

# 1 PSYCHOLOGICAL WELLBEING BENEFITS OF SIMULATED EXPOSURE TO FIVE 2 URBAN SETTINGS: AN EXPERIMENTAL STUDY FROM THE PEDESTRIAN'S 3 PERSPECTIVE

## 4 **Abstract**

5 The potential health benefits of walking in attractive, predominantly built-up urban  
6 settings have not received much attention from scholars, despite the global need to  
7 increase walking levels in cities. The current experimental study assessed the affective  
8 outcomes associated with several urban walking settings, with a focus on the presence  
9 of motor-traffic and architectural styles from different historic periods. We employed a  
10 mixed within-between subjects design (n = 269) with employees and students from  
11 Bristol (UK) and measured relaxation and hedonic tone experiences, perceived  
12 restorativeness, and environmental perceptions following exposures to one of five  
13 urban settings. Results identified three categories of affective outcomes, rather than  
14 the classic dichotomy 'urban vs natural': the simulated walks in areas with greenery  
15 rated significantly better than the others; however, the pedestrianised settings were  
16 associated with neutral or positive affective outcomes and perceptions, with  
17 statistically significant differences with an area with traffic. These results suggest that  
18 walking in high-quality urban settings can have positive outcomes, and highlight the  
19 negative role of traffic and the potential benefits of historic elements in the affective  
20 walking experience. From a policy perspective, findings strengthen the case for traffic  
21 removal, and indicate that exposure to high quality urban design that includes some  
22 natural elements can offer the same affective benefits offered by large green spaces.

## 23 **Key phrases and keywords:**

- 24 • Walking
- 25 • Affective benefits
- 26 • Psychological wellbeing
- 27 • Built environment
- 28 • Virtual walk experimental methodology
- 29 •

## 1. Introduction

31 There is growing consensus on the notion that built environments have an impact on  
32 the health and psychological wellbeing of individuals living or working in cities (e.g.,  
33 Frank et al., 2016; Frumkin, 2003). Research has shown that urban living is associated  
34 with increases in mood and anxiety disorders compared to rural living (Gruebner et  
35 al., 2017; Peen et al., 2010). The global trend is for populations to urbanise, with 66  
36 percent of the global population likely to live in cities by 2050 (United Nations, 2014).  
37 Therefore, understanding how built environments can support psychological wellbeing  
38 is a priority for research and practice, and strategies to improve urban dwellers'  
39 psychological wellbeing are needed. Walking is an activity that entails psychological  
40 wellbeing benefits (Gatrell, 2013; Robertson et al., 2012). Thus, exploring what factors  
41 can increasing urban walking could serve as a public health strategy that might  
42 subsequently have positive implications for the psychological wellbeing of individuals  
43 that reside in urban locations.

44 However, settings vary in the extent to which they support particular activities, and the  
45 benefits of walking are moderated by the environments in which this is performed (e.g.,  
46 Johansson et al. 2011). In this respect, a rich body of research attested that walking  
47 in natural spaces entails psychological wellbeing benefits (Hartig et al., 2003; Tilley et  
48 al., 2017; Van den Berg et al., 2003). Nevertheless, opportunities to visit green spaces  
49 during everyday life are limited for urban dwellers, and experiencing nature is a 'rarity'  
50 for most, as attested by a British research (Cox et al., 2017). It is, therefore,  
51 increasingly important to explore which characteristics of current built environments  
52 support psychological wellbeing in everyday situations, specifically during walking.  
53 The current study addresses part of the gap in the literature by comparing  
54 experimentally the moderating effect on psychological variables of virtual exposure to  
55 five urban walking settings in the city centre of Bristol, UK. The virtual walk  
56 experimental methodology is well established in psychological research, with  
57 numerous applications in the investigation of the affective benefits of walking in natural  
58 settings within psychology and public health research (e.g., Gatersleben and Andrews,  
59 2013; Van den Berg et al. 2014). However, it has hitherto had limited application in the  
60 field of transport studies (with some exceptions: e.g., Johansson et al., 2016). The  
61 experimental virtual walk methodology offers an effective way to study the impact of

62 built environment characteristics on walking experiences and health outcomes. The  
63 findings offer practical recommendations for planning and design strategies to improve  
64 the affective walking experience in cities.

65 The affective construct is a specific aspect of the umbrella term psychological  
66 wellbeing (Ekkekakis, 2013), and refers to the so-called hedonic wellbeing (Ryan and  
67 Deci, 2001). Examining immediate wellbeing responses is important because positive  
68 affect can be beneficial to long-term health (Consedine and Moskowitz, 2007;  
69 Fredrickson and Branigan, 2005). In addition, affective experiences influence  
70 subsequent activities, with two general forms of behaviour elicited: approach (desire  
71 to stay and explore) or avoidance (desire to leave) (Mehrabian and Russell, 1974).  
72 Therefore, examining affective walking experiences produce important implications for  
73 the promotion of sustainable transport, as they might influence walking intentions and  
74 behaviours (Gatersleben and Uzzell, 2007; Johansson et al., 2016).

75 In environmental psychology, Russell's circumplex mode of affect (Russell, 2003;  
76 Russell and Barrett, 1999; Russell and Pratt, 1980) offers theoretical insights on the  
77 influence of environments on affective states, and defines core affect as "the most  
78 elementary consciously accessible affective feeling" (Russell and Barrett, 1999, p.  
79 806). An environment is automatically perceived in terms of two dimensions: *valence*  
80 (degree of pleasantness) and *arousal* (degree of intensity). Core affect can be  
81 unconscious and free-floating, or directed at something such that emotions originate  
82 (Russell and Barrett, 1999). Affective and emotional states include, for example,  
83 stress, energy, and happiness (Russell and Barrett, 1999).

84 In parallel, Ulrich's Stress Recovery Theory (SRT) (Ulrich, 1983; Ulrich et al., 1991),  
85 looks specifically at the stress-relieving and *restorative* properties of environments,  
86 hence focusing on stressed individuals. Restorative environments are defined as  
87 those settings that contribute to stress recovery and to positive affect in individuals  
88 with a depleted mental state. While Russell does not advance a hypothesis on the  
89 types of settings that support affect, according to Ulrich (1983), it is exposure to natural  
90 settings that promotes restoration, as opposed to exposure to urban environments.  
91 This idea is based on the psycho-evolutionary hypothesis that, having evolved over a  
92 long period in natural environments, humans have an innate inclination towards  
93 natural environments (Ulrich et al., 1991). SRT is complemented by Kaplan and

94 Kaplan's Attention Restoration Theory (ART) (Kaplan, 1987; Kaplan and Kaplan,  
95 1989), which rather than looking at affective outcomes focuses on attention fatigue  
96 (the depleted capacity to direct attention). ART holds that exposure to natural  
97 environments can promote greater cognitive restoration than exposure to built  
98 environments. Despite the focus on cognition, measures of perceived attention  
99 restoration are generally positively associated with affective restoration (e.g., Fornara  
100 2011; White et al., 2010); hence, perceptions on cognitive restoration are likely to say  
101 something about the affective potential of settings. According to Kaplan and Kaplan  
102 (1989), several properties can make an environment restorative, and these include:  
103 *being away* (feeling away from routine or demanding activities), *fascination* (being  
104 engaged without effort), *compatibility* (good fit between environments and one's  
105 purposes), and *scope* (the environment has sufficient content that it can occupy the  
106 mind for an extended period).

107 Building on the theories outlined above, extensive empirical research has assessed  
108 the affective benefits of walking in natural areas. This growing body of evidence has  
109 confirmed that walking in natural settings supports affect and restoration (e.g., Hartig  
110 et al., 2003; Roe and Aspinall, 2011; Tilley et al., 2017). Studies have also shown that  
111 incorporating natural elements in cities elicits affective and restorative outcomes  
112 (White et al., 2010; WHO, 2016) and improves perceived restoration of built settings  
113 (Lindal and Hartig, 2015; White et al., 2010; Nordh et al., 2009). Hence, there is  
114 general agreement on the notion that natural settings support walking and  
115 psychological wellbeing relatively more than built-only settings do. In addition, despite  
116 a discussion on the daytime-night time perspective was beyond the scope of the  
117 current research, it should be noted that the literature on the affective benefits of  
118 walking in natural settings refers to daylight situations, while walking in natural spaces  
119 at night time is likely to trigger safety concerns (e.g., Gatersleben and Andrews, 2013).

120 However, little attention has been given to the affective potential of walking in the full  
121 range of typically encountered non-natural built settings (as noted by Karmanov and  
122 Hamel, 2008; Velarde et al., 2007). Specifically, research studies assessing affective  
123 and restorative outcomes of walking in urban settings have tended to select locations  
124 with attributes defined negatively in sociocultural terms, e.g., urban *grey settings* such  
125 as commercial and industrial areas (Johansson et al., 2011), urban outskirts (Hartig et

126 al., 2003), or streets with heavy motor-traffic density (Kinnafick and Thøgersen-  
127 Ntoumani, 2014; Tilley et al., 2017; Van den Berg et al., 2014). Hitherto, and to the  
128 best knowledge of the authors, no current experimental study has involved comparing  
129 the psychological wellbeing potential of different urban walking settings including a  
130 *non-grey setting*. One exception is the study by Lindal and Hartig (2013), which  
131 examined the role of architectural variation and building height in several residential  
132 streetscapes on judgments of restoration likelihood. However, the study did not assess  
133 how these characteristics influence affective outcomes. The general lack of  
134 comparisons between different urban settings is partially related to the fact that urban  
135 settings were included as comparison groups in studies examining the affective and  
136 restorative potential of natural settings, rather than being the focus of research. As a  
137 consequence, the potential for some urban environments to offer affective benefits  
138 has been effectively ruled out despite there being a limited knowledge base, as already  
139 noted by some scholars (Karmanov and Hamel, 2008; Velarde et al., 2007). The  
140 current study aimed to reassess this generalisation about urban environments by  
141 focusing on two factors that might contribute to positive affective experiences in urban  
142 settings.

143 The first factor is motor-traffic. The literature indicates that walks in areas with traffic  
144 is associated with negative affective responses (e.g., Hartig et al., 2003; Johansson  
145 et al., 2011; Van den Berg et al., 2014). However, affective outcomes of walking in  
146 urban areas without traffic seem to have received little attention. Ulrich et al.'s (1991)  
147 research seems to be the only existing study comparing affective outcomes between  
148 pedestrianised areas and streets with traffic. However, Ulrich et al. (1991) found no  
149 significant differences between the two conditions in terms of fear, positive affect,  
150 sadness, and attentiveness, although there was a non-predicted difference in anger  
151 recuperation, which surprisingly was higher in the setting with traffic. Nevertheless, it  
152 is here hypothesised that exposure to urban environments with traffic will elicit  
153 negative affective responses, while exposure to pedestrianised urban environments  
154 will elicit positive affective responses.

155 The second factor of interest is the architectural style of built environments, specifically  
156 historic styles. Previous research has suggested that places with a strong historic  
157 value are perceived as restorative (Fornara, 2011; Hidalgo et al., 2006). These have

158 included museums (Kaplan et al., 1993), houses of worship (Herzog et al., 2010), and  
159 historic urban settings (Fornara, 2011; Galindo and Hidalgo, 2005). For example,  
160 Fornara (2011) reported that an urban historic-panoramic setting was perceived as  
161 restorative as an urban park, and more relaxing, pleasant, and restorative than a  
162 shopping mall. Along the same lines, Roe and Aspinall (2011) found that an urban  
163 walk had affective benefits among individuals with poor mental health, and speculated  
164 that the historic character of place might have played a role. The current study sets  
165 out to test Roe and Aspinall's (2011) suggestion that exposure to historic areas can  
166 support psychological wellbeing.

167 Addressing these two factors together, the current study employed an experimental  
168 design to compare affective outcomes of virtual exposure to several urban walking  
169 environments with different characteristics relative to motor-traffic and architectural  
170 style. It was hypothesised that urban settings without traffic would elicit affective  
171 benefits (H1) and would be perceived as restorative (H2), attractive and interesting  
172 (H3) as opposed to a *grey setting* (a commercial road with traffic). Among  
173 pedestrianised settings, it was expected that an historic environment would elicit  
174 greater affective benefits than a modern setting (H4).

## 175 **2. Materials and methods**

### 176 *2.1 Participants*

177 An online experiment was conducted with adults who work and/or study in Bristol, UK.  
178 Participants were 269 individuals (69.1% females) ranging from 18 to 67 years old ( $M$   
179  $= 31.69$ ,  $SD = 13.63$ ) and mainly White British (82%). One-hundred and twenty nine  
180 were undergraduate psychology students and 140 were employees of public and  
181 private organizations based in Bristol city centre. While the involvement of student  
182 samples is popular in restorative environments research (e.g., Van den Berg et al.,  
183 2014; Johansson et al., 2011; Karmanov and Hamel, 2008; Hartig et al., 2003), some  
184 study has highlighted that it presents some limitations, as results might not be  
185 generalizable to other populations (e.g., Bowler et al., 2010). Related to this, the  
186 current study involved an employee sample, in addition to the student one, in order to  
187 compare the findings with previous studies, whilst at the same time extending the  
188 existing body of research.

189 The study was approved by the faculty's Ethics Committee. Students involved in this  
190 study participated through an undergraduate psychology degree research methods  
191 course. Students who participate in studies receive a contribution to their course  
192 credits, but can choose which studies they participate in from a wide range. They could  
193 withdraw at any time and request deletion of their data up until an agreed date.  
194 Employees were approached via key contacts in organizations, such as staff travel  
195 managers, who facilitated the forwarding of an invitation email to internal staff lists,  
196 and did not receive an incentive to take part.

## 197 *2.2 Materials*

198 Five environmental simulations involving different videos, each of a walk in a single  
199 location were used. These consisted of five predominantly non-residential,  
200 recognizable areas in the city centre of Bristol (UK) that reflected one of five  
201 environmental conditions. Settings were selected to be equivalent in levels of  
202 maintenance and upkeep, complexity, and openness (Nasar, 2008). Three non-grey,  
203 relatively luminous, open and complex, clean and well-kept urban settings included:

204 Pedestrianised Historic Environment, hereafter *PedHist* (Figure 1). A cobbled, historic  
205 street (Corn Street) located in Bristol's Old Town. It is dominated by neoclassic  
206 buildings, of which four are listed as national heritage. The area has no evident  
207 greenery, apart from five small flowerpots that are attached to the Corn Exchange  
208 building.

209 Pedestrianised Modern Environment, hereafter *PedMod* (Figure 2). A modern street  
210 (Millennium Promenade) built as part of the Harbourside Masterplan. The area is a  
211 modern complex of residential buildings, cafes and restaurants. It has no evident  
212 greenery, with sporadically placed plants on the side of the road.

213 Pedestrianised mixed environment, hereafter *PedMixed* (Figure 3). A stone-paved  
214 pedestrian/cycle route (Deanery Street) located in the public open space of College  
215 Green. The route is framed on one side by Bristol Cathedral, and on the other side by  
216 a semi-open area with grass, trees, and lampposts. The route has some greenery,  
217 with trees and grass on the left side of the path.

218 Two settings were included as comparison stimuli: one was a *grey setting*, e.g., a  
219 commercial area with traffic, hereafter *CommTraf* (Figure 4). Located in the  
220 Broadmead shopping area of Bristol, it has many high street retail outlets and cafes.  
221 The road is one-way and supports bus stops, taxi ranks and special needs parking.  
222 Traffic is moderate, flow variable, but with a high density of diesel-powered buses,  
223 delivery vehicles and taxis. The other was an inner city urban park, hereafter *Park*  
224 (Figure 5). The environment is clean, well kept, and luminous, with sporadic trees on  
225 the side of the path.



Figure 1: PedHist



Figure 3: PedMixed



Figure 2: PedMod



Figure 4: CommTraf





226

227 **Figure 5: Park**

228 A one-minute video of a simulated walk was filmed for each environment, a tool which  
229 has been extensively used in the literature (Gatersleben and Andrews, 2013; Laumann  
230 et al., 2003; Van den Berg et al., 2014). Videos were filmed with a GoPro HERO 35mm  
231 camera during several weekday afternoons (1 pm to 4 pm) with cloudy but dry weather  
232 outside of busy commuting times in October 2015. The number of pedestrians was  
233 similar across locations, with settings not crowded (5 to 10 pedestrians per video).  
234 Videos were accompanied by an audio file containing the original naturalistic sounds,  
235 as the aural dimension is an integral part of the restorative experience (Conniff and  
236 Craig, 2016).

237 The goal of each video was to give the feeling of movement whilst avoiding vibrations  
238 and bumpy recordings that are not representative of natural walking. To this end, the  
239 camera was mounted on a bicycle with the experimenter pushing it whilst walking at a  
240 slow steady pace, akin to a comfortable walking speed. The video length reflected the  
241 standard time needed to walk through the case study areas (approximately 200-meter  
242 long streets). While previous research has presented the urban street condition as a  
243 collage of areas with varying traffic levels and architectural styles (Laumann et al.,  
244 2003; Van den Berg et al., 2014), the goal of the current research was to identify  
245 specific micro-qualities related to traffic and architectural style that could influence  
246 affective experiences. Hence, segments were purposively short in order to isolate such  
247 specific characteristics, whilst at the same time allowing for emotional reactions –  
248 which last “seconds to minutes” (Ekkekakis, 2013, p. 47).

249

250 2.3 Measurements

251 Measured affective states included *relaxation* and *hedonic tone*, from the University of  
252 Wales Institute of Science and Technology Mood Adjective Checklist (UWIST MACL  
253 scale) (Matthews et al., 1990). The two variables were selected due to relevance of  
254 stress/relaxation and pleasure/displeasure dimensions in the travelling experience  
255 (Anable and Gatersleben, 2005). The scale is based on Russell’s circumplex model of  
256 affect (Russell and Pratt, 1980). Each dimension is made up of four items measured  
257 on a 4-point Likert scale: hedonic tone (*hedtone*) is measured by happy, sad, content,  
258 sorry; relaxation is measured as relaxed, nervous, calm, edgy. Each variable (*hedtone*,  
259 *relaxation*) ranges from 4 to 16, with 16 corresponding to the maximum value given to  
260 each item. Measures were taken before and after watching the video.

261 Perceived restorativeness was measured by the Perceived Restorativeness Scale –  
262 short version (PRS scale) (Berto, 2005). The scale was included to compare the  
263 judged restoration likelihood of built-only settings to that of natural settings. It has four  
264 statements, each corresponding to one of Kaplan and Kaplan’s (1989) restorative  
265 properties, rated on a 7-point Likert scale. Measures were taken after watching the  
266 video. Statements were adapted to the walking context (Being away: “*Walking in this*  
267 *setting allows me to get away from it all and relax*”; Scope: “*Walking in this setting*  
268 *feels like being in a world of its own, where I can get completely involved and not think*  
269 *about anything else*”; Fascination: “*When I walk in this setting my attention is drawn*  
270 *without effort and my interest is engaged*”; Compatibility: “*Walking in this setting makes*  
271 *me feel comfortable and at ease*”).

272 Environmental perceptions included measures of attractiveness and interestingness  
273 (Karmanov and Hamel, 2008): *attractiveness* (ugly–beautiful, unpleasant–pleasant,  
274 unfriendly–friendly, unenjoyable–enjoyable, repulsive– inviting) and *interestingness*  
275 (uninteresting–interesting, average–exceptional, dull–exciting), both measured on a 5-  
276 point Likert scale. The scales were included to assess differences in environmental  
277 preferences between the non-grey and grey settings. Socio-demographic questions  
278 (age, gender, ethnicity) were also included.

279

280

281 *2.4 Procedure*

282 The web page contained general information about the study and a section to confirm  
283 participant consent to a) take part in the experiment and b) data being saved  
284 anonymously. Applying a between-subjects design, each participant was randomly  
285 assigned to one environmental condition. Participants were initially asked to complete  
286 the affective scale, and then to watch the video (with the following instruction: "*Please*  
287 *watch this 1-minute video. Imagine you are taking a walk in this environment during*  
288 *the daytime. Make sure the sound is switched on and set at a comfortable audible*  
289 *volume. If you can, please wear headphones*"). After the video, participants completed  
290 the affective scale for the second time ("*You just experienced an urban walk through*  
291 *watching the video. How did it make you feel?*") and the rest of the questionnaire. Data  
292 were analysed using SPSS 23.

293 **3. Results**

294 *3.1 Initial Conditions*

295 Despite the data not being normally distributed, analysis of variance (ANOVA) was  
296 used, as it assesses post-hoc comparisons between more than two groups. ANOVA  
297 is "robust" to violations of normality when there are at least 40 degrees of freedom and  
298 when group sizes are roughly equal (Field, 2009, p.360). The assumption of  
299 homogeneity of variances was met (Levene's test) for all variables in all settings ( $p >$   
300  $.05$ ). Partial eta square values were used to interpret size of effects (small effect with  
301  $\eta_p^2 = .01$ ; medium effect with  $\eta_p^2 = .06$ ; large effect with  $\eta_p^2 = .14$ , Cohen, 1988).

302 Within the current study, hedtone, relaxation, and PRS scale had very good inter-item  
303 reliability (Chronbach's alpha:  $\alpha = .789$ ;  $\alpha = .827$ ;  $\alpha = .896$  respectively). A series of  
304 one-way between-subjects ANOVAs and Chi-squared tests showed that there were  
305 no statistical differences between the five experimental groups in terms of socio-  
306 demographics and pre-test affective states (Table 1).

307

**Table 1: Pre-test differences in socio-demographics and affective states between the five experimental groups**

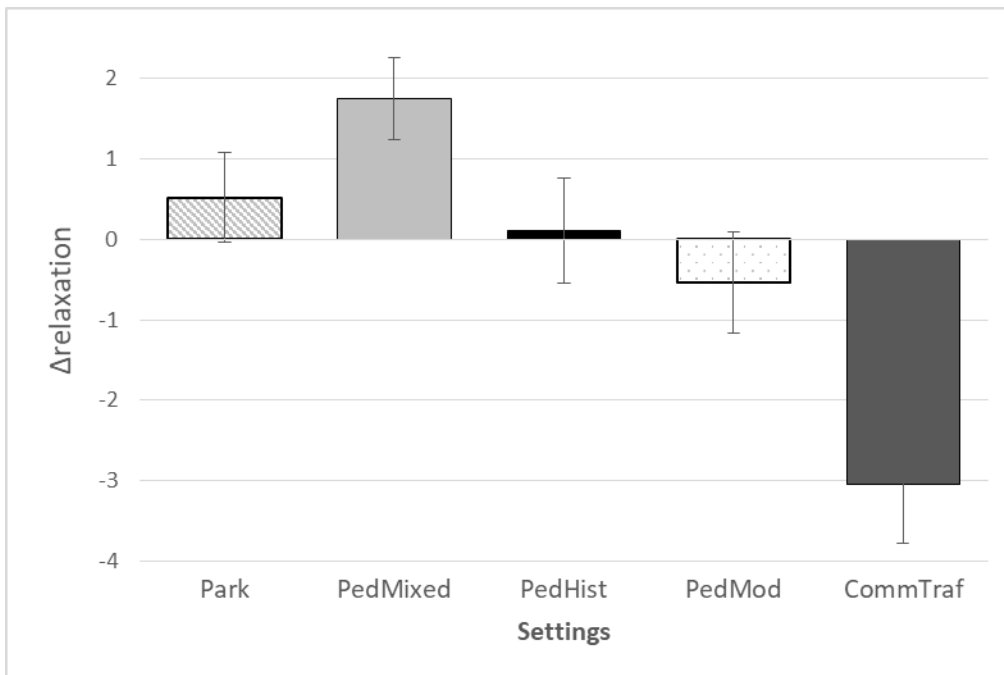
| Variable                         | <i>p</i> | Test          |
|----------------------------------|----------|---------------|
| <b>Socio-Demographics</b>        |          |               |
| <i>Age</i>                       | .343     | One-way ANOVA |
| <i>Gender</i>                    | .122     | Chi-squared   |
| <i>Ethnicity</i>                 | .110     | Chi-squared   |
| <b>Pre-test affective states</b> |          |               |
| <i>Hedonic tone</i>              | .800     | One-way ANOVA |
| <i>Relaxation</i>                | .639     | One-way ANOVA |

308 *3.2 Affective Experiences*

309 In order to test whether some built settings offered affective benefits (H1), a mixed 5  
 310 (setting – between participants) x 2 (test time: pre- and post- simulated walk – repeated  
 311 measure) ANOVA was conducted on relaxation and hedtone (thus also addressing  
 312 H4). Results are summarised below.

313 *3.2.1 Relaxation*

314 The mixed ANOVA revealed that the main effect of time was not statistically significant,  
 315  $F(1, 241) = 1.807, p = .180, \eta_p^2 = .008$ , but there was a statistically significant main  
 316 effect of setting with medium effect size,  $F(4, 238) = 7.689, p = .008, \eta_p^2 = .114$ .  
 317 Relaxation decreased in the commercial area with traffic ( $p < .000$ ) and increased in  
 318 the pedestrianised mixed environment ( $p < .000$ ). In Park ( $p = .123$ ) and the  
 319 pedestrianised historic setting ( $p = 1.000$ ) the increase in relaxation was non-  
 320 significant. In the pedestrianised modern setting there was a non-significant decrease  
 321 of relaxation ( $p = .144$ ). There was a statistically significant setting group x test time  
 322 interaction with a large effect size,  $F(4, 238) = 23.858, p < .000, \eta_p^2 = .286$ . Bonferroni  
 323 post-hoc tests indicated that the walk in the commercial area with traffic led to a  
 324 decrease in relaxation that was statistically different from the increase in the  
 325 pedestrianised historic ( $p < .000$ ), modern ( $p < .000$ ), mixed environments ( $p < .000$ ),  
 326 and Park ( $p < .000$ ). The walk in the pedestrianised mixed environment led to a  
 327 relaxation increase that was statistically different from the relaxation decrease in the  
 328 modern one ( $p = .001$ ) (Figure 6).



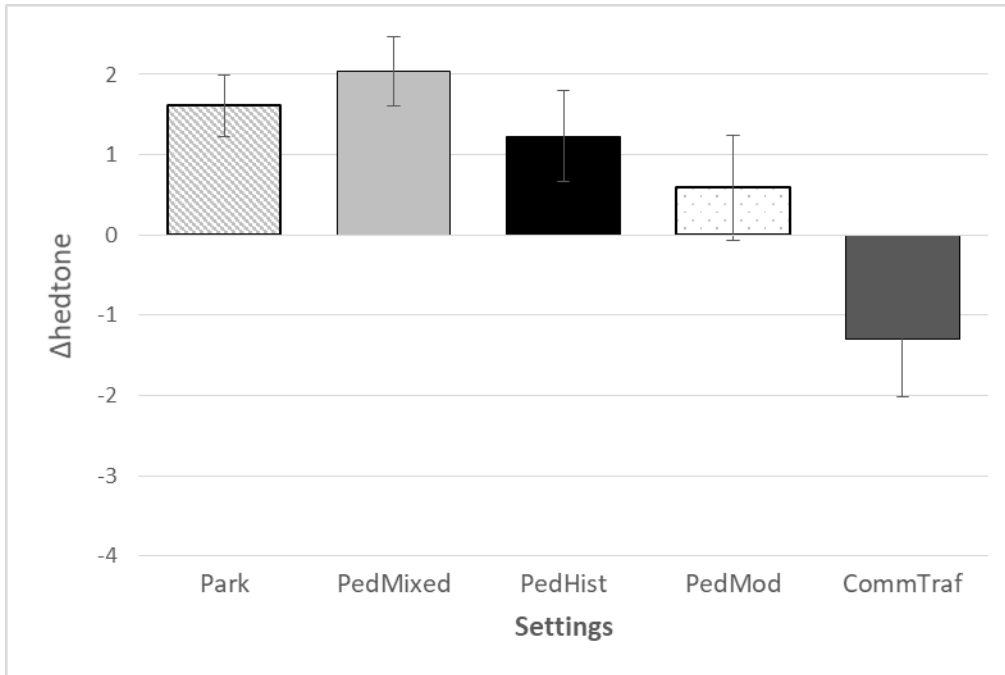
329

330 **Figure 6: Δrelaxation per setting**

331 **Note:** Difference between pre–post scores on relaxation scale in five settings. Maximum score is 16. The  
 332 y-axis shows the change in relaxation (post *minus* pre-test scores); a bar above the y-axis represents an  
 333 increase in relaxation. Error bars (95% confidence intervals) are shown. Park = inner city park; PedMixed  
 334 = pedestrianised setting with green and historic elements; PedHist = pedestrianised historic setting;  
 335 PedMod = pedestrianised modern setting; CommTraf = commercial area with traffic.

336 **3.2.2 Hedonic tone**

337 The mixed ANOVA revealed a statistically significant main effect of time with medium  
 338 effect size,  $F(1, 226) = 26.338, p < .000, \eta_p^2 = .104$ , and setting,  $F(4, 226) = 5.407, p$   
 339  $< .000, \eta_p^2 = .090$ . Hedonic tone increased in the pedestrianised historic setting ( $p =$   
 340  $.001$ ), pedestrianised mixed setting ( $p < .000$ ) and Park ( $p < .000$ ) and decreased in  
 341 the commercial area with traffic ( $p < .000$ ). In the pedestrianised modern environment,  
 342 the effect was non- statistically significant ( $p = .113$ ). There was a statistically  
 343 significant setting group x test time interaction with a large effect size,  $F(4, 226) =$   
 344  $13.637, p < .000, \eta_p^2 = .194$ . Bonferroni post-hoc tests indicated that the walk in  
 345 CommTraf led to a decrease in hedonic tone that was statistically different from the  
 346 ones relative to the pedestrianised historic ( $p < .000$ ), modern ( $p = .001$ ), mixed  
 347 environments ( $p < .000$ ), and Park ( $p < .000$ ). In addition, there was a statistically  
 348 significant difference between the walk in PedMod and PedMixed ( $p = .015$ ), with  
 349 PedMixed associated with a larger increase in hedtone (Figure 7).



350

351 **Figure 7: Δhedtone per setting.**

352 **Note:** Difference between pre–post on hedonic tone scale in five settings. Maximum score is 16. The y-axis  
 353 shows the change in hedtone (post minus pre-test scores). Error bars (95% confidence intervals) are  
 354 shown. Park = inner city park; PedMixed = pedestrianised setting with green and historic elements; PedHist  
 355 = pedestrianised historic setting; PedMod = pedestrianised modern setting; CommTraf = commercial area  
 356 with traffic.

357 **3.3 Perceived Restorativeness**

358 In line with H2, a high PRS score in the three *non-grey* urban settings was expected,  
 359 and a lower score in the commercial road with traffic setting. This was confirmed, as  
 360 participants rated positively the three pedestrianised settings, while the commercial  
 361 area with traffic was rated negatively. In line with the literature, the park was also rated  
 362 positively. In other words, all the non-traffic conditions were associated with perceived  
 363 restorativeness, as opposed to the traffic condition (Table 2).

364

**Table 2: Mean ratings (standard deviations) for PRS score, attractiveness, and interestingness across the five setting conditions**

| Setting  | M (SD)      |                |                 |
|----------|-------------|----------------|-----------------|
|          | PRS         | Attractiveness | Interestingness |
| CommTraf | 2.98 (1.18) | 2.41 (.72)     | 2.33 (.77)      |
| PedMod   | 4.09 (1.25) | 3.33 (.87)     | 3.04 (.89)      |
| PedHist  | 4.15 (1.14) | 3.48 (.60)     | 3.29 (.65)      |
| PedMixed | 4.95 (1.11) | 3.96 (.68)     | 3.59 (.49)      |
| Park     | 4.96 (1.18) | 3.71 (.72)     | 3.01 (.62)      |

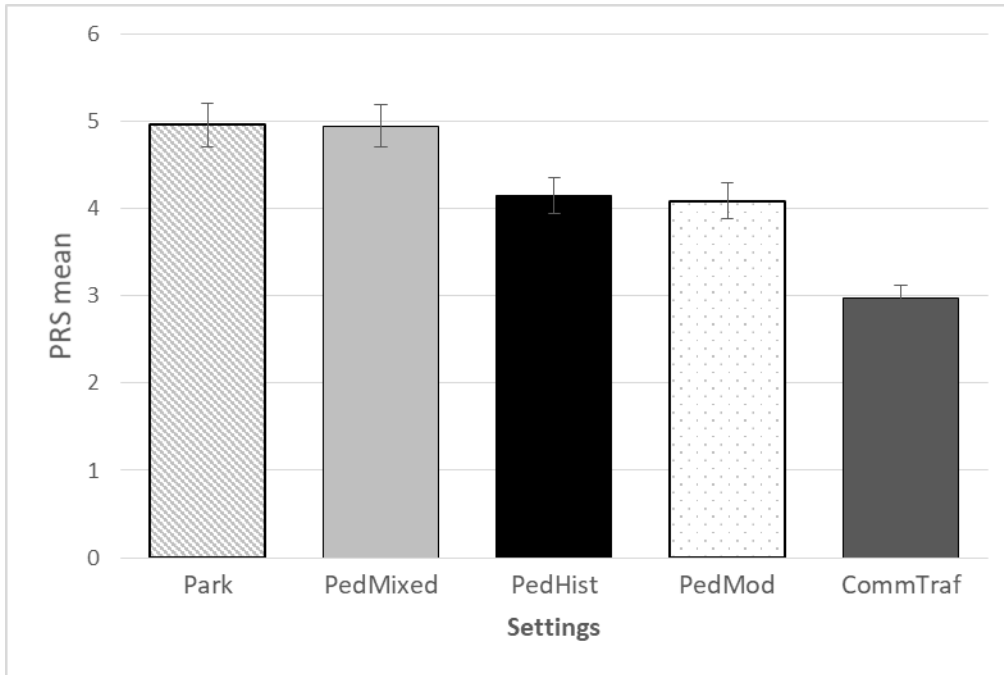
Mean (Standard Deviation)

PRS rated on 7-point Likert scale

Attractiveness and Interestingness rated on 5-point Likert scales.

Park = inner city park; PedMixed = pedestrianised setting with green and historic elements; PedHist = pedestrianised historic setting; PedMod = pedestrianised modern setting; CommTraf = commercial area with traffic.

365 A one-way between-subjects ANOVA was conducted to test for possible differences  
366 between settings in perceived restorativeness, and this identified a statistically  
367 significant main effect with a large effect size,  $F(4, 265) = 25.774$ ,  $p < .000$ ,  $\eta_p^2 = .283$ .  
368 Scheffe post hoc analyses indicated that the commercial area with traffic was  
369 perceived as statistically less restorative than the pedestrianised historic ( $p < .000$ ),  
370 pedestrianised modern ( $p < .000$ ), pedestrianised mixed ( $p < .000$ ), and Park ( $p <$   
371  $.000$ ). In addition, PedMixed was perceived as more restorative than PedMod ( $p =$   
372  $.009$ ) and PedHist ( $p = .021$ ). Park was perceived as more restorative than PedMod  
373 ( $p = .006$ ) and PedHist ( $p = .014$ ) (Figure 9).



374

375 **Figure 9: Perceived Restoration by setting and between-groups differences.**

376 **Note: PRS maximum score is 7 (single-column figure). Park = inner city park; PedMixed = pedestrianised**  
 377 **setting with green and historic elements; PedHist = pedestrianised historic setting; PedMod =**  
 378 **pedestrianised modern setting; CommTraf = commercial area with traffic.**

379 **3.4 Environmental perceptions**

380 In line with H3, it was expected that the *non-grey* urban settings would be perceived  
 381 as attractive and interesting as opposed to the commercial road with traffic. H3 was  
 382 confirmed, as participants regarded PedHist, PedMod, and PedMixed as attractive and  
 383 interesting, while CommTraf was perceived as not attractive nor interesting (Table 2).

384 Two one-way between subjects ANOVAs were conducted to test for possible  
 385 differences between settings in terms of attractiveness and interestingness. These  
 386 identified a statistically significant main effect of attractiveness also with a large effect  
 387 size,  $F(4, 268) = 35.485, p < .000, \eta_p^2 = .350$ , and of interestingness with large effect,  
 388  $F(4, 268) = 23.421, p < .000, \eta_p^2 = .262$ . Scheffe post hoc analyses indicated that the  
 389 commercial area with traffic was perceived as statistically less attractive than the  
 390 pedestrianised historic ( $p < .000$ ), modern ( $p < .000$ ), mixed environments ( $p < .000$ ),  
 391 and Park ( $p < .000$ ). CommTraf was also perceived as statistically less interesting than  
 392 PedHist ( $p < .000$ ), PedMod ( $p < .000$ ), PedMixed ( $p < .000$ ), and Park ( $p < .000$ ). In  
 393 addition, the pedestrianised mixed environment was perceived as statistically more  
 394 attractive than CommTraf ( $p < .000$ ), PedMod ( $p = .001$ ), and PedHist ( $p = .026$ ), and  
 395 statistically more interesting than PedMod ( $p = .004$ ) and Park ( $p = .001$ ).



#### 4. Discussion and Conclusions

397 The current study set out to investigate the immediate psychological wellbeing benefits  
398 of virtual exposure to different urban walking settings employing a mixed within and  
399 between-subjects experimental design. Settings included two pedestrianised streets  
400 with no evident natural elements (PedHist and PedMod), a predominantly built-up area  
401 with historic and green elements (PedMixed), one *grey setting* (an area with motor-  
402 traffic, CommTraf) and an urban park (Park). Results confirmed H1, as the simulated  
403 walks in PedHist, PedMod and PedMixed promoted an increase of hedonic tone, with  
404 the simulated walk in PedMixed also increasing relaxation levels. Conversely, the walk  
405 in the area with traffic decreased both relaxation and hedonic tone. H2 and H3 were  
406 also confirmed, as participants attributed higher perceived restorativeness,  
407 attractiveness, and interestingness to the simulated walks in the two pedestrianised  
408 settings compared to the traffic setting. Finally, H4 was partially confirmed, as PedHist  
409 scored relatively better than PedMod in relaxation and hedtone measurements, even  
410 though no between-settings differences were detected on any measure. These  
411 findings have relevance given the public health needs to create urban settings that  
412 support psychological wellbeing and to increase walking levels in cities. The  
413 implications are discussed in more detail below where they are placed in the context  
414 of the existing literature.

415 As noted above, the analysis revealed that there was a significant difference in  
416 affective outcomes, restorativeness perceptions, and environmental ratings between  
417 the simulated walks in the traffic environment and the two pedestrianised settings  
418 respectively. In ranking the five settings according to their affective and restorative  
419 potential, three categories of affective and restorative outcomes, rather than two (e.g.  
420 the classic dichotomy 'urban vs natural', e.g., Karmanov and Hamel, 2008), were  
421 highlighted. First, the two areas with green elements (Park and PedMixed). Second,  
422 the two pedestrianised areas with no evident greenery (PedHist and PedMod). Third,  
423 the *grey setting* with traffic (CommTraf). Importantly, the only simulated walk that was  
424 associated with negative effects and perceptions was the one in the area with traffic.  
425 Hence, the role of traffic emerges as key element linked to psychological wellbeing  
426 outcomes of walking. Arguably, motor-traffic could be the critical factor that caused the  
427 reduction in reported wellbeing in urban settings as identified by previous studies, as

428 these were performed in areas with medium to heavy traffic (e.g. Hartig et al., 2003;  
429 Johansson et al., 2011; Tilley et al., 2017). Several observational studies have attested  
430 the negative influence of traffic exposure on affective variables in the urban (Knöll et  
431 al., 2017) and residential context (Von Lindern et al., 2016). The current results  
432 suggest that traffic could also have a role in immediate affective walking experiences  
433 and be one of the common denominators for those studies that identified negative  
434 psychological effects following walks in urban settings.

435 On the other hand, the simulated walks in the two pedestrianised settings with no  
436 evident natural elements (PedMod and PedHist) were associated with neutral or  
437 positive affective outcomes, and were perceived as mildly restorative, attractive, and  
438 interesting, as opposed to the *grey setting* with traffic. This finding contradicts Ulrich  
439 et al.'s (1991) research that found that virtual exposure to an area with traffic was  
440 associated with higher anger recuperation compared to a pedestrianised area.  
441 Arguably, their results might have been related to the fact that the pedestrianised  
442 street was an outdoor shopping mall with a relatively high pedestrian flow (7 to 35  
443 pedestrians passing/min, Ulrich et al., 1991, p. 211), which might per se elicit stress  
444 and negative feelings for some participants (e.g., Evans, 1984). Hence, the current  
445 study reveals that exposure to some pedestrianised, non-crowded urban walking  
446 settings can support wellbeing despite the absence of major natural features. It should  
447 also be noted that the only walks associated with an increase in relaxation levels  
448 contained natural elements – a result which confirms theoretical and empirical claims  
449 on the stress relieving properties of nature (Kaplan, 1987; Ulrich, 1983).

450 Turning to H4, it was expected that virtual exposure to the pedestrianised historic  
451 environment (PedHist) would elicit greater affective benefits than exposure to the  
452 pedestrianised modern environment (PedMod). This was partially confirmed, as  
453 PedHist was associated with a significant increase of hedonic tone, while in the  
454 modern setting the increase was not significant. In addition, ratings for relaxation,  
455 perceived restoration, attractiveness, and interestingness were higher for the historic  
456 setting – even though no significant difference was detected between PedMod and  
457 PedHist on any measure. Hence, these findings are mixed, making it difficult for final  
458 conclusions to be drawn. However, both settings with historic elements (PedHist and  
459 PedMixed) scored positively on affective measures and environmental ratings. These

460 results partially confirm the idea that the historic character of place might contribute to  
461 restoration (Fornara, 2011; Galindo and Hidalgo, 2005; Hidalgo et al., 2006), and  
462 extend previous research by attesting that such benefits also seem to take place in  
463 urban walking settings. The fields of urban planning and heritage studies hold that  
464 historic places offer an engaging and symbolic narrative linked to the relational value  
465 of cultural heritage (Hayden, 1997; Lynch, 1981; Smith, 2006). Based upon some of  
466 the current findings, it is suggested that such a narrative may elicit affective benefits  
467 and relieve attentional fatigue. In fact, scholars have already claimed that historic  
468 architectural styles reflect individuals' place identity (Fornara, 2011) and hence  
469 support place attachment (Cerina et al., 2016).

470 In addition, H4 is also partially corroborated by scores in the pedestrianised settings  
471 with historic and green elements (PedMixed). In fact, in PedMixed the affective  
472 outcomes and PRS ratings were comparable to those in the park setting, against  
473 expectations. Previous research has found that the presence of grass, trees, and  
474 bushes in pocket parks (Nordh et al., 2009) increase restoration likelihood. However,  
475 the current study has found that PedMixed was as restorative as the park setting, a  
476 result which perhaps comes as a surprise considering that PedMixed is a  
477 predominantly built-up urban setting, whilst the park is predominantly natural. Indeed,  
478 in contrast, some authors have associated the amount of grass surface and park size  
479 with restoration likelihood (Nordh et al., 2009). Hence, it is possible that the historic  
480 character of PedMixed, which was also significantly more interesting than the Park  
481 setting, contributed to its affective and restorative benefits. This warrants future  
482 investigation to try to establish the degree of natural elements combined with the  
483 degree of historic elements that are required for an environment to have such an effect  
484 on wellbeing during walking.

#### 485 *4.1 Limitations*

486 There are limitations to the current study that need to be discussed. The first is related  
487 to the fact that this research was based on a simulation. Watching a video remains a  
488 proxy of walking, and the sensory experience is limited to the visual and aural  
489 dimensions, while research has indicated that other senses might represent important  
490 aspects of restorative and affective experiences (Conniff and Craig, 2016; Shaw et al.,  
491 2015). However, compared with photographic slideshows (Van den Berg et al., 2003;

492 Berto, 2005) using videos has the advantages of containing sound and reproducing  
493 the movement of walking in a more realistic way. In line with this, differences in  
494 affective measures between areas with and without traffic were significant and most  
495 had large effect sizes, giving an indication that the simulated walking paradigm was  
496 effective enough to elicit differences. Some previous research suggests that  
497 simulations offer a valid evaluation of restorative potential (Velarde et al., 2007) but  
498 are likely to underestimate restorative and affective benefits (Mayer et al., 2009).  
499 Hence, the current post-test assessments of affect might have *underestimated* both  
500 the negative effects of actual walking in areas with traffic and the benefits of actual  
501 walking in green areas. This could also explain why the increase in relaxation in the  
502 park setting was not significant. Future research could try to possibly extend these  
503 findings in a real-world scenario. A natural experiment (e.g. comparison in same area  
504 with traffic and during road closure) could also be performed to further test the effects  
505 of traffic on psychological wellbeing.

506 Second, findings are based on immediate self-reported data, which may be subject to  
507 response bias and may not reflect an enduring affective state. Nonetheless, previous  
508 research indicates that self-reported and physiological measures are generally  
509 consistent (Johansson et al., 2011). Future research could employ physiological  
510 measurements (e.g., Roe et al., 2013) and/or include stimuli with a longer time span  
511 in order to assess medium-term affective benefits. However, recent research has  
512 illustrated some challenges of using physiological measurements such as  
513 electroencephalogram (EEG), as these are not always consistent with participants'  
514 verbal accounts, so are best supported with participant interviews (Tilley et al., 2017).  
515 Therefore, mixed-methods designs that also include qualitative research are  
516 especially recommended. In addition, among the students it was not possible to  
517 determine whether participating in research was guided by intrinsic motivation.  
518 However, students who participated could choose from a wide range of research  
519 studies. In addition, the majority of respondents were from the employee group, and  
520 results extend previous research on psychological experiences of walking that was  
521 based exclusively on student samples (e.g. Johansson et al., 2011; Karmanov and  
522 Hamel, 2008), thus representing a strength of the current study.

523 Third, no significant differences between PedHist and PedMod were detected, against  
524 expectations. This is possibly due to the fact that PedMod was a high quality setting  
525 that can partially support wellbeing too, which is a finding in itself. Nonetheless, the  
526 current study did find that a setting with historic elements and little or no natural  
527 elements was associated with immediate affective benefits, thus confirming the  
528 potential of historic elements to support affect. Importantly, the current findings  
529 revealed that an urban street with traffic is not representative of all urban settings, as  
530 already noted by Staats et al. (2016). These results also warrant further research on  
531 the affective potential of the full range of urban settings, other than streets with traffic.  
532 Different kinds of environments in each category could be taken into account to extend  
533 these findings, with the ultimate aim of further improving the affective walking  
534 experiences in cities.

535 Fourth, it is possible that the affective outcomes were triggered by specific elements  
536 of the video stimuli. Despite settings were equivalent in terms of visual characteristics,  
537 number of passing pedestrians, and weather, city environments include a multitude of  
538 different sensorial features that are often unpredictable and uncontrollable, even more  
539 so than natural environments. In this sense, the simulation, as opposed to a field  
540 experiment, offered higher internal validity; future research might also employ virtual  
541 simulations to minimise confounding effects. Also, it is possible that perceived safety  
542 in particular might have influenced the experimental effect, as a trafficked road might  
543 be perceived as more dangerous than a traffic-free setting. In addition, despite  
544 participants were randomly assigned to the experimental conditions, it is possible that  
545 personal connections to place might have influenced the affective experience (see  
546 Ratcliffe and Korpela, 2016). For future investigations, qualitative research can offer  
547 useful insights to assess which specific elements of the experimental simulations –  
548 whether related to specific senses, perceived safety, or personal connections with  
549 place – have influenced the outcome (see Author hidden 2018a and 2018b).

550 Finally, it is possible that results might not generalise to rural inhabitants or non-  
551 Western cultures due to the varying values and conceptualisations of nature, motor  
552 traffic, and historic environments. For example, ethnic minorities or non-Western  
553 groups might have different perceptions over the historic features of the urban realm.  
554 In addition, results might not be generalizable to different age groups such as older

555 adults, who may have different perceptions of safety and comfort, and to night time  
556 situations, with recent research showing that at night walking perceptions are also  
557 influenced by the type of artificial light (Johansson et al., 2014). Therefore, future  
558 research could focus on different socio-demographic groups, geographical contexts,  
559 and light conditions. The affective outcomes of walking in urban settings at night time  
560 are particularly relevant, considering that walk commuting takes place in the dark for  
561 many urban dwellers.

#### 562 *4.2 Conclusions and Implications*

563 The current experimental study revealed that three daytime simulated walks in  
564 pedestrianised built-up settings led to a positive affective response and that the three  
565 settings were perceived as restorative, as opposed to a simulated walk in a *grey*  
566 setting – an area with motor-traffic. These results affirm the potential of some  
567 quintessentially urban walking settings to support immediate psychological wellbeing.  
568 In particular, exposure to a pedestrianised historic built area with no major natural  
569 elements elicited positive changes in hedonic tone and was perceived as more  
570 restorative than one area with traffic. Also, exposure to a pedestrianised area with  
571 historic and natural elements elicited an increase in relaxation hedonic tone, and was  
572 perceived as restorative as a park. Scholars and policy makers are already aware of  
573 the benefits of walking in nature as well as possible negative effects of walking in  
574 certain urban settings. This study, employing a simulated walk methodology, has  
575 shown that exposure to some urban pedestrianised walking settings have the potential  
576 to support affect, which is also among the predictors of behaviours (Mehrabian and  
577 Russell, 1974). This represents a first, important step in the examination of the  
578 psychological wellbeing outcomes of walking in urban, non-natural settings. Whilst  
579 previous research has attested that walking to work is associated with increased  
580 leisure time satisfaction (Chatterjee et al., 2017) and long-term psychological  
581 wellbeing (Martin et al., 2014), the current findings stress the importance of verifying  
582 the long-term effects of walking in positive urban settings, for example with longitudinal  
583 analysis on transport modes, environmental features, and health and wellbeing  
584 variables.

585 Practical implications related to public health, transport, and urban planning are also  
586 identified. First, the findings suggest that some of the benefits of being in nature can

587 be offered by the highest quality traffic-free, pedestrian-priority urban environments  
588 with greenery (such as PedMixed). Hence, when it is not possible to include large  
589 green spaces in the urban fabric, high-quality urban design can still promote  
590 psychological wellbeing. Related to this, the results also confirm that incorporating  
591 natural elements in predominantly built settings is a successful strategy for improving  
592 wellbeing and the daytime walking experience. Second, policymakers and planners,  
593 when designing the management of traffic and allocation of space for pedestrians,  
594 should consider the psychological wellbeing benefits associated with exposure to  
595 pedestrianised settings, as opposed to settings with traffic. This is particularly relevant  
596 in locations within urban areas with high existing levels of walking, or in  
597 neighbourhoods in which there is little access to natural and/or public open spaces.  
598 Third, walking practitioners and tourism bodies should consider the added benefits on  
599 psychological wellbeing of walking in historic places, and encouraging daytime walks  
600 in old towns and historic parks.

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