

# Using artificial ground color to promote a restorative sidewalk experience: an experimental study based on manipulated street view images

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## Abstract

Color is frequently used in urban outdoor spaces, but little research has studied its psychological effects. This study explores the influence of sidewalk floor color on the restorative walking experience in a busy, inner city street lacking natural greenery. We used an achromatic street view image with no vegetation or trees as control. Red, green, and blue were used as “artificial” intervention colors in the sidewalk ground plane to generate 3 visual stimuli. Participants (n=66) rated the perceived restorativeness of the scene and their subjective mood on viewing each image via an online survey. The results indicate “artificial” green ground color, e.g. provided by paint or colored material, promoted a more restorative walking experience enhancing hedonic tone and arousal and increased relaxation more than red ground color. All three color-interventions improved perceived restorativeness and arousal. This study advances the understanding of the psychological impact of color in urban design.

**Keywords:** *Urban design, psychology, walking environment, perceived restoration, ground color*

## INTRODUCTION

In the built environment, colors have been used in various situations and the psychological effects of colors include effects on happiness, relaxation, and arousal (Güneş and Olguntürk 2020; Akers et al. 2012). However, most of these studies look at interior space; little research has focused on the psychological effects of colors in outdoor urban environments.

Walking in a lacking-greenery urban environment with historical elements and various architectural features can be restorative as walking in a natural environment (Lindal and Hartig 2013; Karmanov and Hamel 2008). Restorative environments are the settings that facilitate recovery from mental fatigue or stress and elicit positive affective states. *Attention Restoration Theory* (ART) (Kaplan 1992) posits the 4 properties of a restorative environment: being away (being mentally away from daily routine which leads to mental fatigue), fascination (being attracted by fascinating stimuli in environment that employ our involuntary attention), extent (the environment is large enough to form “a whole different world”) and compatibility (the actions required by the environment fit with an individual’s inclinations). Being away and fascination were selected to be the metrics in this study.

Sidewalk ground surface plays an important role in the walking experience, as it has the direct, tactile contact with users and its features could affect user’s perception and behavior (Van Cauwenberg et al. 2016). However, no study has explored the effects of sidewalk ground color on mental wellbeing even colors have been extensively applied in transport projects to demark zones and convey information. We argue that there is a need to pay more attention to using color intervention (e.g., applying paint) in urban design to improve place quality, as it is more economical, feasible, and effective compared to other design approaches (e.g., urban vegetation).

In this study, we aim to use manipulated street view images to examine sidewalk ground color's effect on perceived restorativeness and affective wellbeing in an urban street scene lacking natural greenery. We tested the effects of red, green, and blue, which are most frequently applied in color psychology research. In previous studies, red increases arousal (Wilms and Oberfeld 2018), while green and blue are linked with positive emotional states such as hedonic tone (e.g., increased relaxation and happiness) (Bellizzi and Hite 1992; Wexner 1954). Based on these findings, we developed the following hypotheses for this study:

H<sub>1</sub>: Green sidewalk ground color is associated with a higher perceived restorativeness compared to other colors.

H<sub>2</sub>: Red sidewalk ground color is associated with higher arousal compared to blue, green and control (achromatic) color conditions.

H<sub>3</sub>: Green and blue sidewalk ground colors are associated with increased hedonic tone compared to red.

## **MATERIALS AND METHODS**

### **Participants**

All the participants were enrolled by online recruitment advertisement. In total, 66 participants completed the survey. Among them, 42 were females. The mean age was 26 (SD=4.6). All data collected were anonymous.

### **Stimuli**

We used manipulated street view images to simulate a walking environment. The street view was selected from Rheinstrasse, Darmstadt, an inner-city arterial street including 4 lanes for cars, a tram and bus corridor in the center, green buffers, and cycle and pedestrian infrastructure. It would, in our view, best represent Rheinstrasse as a typical arterial street in a medium sized European city. The street view photo was taken on an overcast winter day. Then, we used the image with major greenery removed as the control condition. Following this, we edited the sidewalk ground color by Photoshop with red (255, 0, 0), green (0, 128, 0), and blue (0, 0, 255), which are additive primary colors in the RGB color model. The intervention design was following the results from a visual realism test among 12 participants: the ground was covered by 40% transparency color with a white outline to demark the zone. Finally, 4 images were included for the study: control, red, green, and blue (Figure 1).



Figure 1: Control condition and red, green, and blue sidewalk ground color interventions.

### **Measurements**

Subjective mood states measures comprised hedonic tone, arousal, and relaxation. The mood assessments were conducted before exposure to image stimuli and after watching each image to measure mood change. The statement for each mood item was rated on a 9-point Likert scale (from 1 = "extremely disagree" to 9 = "extremely agree"). The three statements were: Hedonic tone: "I feel happy"; Arousal: "I feel energetic"; Relaxation: "I feel calm".

Perceived restorativeness is measured by the Perceived Restorativeness Scale – short version (PRS scale) (Berto 2005). Two statements corresponding to “fascination” and “being away”, which are two restorative properties of the environment in ART, were rated on a 9-point Likert scale (from 1 = “extremely disagree” to 9 = “extremely agree”). The statements were re-edited for the walking context (Fascination: “This place is fascinating and it is hard to be bored”; Being away: “Spending time here gives me a break from my day-to-day routine”).

## Procedure

All participants were required to do the online survey with a computer screen. They were first asked to standardize the screen settings regarding color, gamma, brightness, and contrast. After this, they did an online color blind test and the participants who did not pass it were excluded from the study. Then, the participants assessed their subjective mood state to create the baseline. Following this, the participants were shown 4 street view images in randomized order. They were asked to watch each image for at least 10 seconds to immerse themselves in the environment and then rate the street view image on perceived restorativeness and subjective mood state. Finally, they were asked to provide information about gender, age, and familiarity with Rheinstrasse.

## RESULTS

Mood change scores were obtained by subtracting baseline score from post test score after viewing each image. A series of repeated measures ANOVA were used to identify significant differences in mood change scores and PRS ratings between intervention conditions. Partial eta squared was used to present effect sizes for each comparison. Mauchly’s W test of sphericity was significant in the hedonic tone, fascination and being away conditions, and sphericity is assumed in other conditions. The Greenhouse Geisser correction was used to report adjusted degrees of freedom for the hedonic tone, fascination and being away outcomes. We used an alpha level of .05 for all statistical tests.

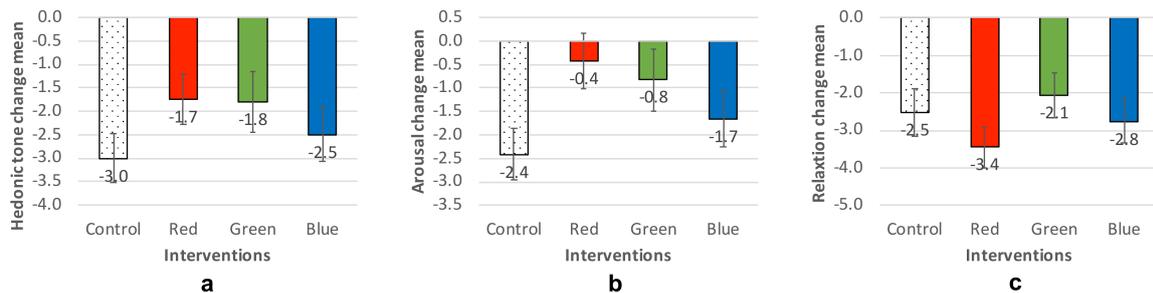


Figure 2: Hedonic tone change (a), arousal change (b) and relaxation change (c) per intervention. Error bars are shown (95% confidence intervals). A bar below zero denotes negative change and a bar above zero positive change. A higher score in hedonic tone indicates more perceived happiness; a higher score in arousal indicates more perceived energy; a higher score in relaxation indicates less perceived stress.

## Mood change

### Hedonic tone change

A repeated measures ANOVA showed a statistically significant difference in hedonic tone change between the red, green, blue and control sidewalk ground color interventions,  $F(2.550, 163.174) = 9.714, p < .001, \eta_p^2 = .132$ . The Bonferroni correction confirmed that the red and green sidewalk ground color interventions increased hedonic tone as compared to the control condition ( $p < .001$ ). The green

sidewalk ground color intervention enhanced hedonic tone as compared to blue ( $p = .008$ ). No significant differences were found between the other conditions (Figure 2a and Table 1).

### Arousal change

There was a statistically significant difference in arousal change between the stimuli,  $F(3, 192) = 25.361$ ,  $p < .001$ ,  $\eta_p^2 = .284$ . The Bonferroni correction shows confirmed that the red, green, and blue sidewalk ground color interventions enhanced arousal as compared to the control condition ( $p < .001$ ,  $p < .001$ , and  $p = .021$ , respectively). The red and green interventions increased arousal when compared to the blue intervention ( $p < .001$  and  $p = .005$ , respectively). No significant differences were found between the red and green interventions (Figure 2b and Table 1).

### Relaxation change

There was a statistically significant difference in relaxation change between the stimuli,  $F(3, 192) = 7.348$ ,  $p < .001$ ,  $\eta_p^2 = .103$ . The Bonferroni correction confirmed the red sidewalk ground color intervention decreased relaxation as compared to the control condition and green sidewalk ground color intervention ( $p = .033$ , and  $p < .001$ , respectively). No significant differences were found between the other conditions (Figure 2c and Table 1).

Intervention	M (SD)		
	Hedonic tone	Arousal	Relaxation
Pre intervention	6.3 (2.33)	5.6 (3.1)	6.8 (2.7)
Post control	3.3 (2.7)	3.2 (2.8)	4.2 (5.0)
Post red	4.3 (3.5)	5.2 (4.2)	3.3 (3.7)
Post green	4.7 (3.2)	4.8 (3.2)	4.7 (4.1)
Post blue	3.8 (3.6)	4.0 (3.5)	4.0 (4.4)

Table 1: Mean value with standard deviations (SD) in subjective mood state assessment pre and post stimuli.

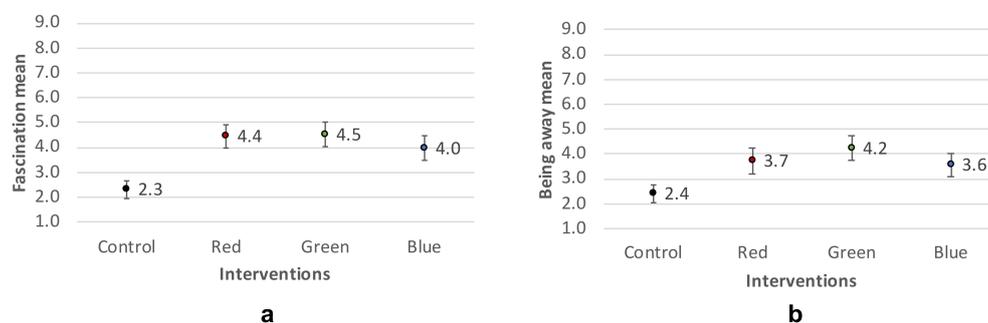


Figure 3: Mean rating scores of fascination (a) and being away (b) per intervention. Error bars are shown (95% confidence intervals). A higher score denotes higher perceived fascination and sense of being away.

## Perceived Restorativeness

### Fascination

There was a statistically significant difference in perceived fascination between the stimuli,  $F(2.647, 169.377) = 34.128$ ,  $p < .001$ ,  $\eta_p^2 = .348$ . The Bonferroni correction showed that all ground color

interventions were perceived as more fascinating than the control condition ( $p < .001$ ). The differences between the other conditions were not significant (Figure 3a).

### *Being away*

There was a statistically significant difference in perceived being away between the stimuli,  $F(2.619, 167.600) = 20.652$ ,  $p < .001$ ,  $\eta_p^2 = .244$ . The Bonferroni correction showed that all ground color interventions were perceived as more being away than the control condition ( $p < .001$ ). The green sidewalk ground color intervention was perceived as more being away than blue ( $p = .021$ ). The differences between the other conditions were not significant (Figure 3b).

## **DISCUSSION**

Our findings are generally consistent with previous literature findings as well as our hypotheses. Firstly, our results confirmed the positive effects of green color on psychological responses: the green sidewalk ground color intervention enhanced the perceived restorativeness of the street environment (i.e., being away and fascination) when compared to the control condition. The green intervention scored higher in hedonic tone and arousal as compared to the blue intervention and improved relaxation as compared to the red intervention. These findings are in line with  $H_1$  and partly with  $H_3$  and consistent with previous studies on the association between green color and positive emotions (Kaya and Epps 2004). Secondly, we observed the red sidewalk ground color enhanced energetic arousal when compared to either the control condition or blue intervention, which is generally in line with  $H_2$ , reaffirming the association of red environment with high arousal (Wilms and Oberfeld 2018). To our knowledge, these findings are for the first time shown with stimuli displaying urban street environment.

We also found that all the color interventions increased perceived restorativeness and arousal as compared to the control condition. The findings implicate that ground color interventions such as paint and colored surface material can enhance restorative quality, especially those lacking greenery, architectural variation, and cultural heritage. For arousal, green and red increased arousal more than blue, but no significant difference between green and red was found in this study, while some research show that red is associated with higher arousal, followed by green (Wilms and Oberfeld 2018). But our study embedded color in a real urban environment, while most studies on color and emotion used color stimuli without connections to reality (Kueller and Mikellides 1993) or in interior spaces. This finding suggests that psychological effects of color may vary with experiment scenes.

We observed that color interventions caused negative change on subjective mood states compared to that measured in a baseline test, which is different from previous studies. In this study, two-thirds of the participants had been to the selected street – Rheinstrasse, which is an inner-city arterial street in Darmstadt with a high traffic flow and noise. Traffic has been shown to be a negative element that decreases place quality related to mental wellbeing (Bornioli et al. 2018). Participants might associate their real walking experience when rating, which leads to negative affective changes. Despite the visual realism test, such large area monochromatic interventions are not common in urban environments, and we speculate that visual stimuli beyond daily experience may lead to negative mood changes. In addition, blue was not found to be associated with increased hedonic tone but slightly increased energetic arousal. These findings again suggest that the psychological responses to color embedded in a real environment will be different from those produced by color stimuli alone.

## **CONCLUSION**

This study reveals that in the urban street setting lacking greenery, green sidewalk color contributed to a more restorative walking experience and enhanced hedonic tone and energetic arousal. It also increased relaxation more than red. In addition, interventions with all three colors – red, green, and blue – improved perceived restorativeness and arousal in a street that lacks natural greenery. The green and red interventions enhanced energetic arousal more than the blue intervention.

The findings suggest that ground color interventions have the potential to be a further effective means of optimizing urban environmental qualities related to mental wellbeing, in addition to inserting much-needed natural green, as a complementing, cost-effective, and temporary response to streets that lack trees. The study provides a preliminary empirical basis for future urban outdoor space design.

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