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Art in the city reduces the feeling of anxiety, stress, and negative mood: A field study examining the impact of artistic intervention in urban public space on well-being

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A R T I C L E I N F O

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A B S T R A C T

Promoting urban well-being is a significant societal task in the context of rapid urbanization. Past research has highlighted that interaction with urban green spaces, such as parks and forests, is key in promoting urban well-being. However, there is limited knowledge regarding the potential in promoting well-being from non-nature elements. In the present study, we explored whether interacting with art could enhance well-being in urban street contexts. In our field experiment, we built two interventions on urban streets, decorating them with either laminated art prints or green elements. We measured subjective and physiological well-being before and after the interaction with the interventions. With this paradigm, we assessed if, not only green, but also artistic interventions can improve well-being. Our results showed that, after interacting with the artistic intervention in an urban environment, the participants reported reduced feelings of anxiety, stress, and negative mood as they did with the green intervention. Further, our results indicate that improvements in well-being were linked to participants' evaluations of the testing location (restorativeness), of aesthetic quality of the intervention (e.g., beauty, meaningfulness), and of their overall experience (e.g., enjoyment). These findings have significant implications in promoting urban well-being and city planning, as they highlight the potential of art as a novel tool for enhancing urban well-being.

1. Introduction

By 2050, 68 % of the world's population are expected to live in cities (United Nations Department of Economic and Social Affairs, 2018). Urbanization is a well-known factor affecting mental health, e.g., higher stress (Adli et al., 2017), due to multiple factors, such as exposure to stimulating environments (e.g., noise, lights), physical inactivity, limited housing spaces, and/or poor quality of social networks (e.g., Hoare et al. 2019, Sundquist et al. 2004). The fast-paced urbanization across the globe highlights the importance of promoting quality of life in urban environments.

Over the past decades, environmental psychology research has

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shown that public urban green spaces have a significant positive influence on urban health and well-being.[h] For example, urban green spaces, such as urban parks and forests, have high restorative potential (Kaplan, 1995), defined as "the experience of a psychological and/or physiological recovery process that is triggered by particular environments and environmental configurations" (p.58, Joye and Van den Berg, 2018). The interaction with such environments results in a positive impact on social, physical, and subjective well-being (see Grinde and Patil 2009, Jabbar et al. 2022, Mensah et al. 2016, Papastergiou et al. 2023, Reyes-Riveros et al., 2021). This shows that natural elements in urban space are a well-established tool to increase well-being.

Traditionally, Attention Restoration Theory (ART: Kaplan and Kaplan, 1989; Kaplan, 1995) and Stress Recovery Theory (SRT: Ulrich et al., 1991) have proposed that it is nature itself that increases the restorative potential of a place and reduces stress. However, a more recent study (Meidenbauer et al., 2020) suggests another mechanism: the aesthetic value of an urban space. They tested whether the positive effects of interacting with nature on well-being result from the natural stimuli per se, or from viewing stimuli high in aesthetic value, i.e., preference value. Through six laboratory-based experiments, they concluded that it is not nature itself that improves our affective state, but that nature likely improves the affective state because of its high aesthetic value, i.e., nature makes the place highly preferred environment. They base their conclusion on two points. First, not all natural environments positively affected anxiety levels (well-being). Specifically, environments with lower aesthetic value did not have a positive impact on well-being, even if they comprised natural elements. Second, environments with higher aesthetic value did have a positive impact on well-being, even if they consisted of human-made elements in urban areas. The findings of Meidenbauer et al. (2020) are in line with a systematic review (Weber and Trojan 2018). In this review, they found that urban built environments can also provide restorative potential. However, the results were mixed (see, Scopelliti et al., 2019 as an example), waiting for further empirical evidence.

The potential of aesthetics as an important factor to promote urban well-being has been actually highlighted from Kaplan et al. (1993), suggesting museums as ideal environments with restorative potential. Following this suggestion, studies in art psychology support this claim. The positive impact of (especially visual) art on well-being has been demonstrated in various settings, such as in museums (Clow and Fredhoi, 2006; Fekete et al., 2023), online settings (Trupp et al., 2022, 2023), hospitals (Karnik et al., 2014; McCabe et al., 2013; Rollins and Wallace, 2017), and interior living spaces (Wikström et al., 1993). These studies quantified well-being with measures such as restorativeness, stress, anxiety, and mood states, using questionnaires or physiological metrics like heart rate, electrodermal activities, and/or saliva samples (e.g., Clow and Fredhoi, 2006; Martínez-Martí et al., 2018; Mastandrea et al., 2019 for a theoretical review). However, the evidence in real urban environments, with few exceptions (e.g., Mitschke et al., 2017; Motoyama and Hanyu, 2014; Zebracki, 2013), is scarce.

The current paper tests if interacting with art in urban public space can promote well-being. We test if and how artistic elements – in comparison to green elements, i.e., plants – improve well-being on urban street environments in Vienna (Austria). To this end, we set up two customized parklet-sized physical interventions, created by artists with sustainable materials, on two streets and used them as our field-testing sites (see *Method* section for detailed description of how they were built). Parklets here can be defined as "small removable, physical intervention platforms made available to the public for recreational use that takes the place of two or more on-street parking spaces, widening the sidewalk" (p.1, Shokry, 2019). In the city of Vienna, the concept of parklet-sized interventions on the street was especially introduced in 2015 by the city government of Vienna, Austria, as a program to promote the use of public space. These parklets are called Graetzloase, combining the terms "neighborhood (Graetzl)" and "oasis (Oase)" in the Austrian language. These street interventions are highly mobile and flexible. As they are easy to build and dismantle, they can be set up in any urban environment, such as streets or squares. We systematically varied the decorations of the interventions between art and plants and compared the impact from the two conditions in terms of how psychological and physiological well-being measures would change after the interaction. Here, we designed the green condition to be an *active control* condition. The implementation of an active control instead of the conventional control, where the participants interact with the intervention without artistic or green elements, brings a practical benefit to draw a meaningful conclusion in our study. Boot et al. (2013) discuss that psychological studies, assessing the effectiveness of intervention(s) to improve education, mental health, well-being, or cognitive performance, should employ an active control condition, where it has "the same expectation of improvement as the experimental group" (p.445). Importantly, the most adequate active control should be expected by the participants to bring more benefit compared to the experimental condition to control for the placebo effects stemming from participants' expectation from the interventions. Hence, to draw a meaningful conclusion on the impact of artistic intervention, the best control condition in our case should bring the same or even bigger expectation of improvement to the participants to rule out the placebo effects. Therefore, we implemented the intervention with green elements as our active control rather than the conventional control, as green has been shown to be one of the most powerful tools to improve health and wellbeing (see Grinde and Patil 2009, Jabbar et al. 2022, Mensah et al. 2016, Papastergiou et al. 2023, Reyes-Riveros et al. 2021). Even more importantly, as evident from the political debates on global warming and/or heat island effect in urban areas as well as the actual practice in city planning (e.g., increment of urban greenery), the active control with green elements should bring higher expectations to the participants than art.

In sum, if we observe the same amount of or even more improvements in well-being in the artistic interevention condition compared to the green one, we could draw a clear conclusion that art is indeed an effective tool to promote well-being, which is equally or more effective as green elements. This point is not only important for our experimental design but also for practical implications in city planning. If art is *not* as strong as or stronger tool to improve well-being than green does, why should we implement art? Overall, due to both experimental and practical benefits, we believe that it is the best practice to set the green condition as our active control, and ask: Is art as powerful a tool as greenery in promoting well-being in urban spaces?

Further, with support from the city of Vienna, we placed our interventions in two different streets: one which had an artistic but not green environment (Burggasse: BG in the following texts), and the other one which was green but not artistic environment (Maria-Tusch-Straße: MT in the following texts). This lead to a fully crossed design (see Fig. 1 for an illustration and Supplementary material Table S1 for detail characteristics of both streets). Here, artistic environment refers to an urban street with art/design shops, buildings with graffiti design walls.

When considering the conclusions we can draw from our field experiments, the addition of the two different street environment, which are compatible to the intervention type, brings additional benefit to

[h] Well-being is a multifaceted concept, having various aspects. According to (Stone & Mackie, 2013), well-being can be categorized based on its temporal aspects (e.g., long-term or short-term). For example, *Evaluative well-being* refers to how satisfied one is with their health, relationships, or social community in a longer time. On the other hand, *Experienced well-being* refers to our emotions or health states in a short time. We note that past related studies introduced here have mainly focus on short-term well-being, e.g., how one's emotion or affect change after the interaction with specific stimuli in a short visit, normally taking 5min to 30min. In the current paper, we follow this focus. Hence, when we refer to (urban) well-being in the current manuscript, we refer to experienced well-being of the participants in terms of one's emotions and affective state.

Intervention type	Street	
	BG	MT
Artistic Graetzloase		
Green Graetzloase		

Fig. 1. Illustration of interventions (Graetzloase)
Note: Detailed photos of our artistic and green decorations in the interventions can be seen in Supplementary Material S1.

interpret our results. First, by having two streets, we can investigate the generalizability of the findings. Second, by testing the effects of artistic and green interventions in two different locations, along with the type of the interventions, we can shed the light on our research question from a different angle. Specifically, when art is truly equivalent to green in terms of the well-being benefit, all four conditions in the experiment should bring the same positive impact on well-being, as the amount of available artistic and green elements in four conditions are the same. But, if art is less beneficial in improving well-being, we shall observe a stronger well-being benefit in MT with the green intervention.

Finally, we assessed how participants evaluate the testing environment in terms of their aesthetics (i.e., beauty, liking, meaningfulness, reflective potential) as well as its restorative potential. This allows us to assess not only if an art intervention can be equally impactful but also whether the aesthetics appraisal (regardless of intervention type) is related to the improvements in well-being.

The present paper addresses the following research questions:

(1) Does the interaction with artistic interventions in urban streets positively impact well-being as quantified by anxiety, stress, affective mood, and the moment of stress measured via physiological markers in comparison to the active control (green intervention)?
(2) How do artistic/green interventions influence the aesthetic evaluation (i.e., liking, beauty, meaningfulness)?
(3) How are these evaluations related to changes in well-being?

Corresponding to the research questions, we postulated the following hypotheses.

(1) Both artistic and green elements in an urban street environment increase well-being. Further, the general level of well-being outcome does not differ between artistic and green interventions in both streets.
(2) Despite the possible inter-individual differences, we expect that both art and green intervention positively impact the aesthetic evaluations, hence higher in liking, beauty, and meaningfulness compared to the reference line.
(3) Improvements in well-being are positively related to the ratings of the environment.

2. Material and methods

2.1. Study design

We used a mixed study design, including three factors: testing locations, two streets (BG, MT), intervention type (artistic, green), and measurement time (pre, post).

First, there were two testing streets (see 2.3. E*nvironments* for the detailed descriptions). Participants were randomly assigned to one of the testing locations. Each participant visited the testing street twice. One visit was done with either artistic or green intervention, and the other one with the other type of intervention. Hence, *Street* was a between-subjects factor, and the *Intervention type* was a within-subjects factor. We note that between the first and second visits, there were at least 13 days in-between to avoid any carry-over effects, such as memory effects for some questions.

As discussed above, for our experiment design, it was optimal to set an active control as an adequate control rather than having a conventional control. Since participants visited twice with both intervention types, when the participants go through the testing environment with an artistic intervention and an empty intervention (the conventional control approach), they could expect the bigger and positive impacts from artistic intervention, potentially leading to response bias, e.g., people may report higher well-being in the art intervention condition because they expect that having art should bring better well-being outcome compared to the empty intervention. With this experimental design we cannot claim a causal inference as this design cannot rule out the possibility of expectation differences in the two conditions. Hence, we employed intervention with greenery as an active control to counteract such an expectation bias.

The order of the intervention type was counter-balanced across the participants by changing the decorations of the intervention. Hence, in both streets, half of the participants had their first visit with the artistic intervention, while the other half had it with the green intervention. During each visit, we measured subjective and physiological well-being before (pre) and after (post) the walk. Hence, *Measurement time* (pre, post) was a within-subjects factor. We note that, in the following text, the above-mentioned factors will be mentioned by the factor names with italics.

2.2. Participants

Participants were recruited from two online platforms: [*platform names are masked for the peer review*]. Our inclusion criteria were: they should be older than 18 years old, speak either English or German fluently, and have no health problems or neurological/psychological conditions. The participants received €40 as participation compensation.

The power analysis, using G*Power (Faul et al., 2007) suggested 90 participants to detect a small to medium effect size (Cohen's $f = 0.14$) assuming power of 90 % and significance level at $\alpha = 0.05$. To account for unforeseen problems during the experiment, e.g., bad weather, participants who fail to return for the second visit, or potential data loss due to issues with the physiological sensors, we recruited 130 participants (94 female, 32 male, 4 other, $M_{age} = 24.96$, $SD_{age} = 8.09$). For the number of participants, who were included in the following analyses, please see *Supplementary material S2.*

This study was approved by the local ethic committee of [name of the University masked for the peer review] (reference number: EK00573) and followed the Declaration of Helsinki.

2.3. Environments

The study took place in two streets in the city of Vienna, Austria. One testing location was a 30 m section of BG, and the other location was a 30 m section of MT (see Supplementary material S3 and Table S1 for detailed descriptions of the testing locations). The starting and ending points on both streets, which define the testing area, are shown in Fig. 2. Testing always started from the starting points, but then participants could walk along the street freely. We decided to start the experiment from the same point, as otherwise the participants had to visually encounter the intervention prior to the experiment which can have a potential impact on the results.

2.4. Intervention

The construction of the basic structures of the interventions and the design of the artistic/green decorations were performed by a close collaboration with local teams of artists, [Artists names removed for the peer reviewing process]. A video showing the construction process can be seen in Supplementary material S4.

Street interventions were essentially ground-level platforms with roughly the size of one standard parking slot that are accessible from the pedestrian walkway, while being closed on three sides towards street and traffic. Two identically structured interventions were built on the testing areas. For the basic structure, metal and steel pipes were used, forming a pergola-like intervention object which is 4.5 m long, 2.10 m wide, and of 2.53 m height (see Fig. 1). The material was gathered from leftovers from former construction areas, as well as re-used bike stands of the city of Vienna. The two interventions were decorated with one of two types of materials. The materials were either 11 laminated abstract art prints, fastened to a metal frame, resulting in an artistic intervention, or four large potted green plants, resulting in a green intervention (see Fig. 1). We ensured that both interventions appeared to have similar amounts of decorations.

2.5. Measurements

Well-being measures used in the present study were chosen based on the frequent use in environmental and art psychology, ensuring homogeneity and comparable interpretation of results with past literature.

2.5.1. Subjective well-being: anxiety, stress, and affective mood state

Subjective well-being was measured using the *State-Trait Anxiety Inventory* (STAI-S: (German version from Grimm 2009, adapted from Spielberger et al. 1999), perceived stress scales, and *Positive and Negative Affect Schedule* (PANAS German version: Krohne et al. 1996).

The STAI-S measures the perceived level of anxiety with 20 items on a four-point Likert-type scale ranging from 1 (not at all) to 4 (very much so). Perceived stress level was measured with a slider-type scale, with possible scores ranging from 0 (not at all) to 100 (completely). The PANAS measures affective mood states with 20 items on a five-point Likert-type scale ranging from 1 (not at all) to 5 (extremely). Each of the items is grouped into two dimensions: 10 positive and 10 negative mood states.

For the scales with multi-items, we computed the internal consistency with Cronbach's alpha (α). Although reporting the internal consistency with α is one of the most common practices, its deficiencies has been well-reported (see, Dunn et al. 2014, McNeish 2018, for the discussion; see also Specker 2021 for a more general argument for the implication). Hence, we also report McDonalds' omega (ω), which is conceptually similar to the α, to supplement the information. In case the scales were measured twice (e.g., pre and post), the internal consistencies were computed separately for each measurement time. For the STAI-S, the internal consistency was $\alpha = 0.90$ ($\omega = 0.92$) and $\alpha = 0.92$ ($\omega = 0.93$) for pre and post measurement, separately. For the PANAS, the internal consistency for the positive mood items was $\alpha = 0.82$ ($\omega = 0.87$) and $\alpha = 0.85$ ($\omega = 0.90$) for pre and post measurement, separately. Those for the negative mood items was $\alpha = 0.81$ ($\omega = 0.85$) and $\alpha = 0.81$ ($\omega = 0.87$) for pre and post measurement, separately. According to the rules of thumb proposed for the Cronback's alpha and for the McDonalds' omega, all values indicate a good (> 0.8) to excellent (> 0.9) internal consistency (Gliem and Gliem, 2003; Stensen et al., 2022).

2.5.2. Physiological well-being: Electrodermal Activity (EDA), Skin Temperature (ST)

To evaluate well-being from multiple aspects, we also measured stress-related physiological parameters of the participants (Kreibig, 2010). We followed the methodology proposed by Kyriakou et al. (2019) to evaluate the stress level of a person based on physiological sensor measurements. More specifically, Electrodermal Activity (EDA) – formerly referred to as Galvanic Skin Response (GSR) – and Skin Temperature (ST) were used to detect states of emotional arousal. Kyriakou et al. (2019) developed a rule-based algorithm that combines the information of EDA and ST, to derive a Moment Of Stress (MOS) score. To compute the MOS scores for each participant, EDA and ST were measured via a non-intrusive wristband, the "Empatica E4", which is a wearable device with medical-grade (Food and Drug Adminstration – FDA) and electronic certifications. The E4 incorporates various sensors that enable real-time measurement of Blood Volume Pulse (BVP), Inter-Beat Interval (IBI), EDA, and ST. Since MOS are solely calculated based on EDA and ST, two primary indictors for acute stress, these variables are the focus here. EDA data was sampled at a frequency of 4 Hz, with a resolution of 900 pico Siemens per digit and a range spanning from 0.01 to 100 μS. ST was also recorded at a sampling frequency of 4 Hz, with a resolution of 0.02 °C, and an accuracy of ±0.2 °C within the range of 36–39 °C.

2.5.3. Perceived restorativeness

After the walk, we asked the participants to evaluate the perceived restorativeness of the testing environment via the *Perceived Restorativeness Scale* (PRS: Hartig et al., 1997). PRS is a scale with 26 items on a seven-point Likert-type scale ranging from 1 (not at all) to 7 (Completely). The items are grouped into four dimensions based on Attention Restoration Theory: *being away, coherence, fascination*, and *compatibility*. The internal consistency was $\alpha = 0.92$ ($\omega = 0.95$).

2.5.4. Appraisals of the intervention and general experience

To capture the appraisals towards the intervention and general experience, the participants evaluated the following aspects. For the intervention itself, they evaluated four aspects: liking ("I liked the intervention,"), beauty ("It was beautiful"), meaningfulness ("It was

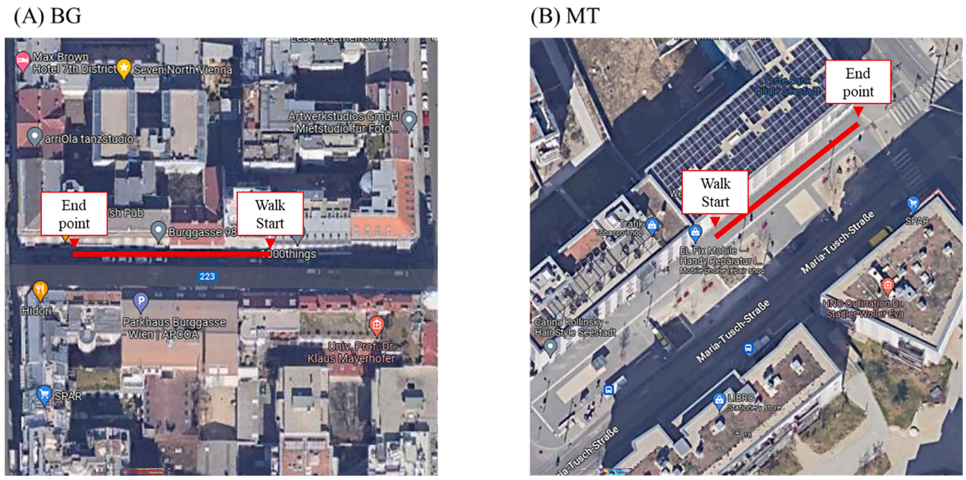

Fig. 2. Google maps satellite images: testing location with the starting and end points in both streets.

meaningful to me"), and reflection ("It made me think/reflect"), which are known to be associated with well-being (see Eekelaar et al. 2012, Fancourt and Finn 2019, Mastandrea et al. 2019).

Regarding the general experience, they evaluated three aspects: enjoyment ("I enjoyed the experience", see Fekete et al., in press), meaningfulness ("It was meaningful", see Eekelaar et al. 2012), and perceived duration of the experiment ("It was too long"). All questions were measured on seven-point Likert-type scales ranging from 1 (not at all) to 7 (very much so).

2.5.5. *General stress level, nature relatedness, art interest*

Finally, we inquired the general stress level of the participants over the past month via the Perceived Stress Scale (PSS: Cohen et al., 1994), nature relatedness via the nature relatedness scale (NR-6: Nisbet and Zelenski, 2013), and general interest in art via The Vienna Art Interest and Art Knowledge (VAIAK: Specker et al., 2018). The internal consistencies for PSS, NR-6, and VAIAK were $\alpha = 0.85$ ($\omega = 0.88$), $\alpha = 0.79$ ($\omega = 0.85$), and $\alpha = 0.94$ ($\omega = 0.96$), separately.

2.6. *Procedure*

Our data collection was conducted from the 2nd of May to the 28th of July 2022, during the weekdays from 9am until 3pm, in good weather conditions. Since we measured physiological sensor data, participants were instructed to not eat, drink, and smoke one hour before and during the experiment. The field experiment was conducted according to the eight steps shown in Fig. 3.

Upon arrival, participants were provided with information about the field study procedure and the equipment. After the instructions, they signed the informed consent sheet. Participants were equipped with physiological sensor devices (E4 wristband) and mobile eye tacker.[i] We provided a small bag to the participants to carry all devices (i.e., their own smartphones to answer the questionnaires, a mobile phone to start recording the physiological activities through an eDiary app proposed by Petutschnig et al. (2022), and a battery of the mobile eye tracker) and to allow them to walk unencumbered. They were also equipped with a white cap to avoid direct sun light interfering with the recording of eye movements. We note that, as the experiment was conducted right after the COVID-19 lockdown, the participants filled out all the questionnaires using their own smartphones to avoid sharing the devices with multiple people. Physiological sensors were disinfected after each use.

Pre-measurements took place in a 10 m distance from the testing area. They completed well-being questionnaires (i.e., STAI-S, Stress level, and PANAS) and then underwent a five-minute measurement of physiological parameters (i.e., EDA and ST). During the measurement, they were instructed to remain seated and minimize movement. We note that the questionnaire completion time also served as the rest time before the measurement of physiological parameters. Specifically, to establish a stable baseline for MOS detection, participants sat for a minimum of five minutes before the measurement started.[j]

After completing the pre-measurements, participants were guided to the testing location. They were instructed about the borders of the testing area and asked to spend time in the testing area for five minutes (five minutes' walk). They were free to explore the area, but not allowed to use their phones, go inside shops, or go to the other side of the street. Right before the start of the walk, we started the sensor devices and the eDiary app (see Petutschnig et al. 2022 for detailed descriptions for the app) for collecting physiological activities. We note that participants went for a walk alone. As one person was tested at a time, there were no other participants on the street during the testing. The experimenters were not following the participants during the walk and were not visible to the participants. Whether the participants remained the testing area was checked after the data collection by going through the video records from the mobile eye trackers.

After the walk, all recording devices were stopped, and participants were led back to the same initial measurement point for the post-measurement. First, the participants answered questions about the perceived restorativeness (PRS), appraisals of the interventions, and their general experience. Afterwards, we moved on to the post-

[i] We note that the present study focuses on the pre and post comparisons of the well-being measured via questionnaires and MOS score. We aim to report the eye tracking results in a separate paper. Hence, although the eye movement data was collected during the walk on the street, we do not report the results of the eye tracking results in the present study.

[j] We decided to combine the time to answer the first questionnaires and the resting period together for the following reason: As a premise, the sufficient resting time prior to the measurement time was implemented to assure the quality of the physiology data by minimizing the effects from any physical activities and possible confounding effects, such as walking to the testing site, feeling comfortable with the equipped devices etc. Especially in the field environment, participants might encounter quite different scenes/scenarios when sitting, e.g., some might see a lot of pedestrians and/or dogs on the street, while the others have no such interactions. Such difference might change experiences during this resting period, potentially affecting physiological activities. Hence, when we combined the resting period with answering questionnaires, the participants were at least engaging the same contents/activities, leading to more homogenous experiences prior to the physiological measurement.

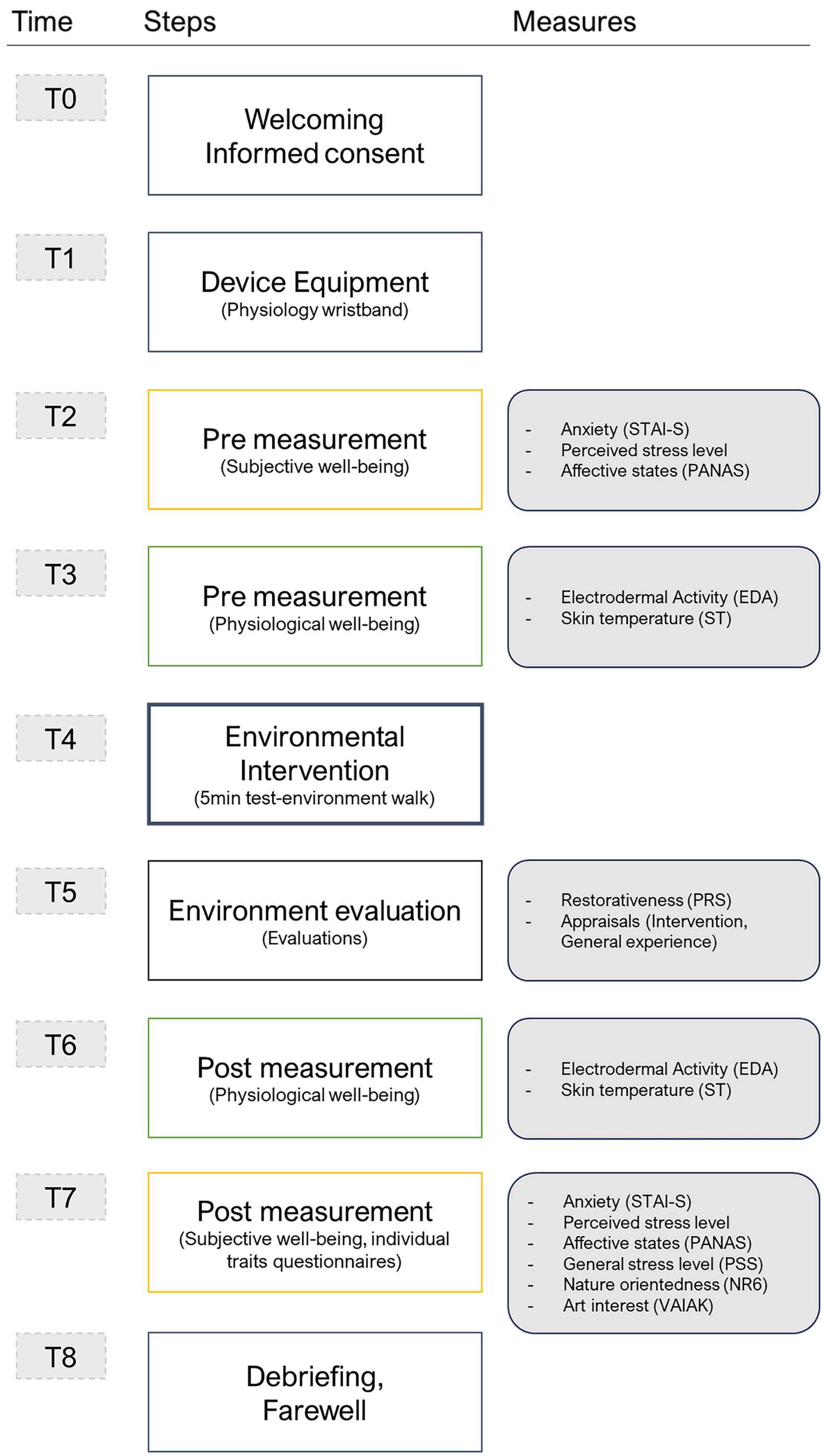

Fig. 3. Experimental procedure schema for each visit.

measurement. We note that, in the post-measurement phase, we first measured the physiological parameters, and then moved on to the well-being questionnaires. Hence, in the post-measurement, the time when the participants were answering the PRS as well as the appraisal questions was used as the resting period prior to the physiological activities' measurement. Other than this change, the procedure was the same as for the pre-measurement. Then, participants answered the personality related questions (i.e., PSS, NR-6, and VAIAK). We note that the personality related questions were only asked after the first visit, as they are stable and not assume to change.

At the end of the first visit, the second date and time was arranged with each participant. After the second visit, participants were debriefed and received a small bag of snacks as an additional thank you.

3. Results

Prior to the main analysis part, we calculated the descriptive statistics for general stress level (PSS), nature orientedness (NR-6), and art interest (VAIAK). Further, we performed a series of 2 × 2 mixed Analyses of Variances (ANOVAs), using the above-mentioned scores as dependent variables, to investigate possible differences between *Street* and *Intervention type*. Descriptive as well as inferential statistics are reported in Supplementary material Tables S2 and S5). The results showed that the above measures did not significantly differ between *Street* and *Intervention type*.

Data of the present studies as well as the analyses codes can be found online on the Open Scientific Framework: https://osf.io/5k8he/?view_only=6eae8a553a274d9e97b449d922f40209.

3.1. Subjective well-being measures (STAI-S: anxiety, perceived stress level, PANAS: affect mood states)

Descriptive statistics (mean, standard deviation, and 95 % confidence interval) for all subjective well-being measures across *Time, Intervention type*, and *Street* are shown in Tables 1 and 2. Additionally, raincloud plots for each measure, combining boxplots and violin plots, are displayed in Fig. 4.

To assess the effect of *Time, Intervention type*, and *Street* on subjective well-being scores, we ran a three-way mixed ANOVA for each dependent variable, that is, anxiety, perceived stress level, positive mood, and negative mood. The independent variables consist of *Time, Intervention type* and *Street*.

The ANOVA statistics for each dependent variable are reported in Table 3, including both Bonferroni-Holm corrected and uncorrected *p*-values. Detailed criteria for the interpretation of the statistical results shown here can be found in Supplementary Material S6. The following results section focuses on the statistics of the ANOVA models. However, LMM statistics were also reported in Supplementary Material S7 and Table S3 to validate our findings, as we observed violations of the assumptions of the mixed ANOVAs (see Supplementary Material S7 for detailed descriptions). When the results of ANOVAs and LMMs were not compatible and critical for the interpretation of our results, we reported these aspects in the following sections.

Time was significant with an effect size considered large for anxiety, perceived stress level, and negative affect (all $ps_{\text{adjusted}} < 0.001$, all $\eta_p^2 \geq 0.132$), but not for positive mood ($p_{\text{adjusted}} = 0.999$, $\eta_p^2 = < 0.001$). Combined with the descriptive statistics (see Table 1 and Fig. 4), the scores for all negative measures of subjective well-being significantly decreased. At the same time, there were no significant main effects of *Intervention type* (all $p$sadjusted > 0.05, all $\eta_p^2 \leq 0.013$). Hence, our results partially supported our first(H1: Not only green but also artistic intervention in urban street environments increase well-being.) and second hypotheses (H2: The amount of the positive impact from artistic and green intervention does not differ.). Importantly, although the complementary robust LMM suggests the same interpretation of the significance, the coefficient for *Time* appears remarkably smaller (see Supplementary Material S7 and Table S3). In short, the ANOVAs appear to overestimate the effect of *Time*.

Furthermore, from the results of ANOVAs, *Street* appears significant (uncorrected *p*-values) with a small-to-moderate effect size for two variables, namely anxiety ($p = .006$, $p_{\text{adjusted}} = 0.024$, $\eta_p^2 = 0.068$) and positive mood ($p = .034$, $p_{\text{adjusted}} = 0.102$, $\eta_p^2 = 0.041$). For both variables, higher subjective well-being scores were found in MT, which has more green contexts. While scores for positive mood were higher for MT ($M = 32.18$, $SD = 6.41$, 95 %-CI = [31.35, 33.01]) than for BG ($M = 30.05$, $SD = 6.05$, 95 %-CI = [29.22, 30.88]), it was the other way around for anxiety (MT: $M = 32.42$, $SD = 7.20$, 95 %-CI = [31.49, 33.35]; BG: $M = 36.20$, $SD = 10.16$, 95 %-CI = [34.81, 37.59]). For anxiety, however, the significant effect of *Street* was not replicated by the adjusted *p*-values of the robust LMM analysis (β = 0.15, CI [.00, 0.29], $p = .045$, $p_{adjusted} = 0.135$; see Supplement Material Table S3) and for positive mood, the significant effect does not hold for the adjusted *p*-values of either statistical analysis. Additionally, we did not find a significant interaction between *Street* and *Time* (all $p$sadjusted > 0.05, all $\eta_p^2 \leq 0.019$). Thus, taken together, our findings provide reasonable evidence for the generalizability of the well-being effects of artistic and green intervention across two testing streets.

Lastly, the interaction between *Street* and *Intervention type* was significant with a small-to-medium effect when considering the ANOVA's uncorrected *p*-value perceived stress level ($p = .022$, $p_{\text{adjusted}} = 0.088$, $\eta_p^2 = 0.048$) and for negative mood ($p = .036$, $p_{\text{adjusted}} = 0.106$, $\eta_p^2 = 0.040$). In addition, both uncorrected and adjusted *p*-values of the robust LMM analysis indicated a significant effect for perceived stress level (β = −0.07, CI [−0.12, −0.03], $p = < 0.001$, $p_{\text{adjusted}} = < 0.001$), but not for the negative mood. Given these results, we decided to look further into the interaction effects of stress only. Based on the robust LMM, we calculated estimated marginal means and compared the corresponding 95 % CIs between each interaction term as suggested by Garofalo et al. (2022). The statistics suggested a higher level of stress for the green intervention in BG compared to the green installation in MT as well as to the artistic condition in BG. No other effects were revealed. The analytical approach as well as observed and estimated marginal statistics can be found in Supplementary material S7 and Table S7, Table S8 respectively.

3.2. Physiological well-being measures (MOS scores, using ST and EDA)

The method for the data pre-processing can be found in

Table 1
Descriptive statistics for anxiety (STAI) and stress (Perceived Stress Scale).

	Anxiety						Stress					
	pre			post			pre			post		
	M	*SD*	95 % CI	*M*	*SD*	95 % CI	*M*	*SD*	95 % CI	*M*	*SD*	95 % CI
BG[1]												
Green	37.65	10.33	[34.78, 40.53]	36.02	11.14	[32.92, 39.12]	27.56	25.34	[20.50, 34.61]	25.19	27.28	[17.60, 32.79]
Art	36.31	9.74	[33.60, 39.02]	34.81	9.44	[32.18, 37.44]	22.13	22.73	[15.81, 28.46]	19.08	21.57	[13.07, 25.08]
MT[2]												
Green	33.86	6.86	[32.06, 35.67]	30.95	6.63	[29.20, 32.69]	17.79	17.41	[13.22, 22.37]	13.47	16.23	[9.20, 17.73]
Art	33.36	6.75	[31.59, 35.14]	31.52	8.20	[29.36, 33.67]	21.79	19.85	[16.57, 27.01]	16.00	17.04	[11.52, 20.48]

Note.
[1] $N = 52$;.
[2] $N = 58$.

Table 2
Descriptive statistics for measures of positive mood and negative mood (PANAS).

	Positive mood						Negative mood					
	pre			post			pre			post		
	M	*SD*	95 % CI	*M*	*SD*	95 % CI	*M*	*SD*	95 % CI	*M*	*SD*	95 % CI
BG[1]												
Green	30.10	5.86	[28.47, 31.73]	30.42	6.29	[28.67, 32.17]	14.08	5.10	[12.66, 15.50]	13.63	4.82	[12.29, 14.98]
Art	30.06	5.91	[28.41, 31.70]	29.62	6.29	[27.86, 31.37]	13.17	3.84	[12.10, 14.24]	12.27	2.72	[11.51, 13.03]
MT[2]												
Green	32.34	5.39	[30.93, 33.76]	32.31	6.62	[30.57, 34.05]	12.79	3.05	[11.99, 13.59]	11.55	2.02	[11.02, 12.08]
Art	32.10	6.32	[30.44, 33.76]	31.95	7.32	[30.02, 33.87]	12.83	3.09	[12.02, 13.64]	12.17	3.80	[11.17, 13.17]

Note.
[1] $N = 52$.
[2] $N = 58$.

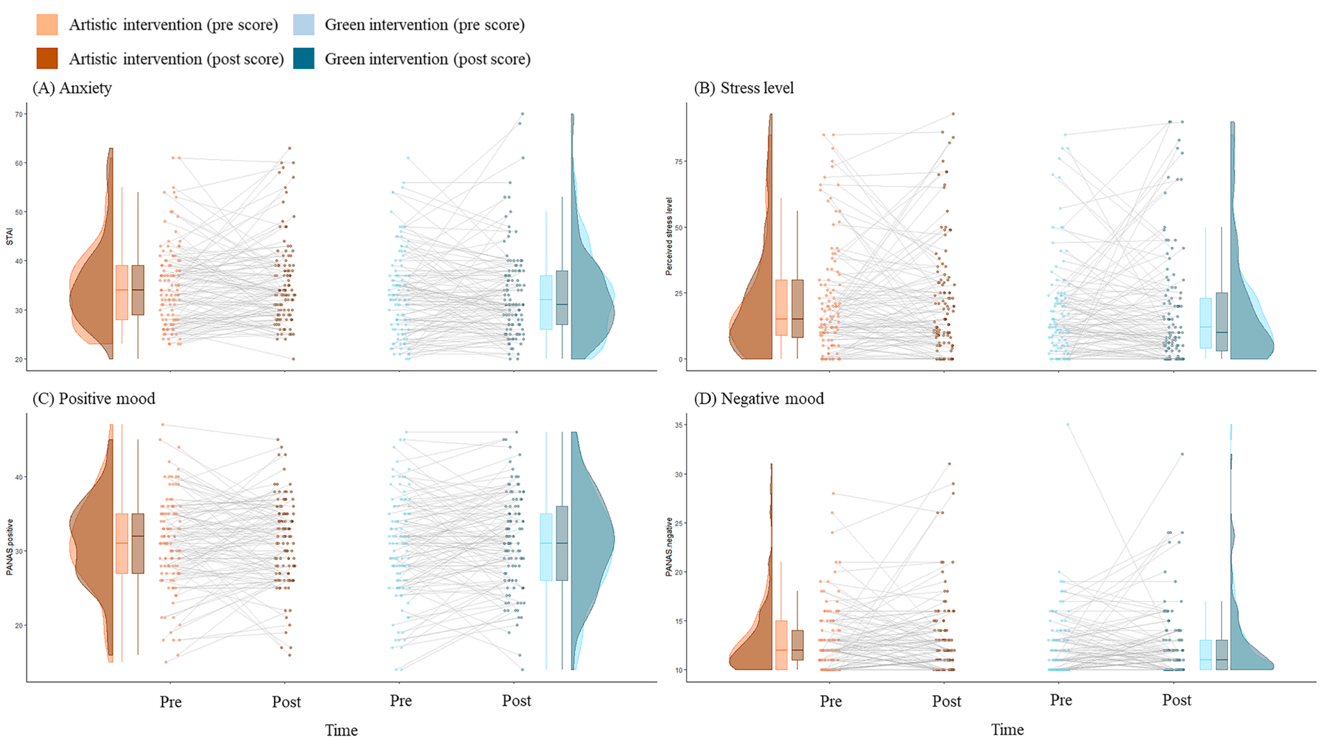

Fig. 4. Raincloud plots of subjective well-being measurements
Notes. (A) Anxiety level (STAI-S), (B) Perceived stress level, (C) Positive mood (PANAS), (D) Negative mood (PANAS). Each point illustrates raw data with data distribution and box plot.

Supplementary materials, S8. MOS score is represented as a binary variable. Namely, when the algorithm detects the moment of stress, it shows 1. On the other hand, when the algorithm does not detect the moment of stress, it shows 0. Hence, by adding up the number of MOS during the measurement time, the total numbers of MOS scores represent how many times the participants felt stress during the measurement. In the following analysis, we used the total number of the MOS as our dependent variable.

Descriptive statistics for MOS scores across *Time, Intervention type*, and *Street* are shown in Table 4.

As with the subjective well-being measures, a three-way mixed ANOVA was performed with the total number of the MOS scores as the dependent variable. The model structure was identical to the ones for the subjective well-being measures. The results are shown in Table 5. Additionally, to counter the deficiencies of the ANOVA model for the given data, we proposed a Poisson-based GLMM with Type III sum of squares adapted contrasts (see Supplementary Material S9). Both analyses yielded no significant effects (all $ps > 0.05$, all $\eta_p^2 < 0.016$).

3.3. Appraisals for the testing location, interventions, and general experience

In this section, the analyses of the T5 phase in Fig. 3 will be presented to understand participants' appraisals and general experiences of the testing environment. The data includes restorativeness of the testing place (PRS), aesthetic evaluation towards the interventions (i.e., beauty, liking, meaningfulness, and reflection), and evaluation towards the general experience (i.e., enjoyment, perceived duration of the walk, and meaningfulness).

3.3.1. Restorativeness of the testing location (PRS)

The PRS represents how restorative the environment was perceived to be, with higher values showing higher restorativeness. In BG, the average PRS scores were 3.28 ($SD = 0.87$, 95 % CI [3.03, 3.52]) for the artistic and 3.23 ($SD = 0.98$, 95 % CI [2.96, 3.50]) for the green intervention type. In MT, the average PRS scores were 3.68 ($SD = 0.88$, 95 % CI [3.44, 3.92]) and 3.76 ($SD = 0.90$, 95 % CI [3.52, 4.01]) for the artistic and green intervention type, respectively. We performed a two-

Table 3
ANOVA statistics for measurements of subjective well-being.

Fixed effects	F (1108)	p	$p_{adjusted}$	η_p^2
STAI				
Street	7.89	.006**	.024*	.068
Intervention type	0.59	.443	.999	.005
Time	21.83	< 0.001***	< 0.001***	.168
Street*Intervention type	0.66	.418	.836	.006
Street*Time	0.92	.339	.999	.008
Intervention type*Time	0.70	.406	.999	.006
Street*Intervention type*Time	0.42	.519	.999	.004
Perceived Stress Level				
Street	3.50	.064	.128	.031
Intervention type	0.41	.522	.999	.004
Time	22.87	< 0.001***	< 0.001***	.175
Street*Intervention type	5.39	.022*	.088	.048
Street*Time	2.09	.151	.604	.019
Intervention type*Time	0.41	.521	.999	.004
Street*Intervention type*Time	0.05	.818	.999	< 0.001
PANAS Positive				
Street	4.60	.034*	.102	.041
Intervention type	0.46	.498	.999	.004
Time	0.06	.803	.999	< 0.001
Street*Intervention type	0.02	.910	.999	< 0.001
Street*Time	< 0.01	.952	.999	< 0.001
Intervention type*Time	0.64	.425	.999	.006
Street*Intervention type*Time	0.34	.561	.999	.003
PANAS Negative				
Street	3.15	.079	.128	.028
Intervention type	1.37	.244	.976	.013
Time	16.40	< 0.001***	< 0.001***	.132
Street*Intervention type	4.50	.036*	.108	.040
Street*Time	0.47	.493	.999	.004
Intervention type*Time	0.02	.878	.999	< 0.001
Street*Intervention type*Time	1.68	.197	.788	.015

Notes. $N = 110$.
$p_{adjusted}$ values were Bonferroni-Holm corrected.
* $p < .05$.
** $p < .01$.
*** $p < .001$.

Table 4
Descriptive statistics for moments of stress.

	Moments of Stress (MOS)					
	pre			post		
	M	*SD*	95 % CI	*M*	*SD*	95 % CI
BG[1]						
Green	5.56	4.09	[4.49, 6.63]	5.73	3.74	[4.75, 6.70]
Art	5.64	3.46	[4.74, 6.55]	6.10	3.59	[5.16, 7.04]
MT[2]						
Green	6.68	3.78	[5.68, 7.69]	6.02	3.14	[5.18, 6.85]
Art	6.33	3.72	[5.35, 7.32]	6.37	3.67	[5.40, 7.34]

Note. 95 % CI = 95 % confidence interval.
[1] $n = 59$.
[2] $n = 57$.

way (2 × 2) mixed ANOVA, using the PRS scores as the dependent variable and *Intervention type* and *Street*, as well as the interaction between the two factors as independent variables. We note that all subsequent ANOVAs in this section have the same structure. The results showed a significant main effect of *Street* ($F(1, 104) = 7.27, p = .006, \eta_p^2 = 0.072$). Considering the descriptive statistics, MT was evaluated as more restorative than BG.

3.3.2. *Appraisals of the street intervention*

Descriptive statistics for the variables targeted in this section are

Table 5
ANOVA statistics for the MOS score.

Fixed effect	F(1114)	p	η_p^2
Street	1.60	.209	.014
Condition	0.10	.757	.001
Time	< 0.01	.996	< 0.001
Street*Condition	0.10	.757	.001
Street*Time	1.83	.179	.016
Condition*Time	1.18	.280	.010
Street*Condition*Time	0.20	.651	.002

Note. $N = 116$.

shown in Table 6. Considering all scales were ranging from 1 (not at all) to 7 (very much so), on average, the participants' evaluations of the intervention tended to be positive.

We performed a series of two-way (2 × 2) mixed ANOVAs, separately for each scale. Note that we applied Bonferroni-Holm corrections to the *p*-values in order to correct for multiple comparisons. The results suggested no significant effects (see Supplementary Material Table S5 for the full ANOVA statistics).

3.3.3. *General walking experience*

The descriptive statistics for the variables targeted in this section are shown in Table 7.

The statistics of the two-way mixed ANOVAs suggested no significant effects (see Supplementary Material Table S6 for the full ANOVA statistics).

3.4. *The relationship between personal appraisals, personal traits, and well-being*

In this section, we assess how appraisals of testing location, intervention, and general experience as well as personal traits of the participants are related to improvements in well-being. To this end, Spearman's rank correlation scores were computed between improvements in well-being and each appraisal score. We note that the general stress levels (PSS) and evaluation for the perceived duration of the experiment ("It was too long") were excluded from the following analysis, as they were collected as a control variable which can potentially influence the results of ANOVAs and as a score to evaluate the study setting.

We note that improvements in well-being are defined as the difference between pre and post measurements. Specifically, for negative well-being measures (i.e., anxiety, stress level, negative mood), well-being benefits were computed by subtracting the pre-score from the post-score. Hence, when the negative well-being scores improved, the value is greater than 0, e.g., 30 (pre-score) – 20 (post-score) = 10. On the other hand, to facilitate the interpretation of the results for the positive well-being measure (i.e., positive mood), well-being benefits were

Table 6
Descriptive statistics of appraisals towards the Graetzloase.

	Beauty	Liking	Meaningful	Reflection
BG[1]				
Art	4.46 [4.08, 4.85]	4.81 [4.43, 5.19]	3.35 [2.99, 3.70]	4.15 [3.77, 4.53]
Green	4.27 [3.88, 4.67]	4.81 [4.47, 5.14]	3.55 [3.13, 3.99]	4.44 [4.03, 4.86]
MT[2]				
Art	4.93 [4.60, 5.25]	5.33 [5.02, 5.64]	3.48 [3.05, 3.91]	4.41 [3.92, 4.90]
Green	4.81 [4.44, 5.19]	5.06 [4.73, 5.38]	3.54 [3.13, 3.95]	4.57 [4.14, 5.01]

Note. Numbers in brackets refer to 95 % confidence intervals (ICs) for the average scores.
[1] $n = 52$.
[2] $n = 54$.

Table 7
Descriptive Statistics for the General Experience of the Walk.

	Enjoyment	Duration	Meaningful
BG [1]			
Art	4.87 [4.46, 5.27]	2.10 [1.64, 2.55]	4.35 [3.92, 4.78]
Green	4.83 [4.48, 5.17]	1.69 [1.39, 1.99]	4.27 [3.86, 4.67]
MT [2]			
Art	5.22 [4.91, 5.53]	1.81 [1.50, 2.13]	4.41 [4.03, 4.78]
Green	5.19 [4.78, 5.59]	2.07 [1.67, 2.48]	4.26 [3.81, 4.71]

Note. Numbers in brackets refer to 95 % confidence intervals (ICs) for the average scores.
[1] $n = 52$.
[2] $n = 54$.

computed by subtracting the post-score from the pre-score. Hence, when the positive mood increased after the experiment, the value is again greater than 0, e.g., 30 (post-score) – 20 (pre-score) = 10. Considering the previous operation and assuming a positive correlation between well-being benefits and rating scores, this means that people show greater well-being benefit, when their rating scores are higher.

Fig. 5 shows a correlation plot. We note that we used a Bonferroni-adjusted alpha level of $p = .00064$ (equal to $p = .05$ divided by 78 correlation tests) to control for multiple comparisons. As a general trend, improvements in well-being, especially in anxiety, were positively correlated with other well-being measures such as positive mood, negative mood, and stress. Additionally, negative mood and stress were interrelated, but showed no connection to positive mood. This suggests that certain facets of well-being develop in a co-dependent manner in response to an environmental stimulus. In a similar way, all appraisal scales were positively correlated.

Importantly, we found a positive relationship between appraisals and improvement in well-being. Specifically, perceived restorativeness (PRS) was positively correlated with improvements in anxiety and positive mood. Further, beauty and meaningfulness ratings of the intervention were also positively correlated with improvement in anxiety and positive mood. Enjoyment of walking experience was positively correlated with improvement in anxiety. Finally, VAIAK interest score was also positively correlated with reflection rating of the intervention.

4. Discussion

In this paper, we aimed to test if artistic interventions in urban street environments improve well-being and if this improvement is related to aesthetic appraisals of the environment. To this end, we tested the following hypotheses: (1) Both artistic and green elements in an urban street environment increase well-being. Further, the general level of well-being outcome is as good in artistic as in green interventions in both streets. (2) Despite the possible inter-individual differences, we expect that both art and green intervention positively impact the aesthetic evaluations, hence higher in liking, beauty, and meaningfulness compared to the reference line. (3) Improvements in well-being are positively related to the ratings of the environment.

The results from a series of ANOVAs for subjective well-being measures supported our first hypothesis. Specifically, our results provided evidence that the person's interaction with artistic intervention in an urban environment improved well-being as much as the interaction with a green one. Further, as the main effect of *Street* was not significant in terms of well-being improvement, the results pattern was the same regardless of the street. Hence, regardless of the testing environments, an artistic intervention improved well-being to the same extent as a green intervention. However, we note that our hypotheses were not fully supported. Negative well-being measures, i.e., anxiety, subjective stress level, and negative mood improved, while we observed no change in positive mood as well as in physiological stress measures.

Regarding positive mood, this result is in line with findings of past studies. For example, Trupp et al. (2022), assessing the impact of brief online interaction with art on well-being, reported similar results. Specifically, after the online interaction with an artwork, their participants reported to feel less anxious, less negative, and less lonely. However,

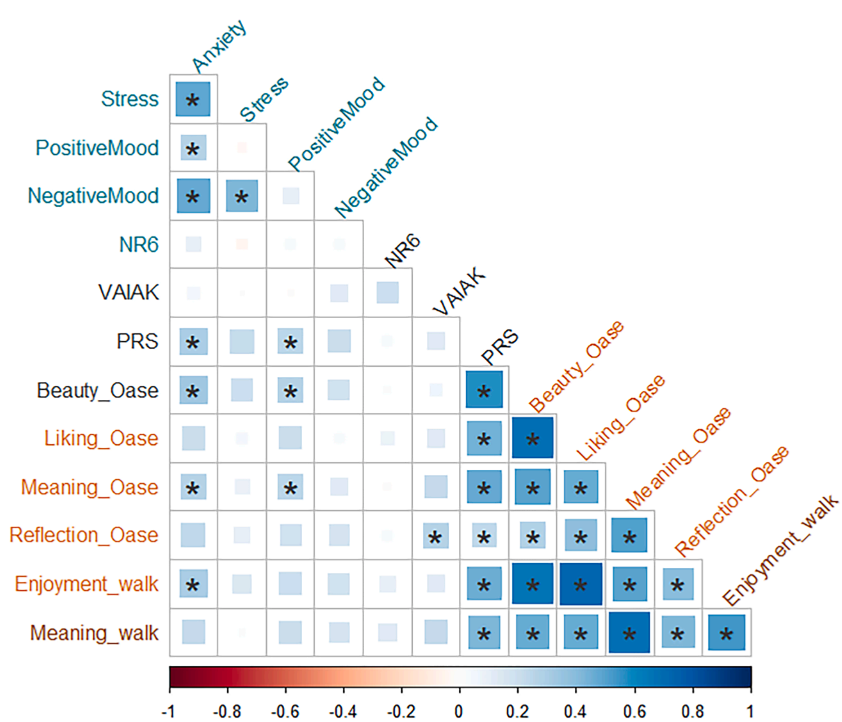

Fig. 5. Correlation plot for well-being improvements and selected measurements
Note. * Significant correlation with an alpha level of 0.00064. Well-being improvements are indicated by anxiety, stress level, positive mood, and negative mood; NR6 and VAIAK are grouped as personal traits; PRS refers to the restorativeness of the testing place; variables with the suffix "Oase" refer to the evaluation of the intervention itself, whereas variables with the suffix "walk" refer to the evaluation of the walking experience.

they did not find improvement in their positive mood. They argue that "It seems that both art and cultural engagement may be specifically better targeted at decreasing negative feelings while not as effective at increasing positive ones." (p.12). Our results further support this claim in a different context: not online interaction, but interaction in urban street environment.

Regarding stress reactions, identified by physiological responses (Kyriakou et al., 2019), these did not differ between the interventions and the study sites. Firstly, it is always a challenge to assess ambulatory physiological responses in the field due to environmental noises in the data. Secondly, this could be due to the algorithm being tailored to detect stress responses to acute and prominent stimuli, which are elements that our study setting, and the proposed interventions did not include. This is likely due to the small difference in EDA and ST variations, which may be caused by the highly dynamic urban environment. In other words, the stimulus induced by the artistic and green intervention may constitute a too weak anomaly to be detected by the algorithm. Lastly, it could be the individuality of each person's stress response and the fact that certain individuals are more stressed than others, without being exposed to any stimuli. It would be interesting to re-evaluate the study and compare the identified number of stress situations considering the individual-based algorithm proposed by Moser et al. (2023).

The descriptive statistics for the appraisals of the interventions show that the participants rated both artistic and green interventions as high in aesthetic evaluation (i.e., beauty, liking, meaningfulness, and reflection). Further, the result of ANOVA using the appraisal showed that there were no significant differences in those ratings between intervention type and street, hence our second hypothesis is supported.

Further, correlation analyses showed that some appraisals (i.e., restorativeness, beauty, meaningfulness, and enjoyment) were related to improvements in anxiety and positive mood. In line with this result, the result of ANOVA using PRS suggests that people in MT tended to evaluate the testing location as more restorative. This finding is again in line with past research showing that urban environments with greener elements are perceived as more restorative (e.g., Kaplan 1995). These findings partially support our third hypothesis, as not all of the ratings were related to the well-being benefit and imply that the above appraisals might be key in promoting well-being benefit. Those key variables have also been described by the past literature in art psychology: Restorativeness as well as beauty has been repeatedly detected as a factor predicting well-being improvement (e.g., Kaplan 1995, Martínez-Martí et al. 2018; Trupp et al., 2023) and meaningful experience has been found to predict well-being outcomes (Trupp et al., 2022, Trupp et al., 2023). In addition, Fekete et al. (2023) have reported that also enjoyment predicted well-being improvement. As these studies were conducted in different experimental settings, such as online art galleries or museums, their similar results seem to indicate that certain key factors for well-being can be generalized across different environments.

Lastly, the correlation matrix for the targeted well-being outcomes, selected personal traits, and evaluations of the environment reveals interesting relationships, which can be tested in the future. For example, among the well-being measures, anxiety appears to be a mutual link for the other well-being measures and the environmental assessments. This pattern can also be seen in restorativeness, which is related to both the appraisals and most of the well-being measures. Such a structure can provide an insight into future analysis methods. Specifically, there might be key variables, such as anxiety (well-being) and restorativeness (aesthetic value), which serve as *nodes* to connect other variables. It might be interesting to apply network modeling or SEM (Structure Equation Models) in a future study, to display the associations between those variables. This can further help us understand what aesthetic features are key in promoting well-being and understand the underlying mechanism.

Our testing settings and results have a high and direct relevance to urban planning and policy making. Firstly, using the mobile and flexible parklet type interventions in the present study provides practical benefits in city planning. Specifically, parklet-sized interventions open the possibility to provide widely accessible and freely available public spaces. They can be implemented in any urban environment, regardless of the size or density of the cities. Moreover, as they can be directly settled on streets/squares, there is no need to coordinate time to visit such places. Hence, although urban populations spend most their time inside and hence have limited time outdoors (e.g., Klepeis et al. 2001), such an intervention opens a possibility for more spontaneous interaction. This aspect might be even more positive for socio-economically deprived populations. Limited financial and social resources and/or multiple occupations can make it difficult to coordinate time to visit somewhere (e.g., Schwanen et al. 2008). Nevertheless, those who have limited time and access to interact with restorative environments are the populations that are at greater risk for mental and physical health issues (Roux, 2001; Wittchen and Jacobi, 2005) and could benefit most from these places. As such, if the spontaneous and brief interaction with the intervention could improve well-being, this would be an option to promote urban well-being, which would be available and accessible for a large proportion of the populations. This argument resonates with the findings of Ward Thompson et al. (2016) and Roe et al. (2013) who found that residents living in disadvantaged districts but with high levels of greenery, showed lower stress levels. Linking these findings with the present results (i.e., art brings the same level of wellbeing as green), the power of art could be also tested in the future in disadvantage area. Secondly, the combinations of the parklet-sized interventions equipped with art provide non-invasive, non-pharmacological, and robust against seasonal tool to promote urban well-being in public spaces. As our results showed that artistic interventions can enhance well-being to the same degree as green interventions, art can be an alternative tool, for example, during the Winter seasons, as it does not get influenced by seasonal effects. We note that we don't aim to claim art should alter green elements in urban environments, especially because nature in cities not only promote urban well-being, but also contribute to the ecological quality and urban environment health (Andreucci et al., 2021), such as reducing heat island effects (Kleerekoper et al., 2012). We hope that this study highlights the potential of art not only as cultural resources, but also as another tool to promote urban well-being, which can go hand in hand with other elements in urban environments, such as nature and greenery.

To establish art as a solid tool to promote urban well-being in urban planning or policy making, further investigation is necessary to validate the effect, as this study also comes with limitations. Firstly, although our studies were carried out in two different urban street contexts to assess the generalizability of our findings, this study is one of the first examples of testing the impact of art in urban space contexts. Hence, in the future, the results should be replicated in different places. Secondly, we only used one set of artworks, designed by one artist. Accordingly, we cannot conclude if the effects of the artistic stimuli can be generalized across other artworks. Hence, further replications with different sets of artistic stimuli are needed to validate our findings.

Overall, our results are among the first to demonstrate that artistic interventions can enhance well-being to the same degree as green interventions. This finding offers a novel venue for urban planning and strongly warrants further research by highlighting the potential of human-made components to promote well-being in urban settings.

Ethics statement

This study was approved by the local ethical committee of University of Vienna (reference number: 00573), following the Declaration of Helsinki.

CRediT authorship contribution statement

Jan Mikuni: Writing – review & editing, Writing – original draft, Visualization, Validation, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Margot Dehove:** Writing – review & editing, Methodology, Investigation, Data curation, Conceptualization. **Linda Dörrzapf:** Writing – review & editing, Software, Resources, Methodology. **Martin Karl Moser:** Writing – review & editing, Software, Methodology, Investigation, Conceptualization. **Bernd Resch:** Writing – review & editing, Software, Resources, Conceptualization. **Pia Böhm:** Writing – review & editing, Investigation, Conceptualization. **Katharina Prager:** Writing – review & editing, Investigation, Conceptualization. **Nikita Podolin:** Writing – review & editing, Investigation, Data curation. **Elisabeth Oberzaucher:** Writing – review & editing, Supervision, Project administration, Methodology, Funding acquisition, Data curation, Conceptualization. **Helmut Leder:** Writing – review & editing, Supervision, Project administration, Methodology, Funding acquisition, Conceptualization.

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.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.wss.2024.100215.

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