	
Greenness – Green	0.05	-0.83	0.93	0,11	0.91	
Time * Greenness	-0.95	-2.19	0.29	-1.49	0.14	
Street 2						0.48 ±4.22%
(Intercept)	12.90	12.08	13.72	30.35	**<.001**	
Time - post	-1.35	-2.36	-0.34	-2.61	0.020	
Greenness - Green	-0.85	-1.86	0.16	-1.64	0.11	
Time * Greenness	0.75	-0.67	2.17	1.02	0.31	
Positive mood						
Street 1						0.50 ±4.44%
(Intercept)	30.15	27.08	35	15.19	**<.001**	
Time - post	-2.85	-5.10	-0.60	-2.46	0.017	
Greenness – Green	-1.60	-3.85	0.65	-1.38	0.17	
Time * Greenness	-1.80	-1.38	4.98	1.10	0.28	
Street 2						0.32 ±3.67%
(Intercept)	30.45	26.07	34.83	13.80	**<.001**	
Time - post	-0.60	-3.10	1.90	-0.47	0.64	
Greenness - Green	-0.85	-3.35	1.65	-0.66	0.51	
Time * Greenness	-0.60	-4.14	2.40	-0.33	0.74	

Note: *The significance level was adjusted to 0.012 (0.05/4) with Bonferroni method.*

3.1.2. POMS-SF

Figure 7 shows the boxplots and the distribution of POMS scores with all sub-groups for Measurement time (pre vs. post), Street greenness (grey in March vs. green in May/June), separately for the two streets (Street 1 and 2). The fixed effects and results of the LMM using POMS scores are shown in **Table 6**. Again, the results, except the main effect of greenness in *Depression* score in the control site, showed no significant main effect of Measurement time, of the Greenness, nor the interaction between the two variables in both streets in all scores. Seeing all BFs are smaller than 1 (all BFs < 0.43), all analyses support the null-hypothesis. One exception was found in *Depression* score in control site. Here, there was a significant main effect of Greenness (β = 1.03), meaning that *Depression* score was higher in May/June compared to that in March only in Street 1 (in general, not pre-post). Hence, even though there are some increments in greenery from March to May/June, the Depression score got lower with higher greenery in Street 1.

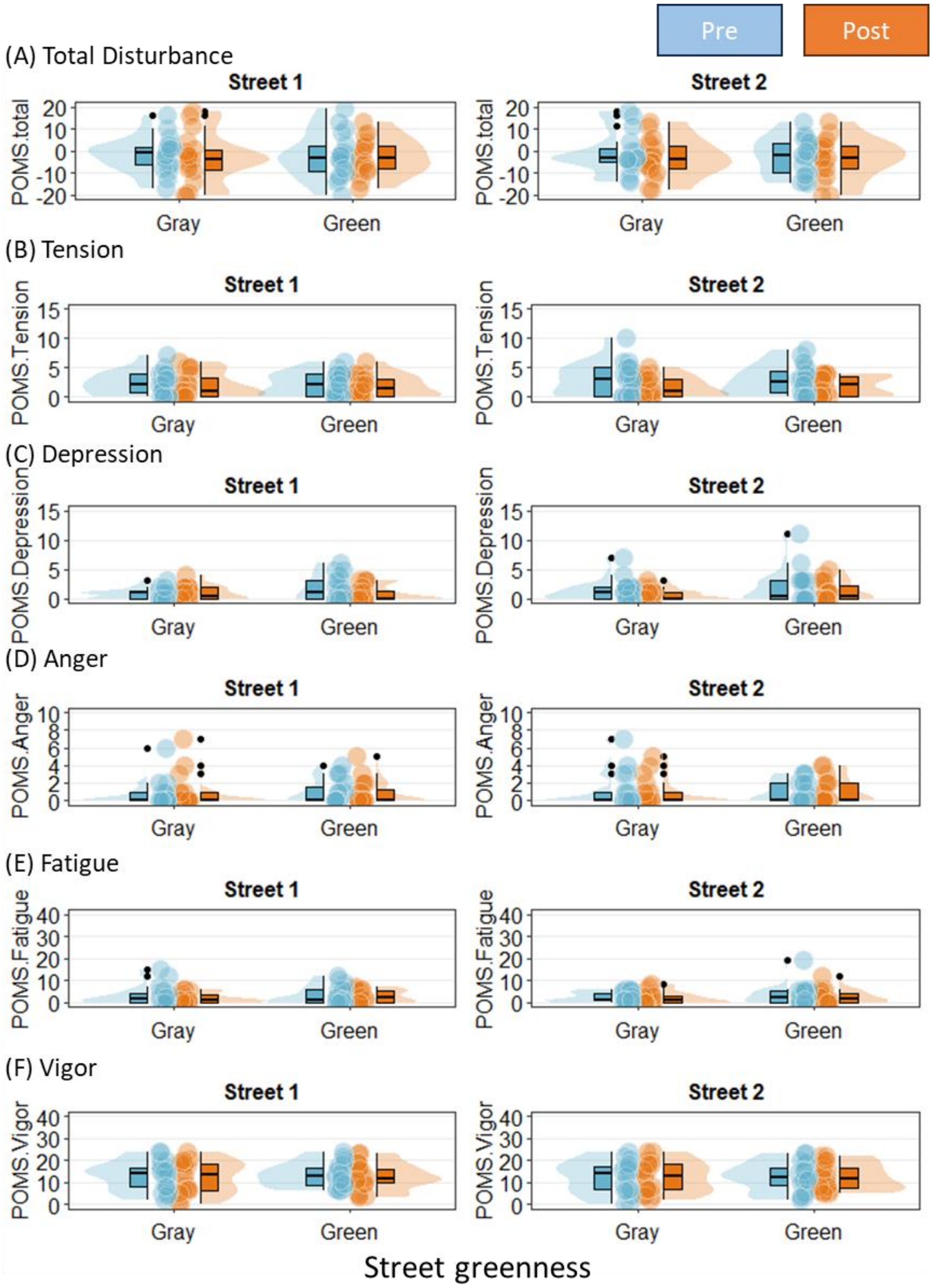

Figure 7. Raincloud plots for (A) Total Disturbance (B) Tension, (C) Depression, (D) Anger, (E) Fatigue, (F) Vigor scores from POMS-SF per Measurement time (pre vs. post) and Greenness (Grey vs. Green), presented separately for the two test sites (Street 1 and 2)

Table 6. Fixed effects and coefficients in the LMMs predicting POMS scores separately for the two testing sites (Street 1 and 2)

Fixed Factors	Estimate	95% CI		t value	Pr(>|t|)	BF
		Lower	Upper			
Total disturbance score						
Street 1						0.33 ±5.59%
(Intercept)	-3.70	-8.29	0.89	-1.59	0.12	
Time - post	-0.85	-4.73	3.03	-0.43	0.67	
Greenness – Green	0.56	-3.44	4.59	0.27	0.79	
Time * Greenness	-0.68	-6.32	4.94	-0.23	0.82	
Street 2						0.34 ±3.15%
(Intercept)	-1.55	-6.65	3.51	-0.59	0.56	
Time - post	-3.75	-8.59	1.06	-1.51	0.14	
Greenness - Green	-0.05	-4.89	4.76	-0.02	0.98	
Time * Greenness	1.17	-5.58	7.93	0.33	0.74	
Tension						
Street 2						0.32 ±4.13%
(Intercept)	2.30	1.45	3.14	5.31	**<.001**	
Time - post	-0.40	-1.26	0.46	-0.90	0.37	
Greenness – Green	-0.09	-0.98	0.80	-0.19	0.85	
Time * Greenness	0.03	-1.22	1.27	0.04	0.97	
Street 2						0.36 ±10.85%
(Intercept)	2.97	1.97	3.96	5.78	**<.001**	
Time - post	-1.37	-2.44	-0.29	-2.47	0.02	
Greenness - Green	-0.22	-1.29	0.86	-0.39	0.70	
Time * Greenness	0.54	-0.97	2.05	0.49	0.49	
Depression						
Street 1						1.97 ±2.66%
(Intercept)	0.80	0.21	1.39	2.65	**0.010**	
Time - post	0.10	-0.54	0.74	0.31	0.76	
Greenness – Green	1.03	0.38	1.70	3.06	**0.003**	
Time * Greenness	-1.05	-1.97	-0.13	-2.21	0.031	
Street 2						0.31 ±3.04%
(Intercept)	1.41	0.55	2.27	3.18	**0.002**	
Time - post	-0.76	-1.83	0.32	-1.37	0.18	
Greenness - Green	0.49	-0.59	1.57	0.89	0.38	
Time * Greenness	0.05	-1.45	1.56	0.07	0.94	
Anger						
Street 1						0.33 ±4.94%
(Intercept)	0.65	-0.003	1.30	1.93	0.058	

Fixed Factors	Estimate	95% CI		t value	Pr(>|t|)	BF
		Lower	Upper			
Time - post	0.20	-0.64	1.04	0.46	0.64	
Greenness – Green	0.37	-0.49	1.24	0.83	0.41	
Time * Greenness	-0.40	-1.62	0.82	-0.63	0.53	
Street 2						0.43 ±14.46%
(Intercept)	1.13	0.44	1.82	3.16	**0.002**	
Time - post	-0.28	-1.07	0.52	-0.67	0.50	
Greenness - Green	-0.18	-0.97	0.62	-0.43	0.67	
Time * Greenness	0.38	-0.74	1.49	0.51	0.51	
Fatigue						
Street 1						0.34 ±3.81%
(Intercept)	3.00	1.56	4.44	4.07	**<.001**	
Time - post	-1.10	-2.45	0.25	-1.58	0.12	
Greenness – Green	0.27	-1.13	1.67	0.38	0.71	
Time * Greenness	0.50	-1.46	2.47	0.50	0.62	
Street 2						0.30 ±2.92%
(Intercept)	2.27	0.84	3.70	3.10	**0.003**	
Time - post	-0.32	-1.78	1.13	-0.43	0.67	
Greenness - Green	0.92	-0.53	2.38	1.23	0.23	
Time * Greenness	-0.31	-2.35	1.73	-0.29	0.77	
Vigor						
Street 1						0.29 ±13.91%
(Intercept)	13.05	10.27	15.83	9.29	**<.001**	
Time - post	-1.00	-2.78	0.78	-1.09	0.28	
Greenness – Green	0.27	-1.58	2.11	0.28	0.78	
Time * Greenness	0.03	-2.55	2.62	0.03	0.98	
Street 2						0.32 ± 3.87%
(Intercept)	12.55	9.58	15.53	8.35	**<.001**	
Time - post	-0.25	-2.08	1.59	-0.26	0.80	
Greenness - Green	-0.10	-1.93	1.74	-0.10	0.92	
Time * Greenness	0.20	-2.38	2.76	0.15	0.88	

Note: *The significance level was adjusted to 0.004 (0.05/12) with Bonferroni method.*

3.2. Restorative potential of the locations (PRS)

Table 7 shows the descriptive statistics for all PRS measures for two streets (Street 1, Street 2) on different of Greenness (grey, green) separately for before and after the walk.

Table 7. Mean values for PRS scores across different greenness for the first street

	total score	being away	coherence	compatibility	fascination
Street 1					
Grey	3.47 (0.98)	2.77 (1.48)	5.07 (0.85)	3.13 (1.08)	3.49 (1.48)
Green	3.70 (1.04)	3.17 (1.56)	5.32 (0.62)	3.57 (1.17)	3.66 (1.74)
Street 2					
Grey	3.58 (1.04)	3.17 (1.65)	4.80 (0.78)	3.19 (1.13)	3.68 (1.51)
Green	3.95 (1.05)	3.41 (1.39)	5.06 (0.96)	3.82 (1.20)	3.89 (1.59)

Note: *The values in brackets represent the Standard Deviations (SDs)*

Figure 8 shows the boxplots of PRS scores with all sub-groups for Measurement time (pre vs. post), Street greenness (grey vs. green), and for the two streets (Street 1 and 2). The fixed effects and results of the LMMs using PRS scores are shown in **Table 8**.

The analyses revealed no significant main effect of Street greenness. However, seeing the BFs for each model, there was a distinct trend in the results. For the LMM results for Street 2, for Compatibility and Coherence scores, the BFs were 5.86±0.85% and 0.71 ±32.69%. First, the result of Compatibility score supported the alternative hypothesis: higher Compatibility score after the green transformation in Street 2 (see also **Figure 6**). Further, the result of Coherence score was less than 1, hence supporting the null hypothesis. But the deviation in the BF was quite large, ±32.69%. Considering this trend, one might argue that on average the Coherence score did not change before and after the green transformation. Yet, there might be inter-individual differences, e.g., some people show quite big changes in Coherence score after the green transformation.

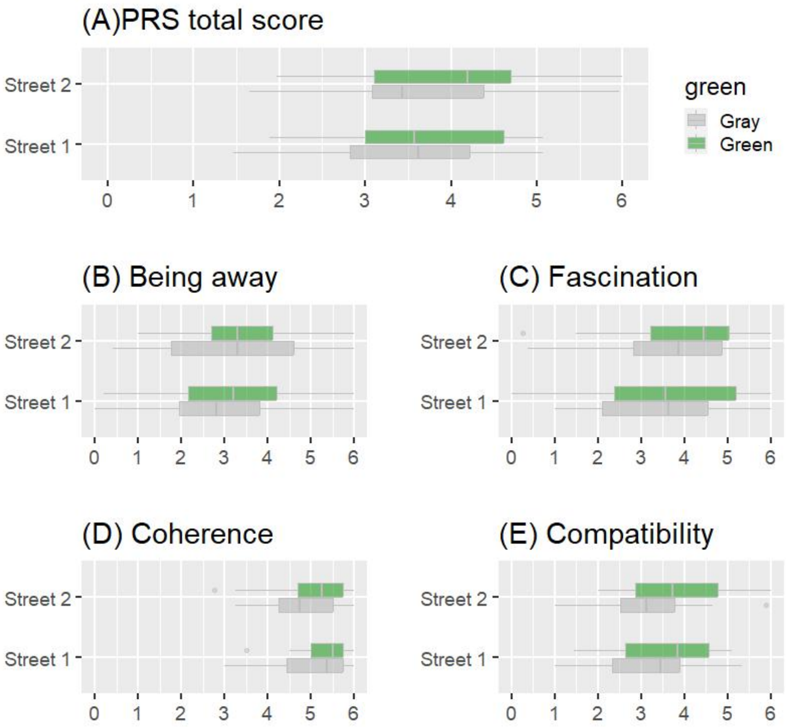

Figure 8. Distribution of scores of Perceived Restorative Scale for each condition and for the total score (A) as well as for the sub-scores for Being away (B), Fascination (C), Coherence (D), and Compatibility (E).

Table 8. Fixed effects and coefficients in the LMMs predicting PRS scores separately for the two testing sites (Street 1 and 2).

Fixed Factors	Estimate	95% CI		t value	Pr(>|t|)	BF
		Lower	Upper			
Total restorative score						
Street 1						0.58 ±4.24%
(Intercept)	3.60	3.17	4.03	16.66	**<.001**	
Greenness – Green	0.16	-0.16	0.46	1.01	0.33	
Street 2						1.40 ±0.68%
(Intercept)	3.77	3.32	4.22	16.63	**<.001**	
Greenness - Green	0.18	-0.25	0.61	0.84	0.41	
Being away						
Street 1						0.70 ±0.51%
(Intercept)	2.92	2.27	3.57	8.85	**<.001**	
Greenness – Green	0.25	-0.33	0.83	0.86	0.40	
Street 2						0.55 ±0.87%
(Intercept)	3.44	2.78	4.10	10.18	**<.001**	
Greenness - Green	-0.03	-0.78	0.72	-0.08	0.94	
Fascination						
Street 1						0.48 ±0.96%
(Intercept)	3.63	2.93	4.32	10.32	**<.001**	
Greenness – Green	0.03	-0.49	0.56	0.12	0.90	
Street 2						0.87 ±0.67%
(Intercept)	3.88	3.20	4.56	11.29	**<.001**	
Greenness - Green	0.01	-0.71	0.71	0.01	0.99	
Compatibility						
Street 1						0.56 ±0.90%
(Intercept)	3.21	2.72	3.70	13.03	**<.001**	
Greenness – Green	0.36	-0.01	0.73	1.93	0.069	
Street 2						5.86 ±0.85%
(Intercept)	3.36	2.85	3.87	13.07	**<.001**	
Greenness - Green	0.46	0.05	0.86	2.24	0.037	
Coherence						
Street 1						0.52 ±0.67%
(Intercept)	5.30	5.02	5.58	37.47	**<.001**	
Greenness – Green	0.02	-0.35	0.39	0.91	0.91	
Street 2						0.71 ±32.69%
(Intercept)	4.90	4.53	5.27	25.69	**<.001**	
Greenness - Green	0.16	-0.26	0.58	0.78	0.45	

Note: *The significance level was adjusted to 0.004 (0.05/12) with Bonferroni method.*

3.3. Exploratory analysis: Relationship between the well-being outcomes, appraisal towards the locations, and personal traits.

Figure 9 shows a correlation plot for each street separately for different Street greenness. Two streets were considered together, as the personal traits were only measured after completing each visit. We note that we used a Bonferroni-adjusted alpha level of $p = 0.00048$ (equal to $p = 0.05$ divided by 120 correlation tests with 16 variables) to control for significance level. As a general trend, we found some correlation patterns. For example, the Vigour score from POMS is negatively correlated with Total disturbance score in both periods. This is logical considering that Vigour measures positive aspects of mood, while Total disturbance measures negative aspects. PRS scores, such as Total restorativeness, Being away, Fascination, and Compatibility, were positively correlated. Last, the general level of stress (PSS) and Nature relatedness (NR-6) were negatively correlated in both periods.

Aside from the above-mentioned trends, there were no significant relationships between well-being outcomes and restorativeness as well as between well-being outcomes and personal traits.

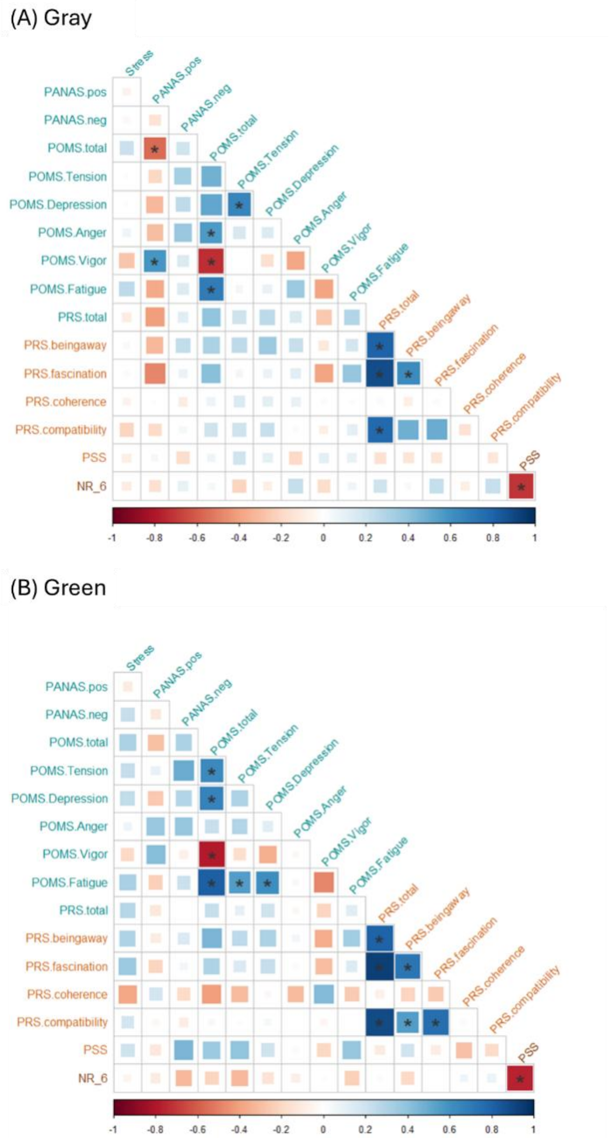

Figure 9. Correlation plot using well-being outcomes and selected measurements (PRS, PSS, and NR6) for (A) Grey period and (B) Green period

4. Discussion

4.1. Brief summary of the results for each research question

This study aimed to assess the impact of greenery and the extent of greenery available in urban street contexts on subjective well-being. To this aim, we conducted the same structured field study in Vienna (Austria) before and after an urban landscape transition period, enabling us to examine the impacts in the same street environment. Two research questions were asked: (1) Do greener urban landscapes (i.e., amount of natural components) positively impact our well-being? (2) Do greener urban landscapes (i.e., amount of natural components) positively impact the restorative potential of the locations? Correspondingly, the two following hypotheses were tested: (1) The greener the streets, the greater the improvements in well-being scores observed among participants (2) The greener the streets, the higher the restorative potential of the locations reported. In an explorative way — the relationship between well-being outcomes, restorative potential of the locations, and personal traits were also analysed.

Regarding our first research question, our results showed no significant improvements in well-being scores in both streets (Street 1 and 2) in both levels of Street greenness (grey and green). Hence, the increased quantity of greenery in both street landscapes did not reveal significant positive impacts on subjective feelings of well-being. Hence, our first hypothesis was rejected. Similarly, regarding our second research question, the results again showed no significant change regarding the restorative potential of the testing locations in both streets (Street 1 and 2) in both levels of Street greenness (grey and green). Again, the increased quantity of greenery in both street landscapes did not reveal positive impacts on the appraisal of the environment.

We also conducted an exploratory analysis, investigating the correlation between the well-being outcome, PRS score, and personal traits (e.g., PSS, general stress level and NR-6, nature relatedness). This analysis will provide further insight from our data regarding if there are any individual differences in well-being outcomes depending on how the participants perceive the environments and their general traits. For example, it might be possible that the more positive the evaluations of the locations and the higher the connection to nature, the greater the improvements in well-being scores observed among participants. Such interindividual differences cannot be investigated from the analyses above. This analysis shows no correlations between well-being outcomes and inter-individual difference scores. Specifically, how much people are generally stressed or related to nature was not related to how people evaluate the environments and the extent of well-being outcomes they showed. However, a negative correlation between general stress and nature-relatedness was observed, meaning those more stressed were less related to nature. This result aligns with past findings, i.e., less relation or contact with nature is related to ill-being (e.g., Bratman et al., 2024), which could be worth further investigation.

4.2. General limitations in the present study

The focal question is why we found no effect of greenery in the present study. From our data, there are several potential answers to this question. First, although the positive impacts of nature and greenery on well-being and evaluations of the environment have been well-documented in the past, our study result suggests that this might only sometimes be the case. One possible explanation for this can be the quantity of greenery. Past studies suggested that the amount of greenery in an environment affects its impact [23,24]. Although the two streets in this study had varying amounts of greenery during the second data collection, more was needed to positively impact subjective well-being and the restorative potential of the streets. However, this does not imply that the green transformation fails to deliver positive impacts, especially in Street 2. As greenery increases over time, with trees and ground-level nature growing, positive effects may emerge. Secondly, by seeing Tables 2 and 6, reporting the means values of well-being measures and restorative potential of the locations, the data shows significant variations in *SD*s. Large variations, especially in well-being measures, are reasonable, considering how one feels stressed or positive/negative moods can broadly vary for multiple reasons. As our study included a small number of participants, we did not exclude the participants who showed extreme high/low values in measurements. This practice might have contributed to cancelling out the possible impact of greenery. Hence replication studies should work with bigger sample size in the future. Third, there is also a methodological limitation in the present study. Namely, due to the nature in different levels of greenery, our participants always experienced grey landscapes first and then green landscapes in both streets. Hence, the order of the experienced Street greenness was fixed in the present study. Without having a different order, i.e., first the green landscape and then the grey landscape, it is difficult to control the impact delivered from the specific experienced order of the conditions. This aspect is generally challenging to overcome in a field environment. Here, a follow-up experiment in a laboratory would be helpful, as when researchers show videos of the same street landscape in different periods, it is relatively easy to counter-balance the presentation order. Further, this approach is also helpful in controlling for other confounding factors, such as temperature and noises in different testing periods. Furthermore, regarding the results of subjective well-being, it might be possible that floor effects occurred. Specifically, seeing the negative sides of subjective well-being, such as stress or negative moods in PANAS and POMS scores, it is clear that before starting the walk, the reported scores from the participants were already relatively low, see Figure 3, 4, and 5. Hence, it might be possible that the negative well-being scores were too low to show any changes from there. For future studies, it might make sense to include some additional tasks before interacting with the environments, which can induce stress or negative emotions and reduce positive emotions to create a baseline of higher stress that could be reduced during the walk. Such a change in procedure could counteract the potential floor and ceiling effects. Lastly only a small sample of 24 participants could be tested in our study. Hence, higher testing power could detect effects that did not turn out significant in our study. The number of participants was challenging in the present study, as only participants who could join the field experiments twice were considered, and there was a two-month gap between both visits.

Overall, any field studies have their limitations. In our case, when we aim to test the impacts of different quantities of greenery, there are confounding factors, such as the differences in temperatures in two testing periods, which are naturally present in the field and cannot be controlled. Hence, we acknowledge that the present study could have been set in a different way to rigorously test our hypotheses in even better situations. Nonetheless, we believe that this is not always possible in the field environment, and hence, we need to evaluate the effects not sorely by a single study, but by accumulated evidence with different methods, populations, and analyses together with (systematic) reviews and meta-analyses. We believe that in this sense, although with limitations, our results are still meaningful in terms of providing empirical evidence on this topic and of promoting this line of research.

5. Conclusion

The present study represents one of the first attempts to scientifically assess the effects of greenery in urban street contexts on subjective well-being and the restorative potential of the locations in an ecologically valid setting, employing empirical study design. Unlike the results shown in past related studies, our results show no effect – the greenery on the street landscapes did not influence either subjective well-being or the restorative potential of the locations. Due to the limitations listed above, further studies are needed to conclude the impact of greenery in urban streets and the minimum quantity of greenery to induce positive impacts. For future studies, it would also be interesting to assess whether the relationship between the greenery effects and their magnitude is linear, e.g., more greenery is always better than less greenery, or if there is a threshold in the quantity to deliver positive impacts. Such an accumulation of knowledge will provide solid guidelines for designers, city planners and developers for reasonable and adequate planning and determining the amount of resources.

Author contributions

J.M., L.A., E.O. wrote the main manuscript text. All authors contributed to discuss theoretical background and designed the study. L.A., M.D., P.B., K.P collected the data. J.M., L.A. prepared the dataset, and J.M. analysed the data. Funding acquisition and supervision were led by H.L. and E.O. All authors reviewed and contributed to the manuscript.

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Conflict of 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.

Disclosure statements

The authors declare no potential conflict of interest.

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