Original Manuscript

Environment and Behavior
1–28

DOI: 10.1177/0013916518788603
journals.sagepub.com/home/eab
SAGE

How to Waste a Break: Using Portable Electronic Devices Substantially Counteracts Attention Enhancement Effects of Green Spaces

Bin Jiang[1], Rose Schmillen[2], and William C. Sullivan[2]

Abstract

Overuse of portable electronic devices depletes one's attention capacity, a critical cognitive resource. Although contact with nature promotes attentional functioning, we do not know the extent to which exposure to nature and the use of electronic devices interact to promote or inhibit attentional functioning. In this study, 81 participants performed cognitive tasks and then were randomly assigned to one of four rest treatments: green settings with or without a laptop computer and barren settings with or without a laptop computer. Attention was measured three times. Analysis showed a significant effect for both setting and use of a laptop as well as a significant interaction between setting and laptop use. A further analysis controlling for time spent focused on the laptop screen produced similar results. The findings show that using an electronic device in green settings substantially counteracts the attention enhancement benefits of green spaces.

[1]The University of Hong Kong, Hong Kong SAR, China
[2]University of Illinois at Urbana–Champaign, USA

Corresponding Author:
Bin Jiang, Virtual Reality Lab of Urban Environments and Human Health, HKUrbanLab, Division of Landscape Architecture, Department of Architecture, The University of Hong Kong, 614 Knowles Building, Pokfulam Road, Hong Kong SAR, China.
Email: jiangbin@hku.hk

Keywords
electronic device, green space, barren space, short rest period, attentional functioning, urban environment

Introduction

Portable electronic devices make it easy to stay connected to people we care about from almost anywhere and provide easy access to information at a global scale. It is not surprising then, that it has become normal to see people staring into their screens no matter where they are: on a train, on a bus, in an office, on the street, or in a park.

Being constantly connected to the world through our electronic devices demands one of our most precious resources: our attention. This constant demand on our attention can leave us cognitively depleted and in need of restoration. One effective source of enhancing attention functioning is to be in, or have a view of, nature—spaces that contain vegetation (Kaplan, 1995; Li & Sullivan, 2016; Roe & Aspinall, 2011; Tennessen & Cimprich, 1995). We do not know, however, the extent to which engaging with electronic devices such as phones, tablets, or laptops affects attentional functioning while we are in nature-rich places.

We explore this issue through a randomized experimental design that compares attentional functioning with and without the use of a laptop in green and barren landscapes. We ask, "To what extent do green settings enhance attentional functioning while people are using laptop computers?"

Rapidly Increased Electronic Device Use

Excessive use of electronic devices has become a worldwide problem and its negative health consequences have been recognized by the World Health Organization (WHO, 2015). With the availability of the smartphone, iPad, Netbook, and laptop, we can be connected anywhere, from the beach to the bedroom, and still pursue work or leisure (Perlow, 2012). At the global scale, the estimated number of Internet users in 2018 is 4.02 billion and estimated time spent online in 2018 is approximately one billion years (Kemp, 2018). The excessive use of electronic devices is even more remarkable if we add usage of electronic devices unconnected to the Internet. In 2012, the average American consumed 13.6 hr of media per day that was not work related, sometimes simultaneously, such as the case of a person browsing the Internet while watching a television program (Short, 2013). By the end of 2016, 78% of U.S. adults owned a desktop or laptop, 95% of adults owned a cell phone, 77% of adults owned a smart phone, 51% of adults owned a tablet computer, and 22% owned an e-reader (Mobile Fact Sheet, 2017). With smart phones, high-speed cellular connections, and public hotspots, people can be connected to the Internet, and therefore to one another, almost everywhere they go. It is clear that hundreds of millions of people in contemporary society are deeply engaged with portable electronic devices across the world (Weiss, Baer, Allan, Saran, & Schibuk, 2011).

There are health risks associated with frequent use of electronic devices (WHO, 2015). Addiction to electronic devices is a growing issue around the world, and excessive use of electronic devices has been correlated with attention-deficit/hyperactivity disorder (ADHD) (Lee, Han, Kim, & Renshaw, 2013; Weiss et al., 2011). This addiction is more prevalent in people younger than 30 years of age, and even more common in persons younger than the age of 19 (Sahin, 2011), suggesting that this problem is likely to get worse in the coming decades.

Heavy reliance on electronic devices can negatively affect health and well-being in a variety of ways. Electronic device distractions reduce people's ability to pay attention, lower productivity, lead to procrastination, and jeopardize academic and work performance (Ai, 2012). Heavy use of electronic devices is correlated with mental health issues: loneliness, low self-esteem, and depressive moods (van der Aa et al., 2009), as well as alcohol, tobacco, and substance abuse (Lee et al., 2013). In addition, reliance on digital screens is changing the way we obtain and process information: A study in *Science* indicates the Internet is depleting our memory capability (Sparrow, Liu, & Wegner, 2011). Heavy reliance on electronic devices is also a source of anxiety and stress (Cheever, Rosen, Carrier, & Chavez, 2014). Studies suggest that overuse of electronic devices can be triggered by mentally demanding activities and that mental fatigue and stress can be caused by overuse of electronic devices, leading to a vicious cycle (Ai, 2012).

One of the greatest costs of being constantly connected to the world through digital technology is the demand it puts on our attention. Our attention is a limited resource: it fatigues with use and requires a period of rest before it is fully restored (Kaplan, 1995; Sullivan, 2015). As anyone who uses a smart phone, tablet, or computer knows, using electronic screens can be mentally distracting and fatiguing, leaving people feeling their attention depleted and their ability to focus reduced (Attia, Baig, Marzouk, & Khan, 2017; Swing, 2012).

Attachment to electronic devices may affect the ways humans interact with urban green environments. It is possible that when people are in an urban green space they may be immersed in a totally different world: the digital world delivered through electronic screens. This possibility has important consequences because of the impact green environments have on our ability to pay attention.

Nature and Attention

Recently, there has been considerable interest in examining the relationships between exposure to urban nature and human well-being (Frumkin et al., 2017; Jiang, Zhang, & Sullivan, 2015; Sullivan, Frumkin, Jackson, & Chang, 2014). One of the most influential works in this area of scholarship is Kaplan and Kaplan's attention restoration theory (Kaplan, 1995; Kaplan & Kaplan, 1989). Many studies have demonstrated the attention enhancement effects of spending time in nature (Beil & Hanes, 2013; Berto, 2005; Korpela, Ylen, Tyrvainen, & Silvennoinen, 2010; Pretty, Peacock, Sellens, & Griffin, 2005; Taylor, Kuo, & Sullivan, 2001). Exposure to a wide variety of natural elements and settings, even urban green settings, helps people recover from mental fatigue (Li & Sullivan, 2016; Wang, Rodiek, Wu, Chen, & Li, 2016).

The costs of low attentional functioning are considerable (Sullivan & Kaplan, 2015). A person who cannot focus his or her attention is likely to miss important details and have trouble remembering details. Compared with someone who is not mentally fatigued, a person with low attention functioning is more likely to be irritable, have trouble with self-management, struggle to resist temptations, and miss subtle social cues. When a person is mentally fatigued, he or she is less effective in pursuing goals and interacting with others (Kaplan, 1995). A person with depleted attention is more likely to say or do things he/she might later regret, which can affect relationships, work performance, and even personal goals such as losing weight or saving money. In short, we are not at our best when our attention is depleted (Kaplan & Berman, 2010; Kaplan & Kaplan, 2003; Kuo & Sullivan, 2001; Poon, Teng, Wong, & Chen, 2016; Sullivan & Chang, 2011).

There is clear evidence supporting the predictions of attention restoration theory for people in age categories across most of the human life span. Compared with their counterparts who spend time in low-nature urban settings, individuals who spend time in nature-rich urban settings are better able to improve their ability to pay attention (Berman, Jonides, & Kaplan, 2008). Children with ADHD performed better on attention tests after taking a walk in a park compared with taking a walk in a neighborhood or urban setting (Kuo & Taylor, 2004). In a study of 101 high schools in Michigan, schools with greener views from cafeteria and classroom windows had significantly higher graduation rates, standardized tests scores, percentage of students planning to attend a 4-year college, and fewer occurrences of criminal behavior (Matsuoka, 2010). A recent study reported positive association between tree density on a school campus and students' academic performance (Kweon, Ellis, Lee, & Jacobs, 2017). In another study, high school students were randomly assigned to classrooms with and without views to green spaces. The students in classrooms with green views performed significantly better on tests of attention than their peers without green views (Li & Sullivan, 2016). Exposure to vegetation and other forms of nature has also been shown to promote attentional functioning in adults, when photographs of green settings (Berto, 2005) or window views to green settings (Chang & Chen, 2005) were the stimuli.

To what extent does engaging with electronic devices affect attentional functioning for individuals in green spaces? Put another way, does engaging in a leisure activity with an electronic device in a green setting allow a person to reap the attention-enhancement benefits of such a space? To address this question, we conducted an experiment using a randomized controlled design in which individuals either used or did not use a laptop computer in a relatively barren or green space.

Method

Experimental Settings and Participants

We selected barren and green sites based on two criteria. First, each site had a nearby building with private indoor rooms of comparable size and layout. Second, the indoor rooms had to be less than a 2-min walk to both an outdoor barren setting and an outdoor green setting. We selected four barren settings in which participants saw no trees or other vegetation, only human-made elements such as parking lots, walls, or the sides of buildings (Figure 1). We also selected four green settings in which participants saw considerable vegetation, especially trees (Figure 2). All outdoor settings had wireless Internet access.

We used the software G*Power 3.0.10. to decide the appropriate sample size, which is a method suggested by the UCLA Institute for Digital Research and Education (n.d.). We set *effect size* at .5, *alpha error probability* value at .05, *power* value at .95, and found that the *total sample size* should be at least 40. To ensure a satisfactory power value, we adjusted the total sample size to 80, and in doing so produced a power value of .99. Eighty-one individuals participated in this study (50 females, 31 males). After we removed four outliers and one participant because it rained during the outdoor portion of the experiment, the power remained at .99.

Participants were recruited with flyers placed in various locations both on and off of the university campus. Individuals were not eligible to participate

Figure 1. The four barren settings to which participants were randomly assigned during the rest portion of the experiment.

in the study if they had consumed caffeine within the past 2 hr, alcohol within the past 12 hr, food or drink within the past hour, or tobacco products within the past hour. If prospective participants had been diagnosed with a mental illness, they did not participate in the study.

We excluded data from five individuals because it either rained during the outdoor portion of the experiment or because the participants' attention scores were more than 2 *SD*s from the mean. Participants' ages ranged from 17 to 35 years ($M = 20.76$, $SD = 3.02$). Participants' sociodemographic information is shown in Table 1.

Experimental Conditions

Participants were randomly assigned to one of four conditions: (a) a barren setting in which they used a laptop, (b) a barren setting with no laptop, (c) a green setting in which they used a laptop, or (d) a green setting with no laptop (Table 2).

Figure 2. The four green settings to which participants were randomly assigned during the rest portion of the experiment.

Procedure

After giving consent to engage in the experiment, participants reviewed the inclusion criteria to confirm that they had not consumed any substance that would affect their normal cognitive performance. To account for confounding factors, all participants completed a general background questionnaire to report their age, gender, race, native language, major of study, and self-reported chronic mental fatigue.

The experiment began in an indoor room in which only the facilitating research assistant and the participant were present. The experimental procedure involved only one participant at a time. Before the experiments, the indoor rooms were arranged in the same configuration and with a consistent room temperature. Participants sat at a table opposite the research assistant. Research assistants were trained to follow an identical procedure (Figure 3). In total, three research assistants administered the experiment to participants. No one research assistant was assigned to any one condition, such that there

Table 1. Demographic Characteristics of Participants.

Demographic variables	Number (percentage)
Gender	
Male	27 (35.5)
Female	49 (64.5)
Race	
African American	3 (3.9)
Asian or Pacific Islanders	45 (59.2)
Caucasian	21 (27.6)
Hispanic	5 (6.6)
Other	1 (1.3)
Native language	
English	36 (47.4)
Other	40 (52.6)

Table 2. Participants Were Randomly Assigned to One of Four Groups With Nearly Equal Representation.

	Laptop use	No laptop use
Barren setting	n = 19	n = 18
Green setting	n = 20	n = 19

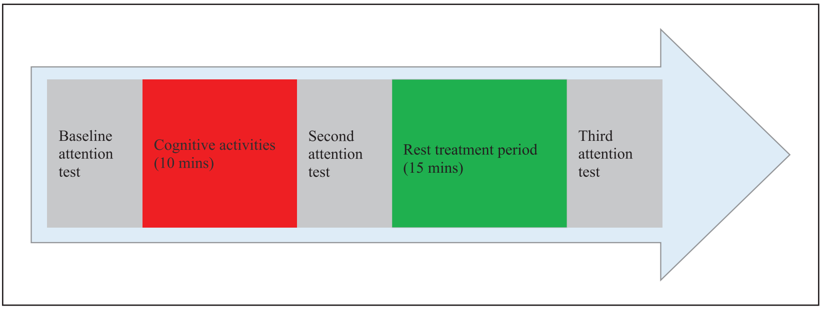

Figure 3. The procedure used in this experiment included five main activities.

was an even distribution of different research assistants to the four different conditions studied.

After collecting background information from participants, we assessed their attentional functioning with baseline attention tests described in the measures section below. Next, to induce a same level of cognitive load among participants, we required participants to engage in 10 min of cognitive activities. These activities included a 5-min proofreading task (Kaplan, 1995; Laumann, Garling, & Stormark, 2003; Li & Sullivan, 2016) and a 5-min subtraction task (Jiang, Chang, & Sullivan, 2014; Li & Sullivan, 2016).

For the proofreading task, participants were given sheets of paper covered in lines of seemingly random sequences of letters. Looking at one line at a time, they were instructed to memorize the first three letters in the line and then identify how many times that exact sequence of letters was repeated in the remainder of that line. They wrote the answer at the end of the line. The three-letter sequence was different for every line. Participants were told to complete as much of the task as they could within 5 min.

For the subtraction task, participants were given a four-digit number (e.g., 1,038) and asked to continuously subtract 13 from that number. If participants made an error, the research assistant instructed them to begin again. Following these activities, participants completed the attention tests for a second time.

The research assistant administering the experiment then took the participant to the assigned outdoor setting. All outdoor settings used were less than a 1-min walk from the indoor spaces. Participants were instructed to sit on a fixed chair or bench in the shade to maintain a comfortable temperature and to reduce screen glare for participants in the laptop group. Participants assigned to use their laptop were instructed to use their laptop in a manner similar to when they were taking a break. The break lasted 15 min.

The investigator left the assigned outdoor spot but remained approximately 50 to 75 ft behind the participant during the rest period. The distance and out-of-sight direction were chosen to avoid creating psychological stress on participants and to ensure the investigator could observe and take accurate notes on participants' behaviors and the environmental conditions during the break period.

We reinforced the notion of taking a break by asking participants not to use their laptops for anything related to work. Individuals in the laptop group were given the following list of suggested activities to reinforce the instruction that they were to use their laptops for leisure activities: social media sites, news sites, YouTube or other video-sharing sites, blogs, online games, online shopping websites, emails (unrelated to work).

Measures of Attention Functioning

Attentional functioning was assessed with the Digit Span Forward and Digit Span Backward tests of attentional functioning (Berman et al., 2008; Li &

Sullivan, 2016; Wang et al., 2016). Both tests required participants to repeat increasing lengths of digit sequences in forward or reverse order until they reached two consecutive failures at the same length. We recorded the number of correct trials before the two consecutive errors as a measure of attentional functioning. These tests have been used to measure attentional capacity, short-term memory, and working memory. Each of these measures was employed three times throughout the experiment: (a) at baseline, (b) after the cognitive activities, and (c) after the rest period.

Measures of Potential Confounding Factors

We measured three categories of potential confounding factors and controlled them in statistical analysis (Table 3). First, immediately before the experiment, participants were asked to answer five questions about their normal attention capabilities (Taylor et al., 2001). These include overall academic performance of the past 12 months, how well they started necessary tasks during the past week, how well they concentrated during the past week, how well they remained patient during the past week, and the frequency of having problems of memory, attention, or taking action during the past week.

Second, immediately after the experiment, participants were asked to answer two questions about their habit of using electronic devices. The questions measured (a) Hours of using electronic screen per week measured by the 10-cm Visual Analog Scale, which is defined by 11 anchors as 10 equal segments (Jiang, Li, Larsen, & Sullivan, 2016) and (b) Reliance on electronic screen for recreation or entertainment measured by the 5-point rating scale (*not at all, a little, somewhat, a lot*, or *very much*; Jiang, Larsen, Deal, & Sullivan, 2015). Third, participants reported the extent to which they used the laptop during the rest period and what portion of the rest period the laptop played sound measured by the 6-point rating scale (100%, 99%-75%, 74%-50%, 49%-25%, 24%-1%, or 0%). Finally, they reported how many types of laptop activities they participated in during the rest period (social media sites, news sites, YouTube or other video-sharing sites, blogs, online games, retail sites, emails unrelated to work, or other).

The experiment was conducted with one individual at a time between 8:30 a.m. and 5:30 p.m. when temperatures were between 70 and 86°F. The weather during the experiment was cloudy, partially cloudy and sunny, or sunny. The experiments were rescheduled when the temperature or weather did not meet these criteria. Data were collected during summer months in a university campus in the Midwestern United States to ensure that the green landscapes were lush and to ensure that the outdoor temperature was comfortable. Another reason for choosing summer time was because the campus

Table 3. Three Categories of Potential Confounding Factors Were Surveyed Before or After the Experiment.

Categories	Factors	*n*	*M*	*SD*	Range	Minimum	Maximum	Instrument
Normal attention capabilities	Overall academic performance of past 12 months	76	3.16	0.59	0-4	2	4	5-point rating scale
	How well to start necessary tasks during the past week	76	3.04	0.60	0-4	2	4	5-point rating scale
	How well to concentrate during the past week	76	3.20	0.57	0-4	2	4	5-point rating scale
	How well to remain patient during the past week	76	3.25	0.70	0-4	2	4	5-point rating scale
	Frequency of having problems of memory, attention, or action during the past week	76	1.11	0.84	0-4	0	4	5-point rating scale
Habit of using electronic device	Hours of using electronic screen per week	76	21.49	10.11	0-40	3	40	Visual Analog Scale with 11 anchors (0-40)
	Reliance on electronic screen for recreation or entertainment	76	2.92	0.83	0-4	1	4	5-point rating scale
Environmental/ behavioral factors of the experiment	Weather	76	1.38	0.54	0-2	0	2	3-point rating scale
	Temperature	76	76.47	7.48	0-120	65	86	Degree Fahrenheit
	How much of the rest period used the laptop	39	2.49	0.64	0-5	2	4	6-point rating scale
	How much of the rest period the laptop played the sound	39	1.41	1.48	0-5	0	4	6-point rating scale
	How many types of laptop activities participated in during the rest period	39	2.31	0.92	0-7	1	4	Seven fixed options and one open-ended option

Note. There were no missing data. The range is for the available range provided by the questionnaire or device.

Table 4. Descriptive Statistics of Three Attention Tests for Four Conditions.

		Baseline test			Second test			Third test		
Conditions	*n*	Range	*M*	*SD*	Range	*M*	*SD*	Range	*M*	*SD*
Green without laptop	19	5.0-9.0	6.50	1.20	4.5-9.5	6.32	1.11	5.0-10.0	7.24	1.37
Green with laptop	20	4.5-7.0	5.83	0.82	4.5-8.0	6.02	1.01	4.5-7.5	6.15	0.86
Barren without laptop	18	4.5-7.5	5.86	0.82	5.0-7.5	6.08	1.01	5.0-8.0	6.31	0.86
Barren with laptop	19	4.5-8.0	5.97	1.06	4.5-8.0	6.05	1.04	5.5-8.0	6.24	0.82

Note. The range is from measured minimum scores to measured maximum scores.

during the summer had few distractions caused by human activities compared with the spring or fall semesters.

Results

Results are presented in three sections. First, we provide descriptive statistics for three attention tests for each treatment condition. We compare the baseline and postactivity attention levels among the four conditions to ensure that there are no pretreatment group differences. Second, we explore the effect of the treatment conditions on participants' attention levels after the break and explore the possibility of an interaction between the conditions. Finally, we address behavioral factors that could have affected the results.

Pretreatment Attention Scores

To compare attention scores across groups, we created a summary attention score from the Digit Span Forward and Digit Span Backward tests and examined the mean differences among the groups before the cognitive tasks, after the cognitive tasks, and after the rest period. Table 4 includes the summary of main descriptive statistics of three tests for four conditions. Did the groups differ before being exposed to the treatment conditions? No, an ANOVA shows there were no significant differences among the attention scores at baseline, $F(3, 72) = 1.86$, $p = .144$. A repeated-measures ANOVA showed no significant differences in the participants' attention levels among the four conditions after participants engaged in the cognitive tasks, $F(3, 72) = 0.35$, $p = .793$. The

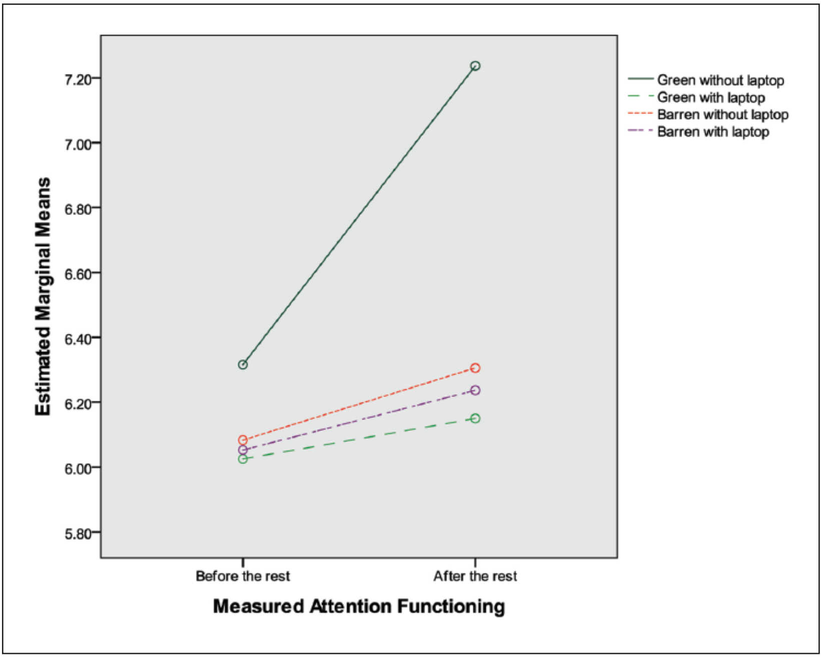

Figure 4. Changes in attentional functioning after the rest treatment for four conditions.

difference between scores of the baseline and second cognitive tasks are also not significant, $t(75) = -1.04$, $p = .303$. None of the groups had advantages or disadvantages before engaging in the cognitive tasks or before the break.

Effect of Four Treatment Conditions

Did the treatment conditions affect participants' attention? We expected participants' scores on attention tests would be higher after a 15-min break than immediately after the cognitive activities. And indeed, attention scores increased an average of 0.4 trials higher, a significant difference, $t(76) = 4.23$, $p < .001$. A multivariate ANOVA confirms there is a significant main effect for the four conditions, $F(3, 72) = 5.69$, $p = .002$, partial eta squared (ηp^2 hereafter) = .19. Further analyses found a significant main effect for setting (green vs. barren setting), $F(1, 72) = 4.14$, $p = .046$, $\eta p^2 = .05$, and a significant main effect for laptop use (with or without laptop), $F(1, 72) = 7.03$, $p = .010$, $\eta p^2 = .09$. Moreover, as can be seen in Figure 4, there is a significant

Table 5. Results of Paired-Samples *t* Test for Four Conditions (Comparison of Attention Functioning Before and After the Rest).

	n	*MD*	*SD*	*SE*	*t*	*df*	Significance
Green without laptop	19	−0.92	0.80	0.18	4.99	18	.001
Green with laptop	20	−0.13	0.63	0.14	0.89	19	.383
Barren without laptop	18	−0.22	0.65	0.15	1.46	17	.163
Barren with laptop	19	−0.18	0.65	0.15	1.24	18	.233

interaction between setting and laptop use, $F(1, 72) = 5.81$, $p = .019$, $\eta p^2 = .08$. The model passes the Levene's Test, $F(3, 72) = 0.35$, $p = .793$, indicating there is equal variance across four treatment conditions.

Do attention scores increase equally across all treatments? To answer this question, we conducted paired-samples *t* tests for each condition and, as can be seen in Table 5, the Green without laptop is the only condition that yielded a significant change in attention scores, $MD = -0.92$, $SD = 0.80$, $t(18) = 4.99$, $p < .001$.

We asked a further question, "Do the findings in Table 3 hold after considering four categories of potential confounding factors?" That is, when we add variables related to demographics, self-assessment of attention functioning, use of electronic devices, and weather conditions during the experiment, do the findings above change? To address this question, we ran a multivariate ANOVA in which these potentially confounding variables and the treatment conditions were included.

The results were indeed the same. We found a significant main effect for setting (green vs. barren setting), $F(1, 59) = 5.82$, $p = .019$, $\eta p^2 = .09$, and a significant main effect for laptop use (with or without laptop), $F(1, 59) = 7.97$, $p = .006$, $\eta p^2 = .12$. Moreover, as can be seen in Figure 4, there is a significant interaction between setting and laptop use, $F(1, 59) = 5.11$, $p = .027$, $\eta p^2 = .08$. Other potential confounding factors yielded nonsignificant results (Table 6).

The only condition that produced an increase of attentional functioning was a green setting in which the participants did not use a laptop. The model passes the Levene's Test, $F(3, 72) = 0.96$, $p = .417$, indicating there is equal variance across four treatment conditions. The pairwise comparisons show that Green without laptop condition yielded significantly better attention functioning than other three conditions. There were no differences among the other three groups (Table 7 and Figure 4).

The significant main effect of physical setting demonstrates that the green setting yielded better attention functioning than the barren setting. The

Table 6. Results of Multivariate ANOVA Analysis for Four Conditions.

Source	*df*	*F*	Significance	ηp^2
Gender	1	0.51	.479	.01
Age	1	0.01	.915	.01
Race	1	3.40	.070	.06
Language	1	1.28	.262	.02
Academic performance	1	1.58	.213	.03
Capability of starting tasks	1	0.13	.722	.01
Capability of concentration	1	1.29	.261	.02
Capability of remaining patience	1	0.01	.905	.01
Capability of memory	1	0.14	.711	.01
Hours per week of using e-device	1	0.64	.428	.01
Reliance of e-device for recreation/entertainment	1	0.49	.486	.01
Temperature	1	0.29	.595	.01
Weather	1	0.90	.347	.02
Laptop condition	1	7.97	.006	.12
Setting condition	1	5.82	.019	.09
Laptop × Setting	1	5.11	.027	.08
Error	59			
Total	76			
Corrected total	75			

Note. R-squared = .34 (adjusted R-squared = .15).

Table 7. Results of Pairwise Comparisons Show Difference Among Four Conditions on Attention Enhancement.

	Green without laptop	Green with laptop	Barren without laptop	Barren with laptop
Green without laptop	—			
Green with laptop	0.80*** (0.22)	—		
Barren without laptop	0.70** (0.23)	−0.10† (0.22)	—	
Barren with laptop	0.88** (0.24)	−0.06† (0.22)	0.04† (0.23)	—

Note. The results are presented as "mean difference (standard error)." The difference is presented as a column value minus a row value.
The significance levels of mean difference are marked as †$p \geq .05$. **$p < .01$. ***$p < .001$.

Table 8. Participants Were Randomly Assigned to One of Six Groups With Nearly Equal Representation.

	Laptop use (≥50% screen time)	Laptop use (<50% screen time)	No laptop use
Green setting	n = 8	n = 12	n = 19
Barren setting	n = 9	n = 10	n = 18

significant effect of laptop use demonstrates that the without laptop condition yielded enhanced attentional performance than the with laptop condition. The interaction and pairwise comparisons make clear that for a person's attention to be enhanced, it was not enough to be in a green space; people must be in a green space without engaging with their electronic device.

A Further Comparison Examining Six Treatment Conditions

Although we have found that laptop conditions yielded significantly different results on tests of attention, it is possible that participants' different amounts of time gazing at the screen contributed to these findings. To examine this possibility, we further divide the two laptop conditions based on the amount of time participants reported looking at their computer screen during the experiment. Data from the posttreatment survey showed that 17 (43.6%) of the 39 participants looked at their screen at least 50% of time while 22 (56.4%) participants looked at their screen less than 50% of time (Table 8). Thus, we divide participants' treatments into six conditions. The six conditions include (a) Green without laptop, (b) Barren without laptop, (c) Green with laptop (<50% screen time), (d) Barren with laptop (<50% screen time), (e) Green with laptop (≥50% screen time), and (f) Barren with laptop (≥50% screen time). Table 9 presents a summary of the main descriptive statistics of three tests for six conditions.

After this recategorization, we conducted paired-samples t test for each condition to see whether it yielded significant attention enhancement effects after the assigned rest treatment. Again, the results show the Green without laptop is the only condition that yielded a significant enhancement in attentional performance (Table 10).

Next, we ran a multivariate ANOVA analysis to examine the difference among six conditions. This analysis resulted in similar findings: After controlling for sociodemographic and chronic psychological factors, there is a main effect for laptop conditions, $F(2, 57) = 4.07$, $p = .022$, $\eta p^2 = .13$. However, the effect of setting conditions and the interactive effect between

Table 9. Descriptive Statistics of Three Attention Tests for Six Conditions.

		Baseline test			Second test			Third test		
Conditions	*n*	Range	*M*	*SD*	Range	*M*	*SD*	Range	*M*	*SD*
Green without laptop	19	5.0-9.0	6.50	1.20	4.5-9.5	6.32	1.11	5.0-10.0	7.23	1.37
Barren without laptop	18	4.5-7.5	5.86	0.89	5.0-7.5	6.08	0.77	5.0-8.0	6.31	0.84
Green with laptop (<50% screen time)	12	4.5-7.0	6.04	0.72	4.5-8.0	6.13	1.09	5.0-7.5	6.17	0.86
Barren with laptop (<50% screen time)	10	4.5-7.0	5.90	0.88	5.0-7.0	5.85	0.67	5.5-7.0	6.05	0.55
Green with laptop (≥50% screen time)	8	4.5-6.5	5.50	0.89	4.5-7.0	5.88	0.92	4.5-7.0	6.13	0.92
Barren with laptop (≥50% screen time)	9	4.5-8.0	6.06	1.29	4.5-8.0	6.28	1.35	5.5-8.0	6.44	1.04

Note. The range is from measured minimum scores to measured maximum scores.

Table 10. Results of Paired-Samples *t* test for Six Conditions (Comparison of Attention Functioning After and Before the Rest).

	n	*MD*	*SD*	*SE*	*t*	*df*	Significance
Green without laptop	19	−0.92	0.80	0.18	−4.99	18	.001
Barren without laptop	18	−0.22	0.65	0.15	−1.46	17	.163
Green with laptop (<50% screen time)	12	−0.04	0.75	0.22	−0.19	11	.851
Barren with laptop (<50% screen time)	10	−0.20	0.67	0.21	−0.68	9	.373
Green with laptop (≥50% screen time)	8	−0.25	0.38	0.13	−1.87	7	.104
Barren with laptop (≥50% screen time)	9	−0.16	0.66	0.22	−0.76	8	.471

laptop and setting conditions are nonsignificant. In addition, all potential confounding factors yielded nonsignificant effects (Table 11). The analysis passes Levene's Test, $F(5, 70) = 1.32$, $p = .267$. Furthermore, results of pairwise comparisons show the "Green without laptop" condition yielded significantly better attention performance than any of the other five conditions (Table 12 and Figure 5). There is no significant difference between any other pair of the five other conditions. These results further confirm physically being in a green space without engaging with an electronic device is the only condition that produced significant enhancement of attentional functioning.

Table 11. Results of Multivariate ANOVA Analysis for Six Conditions.

Source	*df*	*F*	Significance	ηp^2
Gender	1	0.43	.512	.01
Age	1	0.02	.887	.01
Race	1	3.34	.073	.06
Language	1	1.51	.224	.03
Academic performance	1	1.27	.265	.02
Capability of starting tasks	1	0.17	.681	.01
Capability of concentration	1	1.03	.314	.02
Capability of remaining patience	1	0.01	.921	.01
Capability of memory	1	0.06	.810	.01
Hours per week of using e-device	1	0.67	.416	.01
Reliance of e-device for recreation/entertainment	1	0.51	.479	.01
Temperature	1	0.18	.669	.01
Weather	1	0.92	.341	.02
Laptop condition	2	4.07	.022	.13
Setting condition	1	2.56	.115	.04
Laptop × Setting	2	2.40	.100	.08
Error	57			
Total	76			
Corrected total	75			

Note. *R*-squared = .34 (adjusted *R*-squared = .14).

Table 12. Results of Pairwise Comparison Analysis Shows Difference among Six Conditions on Attention Enhancement.

	1	2	3	4	5	6
1	—					
2	0.70** (0.23)	—				
3	0.88*** (0.26)	0.18† (0.26)	—			
4	0.72** (0.27)	0.02† (0.27)	−0.16† (0.30)	—		
5	0.67* (0.29)	−0.03† (0.29)	−0.21† (0.32)	−0.05† (0.33)	—	
6	0.75** (0.28)	0.05† (0.28)	−0.13† (0.31)	0.03† (0.32)	0.08† (0.34)	—

Note. The numbers indicate six conditions: (a) green without laptop, (b) barren without laptop, (c) green with laptop (<50% screen time), (d) barren with laptop (<50% screen time), (e) green with laptop (≥50% screen time), and (f) barren with laptop (≥50% screen time). The difference is presented as a column value minus a row value. The results are presented as "mean difference (standard error)."

The significance levels of mean difference are marked as †$p \geq .05$. *$p < .05$. **$p < .01$. ***$p < .001$.

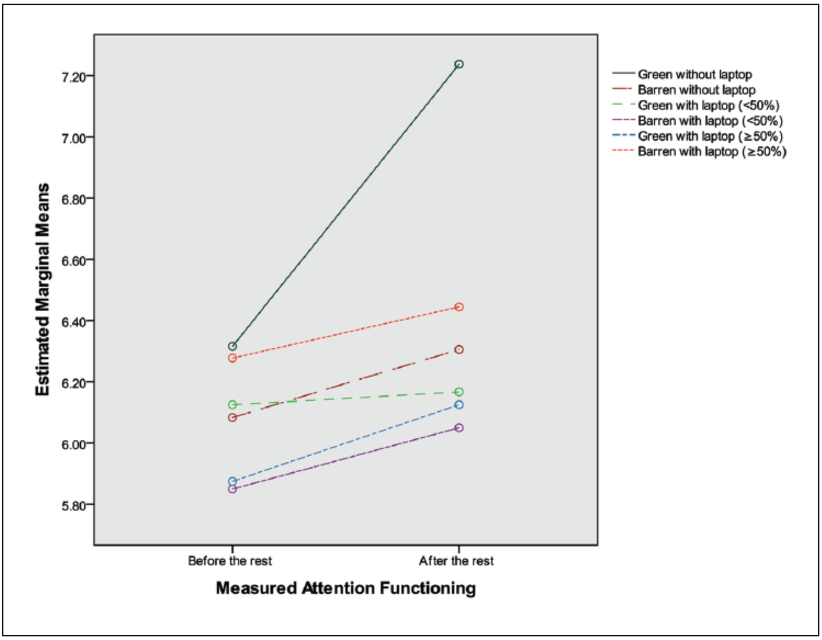

Figure 5. Changes in attentional functioning after the rest treatment for six conditions.

Discussion

In this study, 81 healthy adults were randomly assigned to outdoor spaces that had views to green or barren settings and, within those spaces, to either use their laptop computers for leisure activities or to sit and relax without using their laptops. At the end of the experiment, participants in the green view condition who did not use their laptops scored significantly higher on tests of attentional functioning than their peers in the other three conditions. There were no significant differences in attentional functioning after the break among participants in the Green with Laptop condition(s) or the two barren conditions. These findings establish a causal relationship: When individuals spend time in green outdoor environments without engaging their laptop computers, their attentional functioning improves. The same is not true for individuals who use their laptops in green settings or for those assigned to the barren environment. For these individuals, a 15-min break was the equivalent of no break at all.

Contributions

To the best of our knowledge, this is the first study to compare the combined effect of exposure to green landscapes and the use of electronic devices on attentional functioning. The findings demonstrate that the attention enhancement effects of green settings are undermined by the use of an electronic device. When individuals used their electronic device in a green setting, they did not experience the benefits to their capacity to pay attention that green spaces typically convey. That is, taking a break in a restorative setting while using a laptop had the same impact on attentional functioning as taking no break at all.

Why did taking a break in a green setting while using a laptop not result in higher attentional scores than participants who took a break in a barren setting? The green settings, after all, were quite green and these same settings produced significant improvements in attention scores for those individuals who did not use their laptop computers. The explanation is likely found in Kaplan's explanation of attention restoration theory (Kaplan, 1995), which describes two ways of paying attention: top-down and bottom-up. Kaplan divides bottom-up attention into two categories: soft fascination and hard fascination. The proposed mechanism behind attention restoration is that urban nature engages soft fascination, where leaves blowing in a breeze or a running stream gently capture people's attention while allowing their mind to wander (Kaplan, 1995).

The participants in the green-no laptop condition likely experienced soft fascination while they looked at the green landscape. Engaging their capacity for soft fascination gave their top-down attention an opportunity to rest and improve. For these participants, the 15-min break resulted in significantly higher scores on the tests of attention. Participants in the green-laptop treatment, however, continued to use their top-down attention as they engaged their computers and thus did not rest or improve their attentional capacities. Note that although participants used their laptops for leisure activities, these activities still required top-down attention. It is interesting to note that even individuals who spent less than 50% of the 15-min break looking at their computer screen in the green setting did not gain significant attention enhancement. Attention restoration theory predicts that without an opportunity to rest one's top-down attention, there will be little to no enhancement of attentional functioning (Kaplan & Berman, 2010). The results here support this prediction to the extent that they show an improvement in attentional functioning only in the green without laptop condition.

Finally, we found the laptop condition (with or without a laptop) had a stronger effect than the setting condition (green or barren) on attention functioning and that there was a significant interactive effect between them. These findings suggest the impacts of electronic devices on our mental health should not be neglected by environmental designers. Content of virtual reality or augmented reality (virtual reality within the context of a physical setting) would be a ubiquitous, even inseparable part of future urban residents' daily contact with physical settings (Chicchi Giglioli et al., 2016). Moreover, it is possible that paying too much attention to electronic devices would reduce the positive impact that some kinds of physical settings (typically green) have on mental health. The findings reveal a new phenomenon that needs environmental planners and designers' great attention (Chi, Kang, & Wang, 2013).

Implications

The initial relationships between treatments and attention held after a number of potentially confounding factors were considered. The evidence presented here demonstrates that human behavior in a restorative setting can affect attentional functioning. Planners, designers, and policy makers can intervene to provide green spaces for different users, but if those users choose to use their laptops or other electronic devices in those spaces, they likely will not reap the attention enhancement benefit of taking a break in a restorative setting. Two implications emerge from these findings.

First, this research is consistent with previous findings showing it is important to transform barren urban settings into greener settings because barren settings do not foster improvements in attention functioning—no matter if people are using computing devices or not. Thus, providing easy access to green spaces (e.g., urban parks, streets lined with trees, roof gardens, rain gardens) is especially crucial for individuals learning and working in settings that are devoid of vegetation (Suppakittpaisarn, Jiang, Slavenas, & Sullivan, 2018). The attentional demands placed on individuals today result in the majority of people experiencing mental fatigue on a daily basis (Sullivan, 2015). Mental fatigue makes individuals prone to errors, impulsivity, and irritability (Kaplan, 1995). Thus, providing greater access to green spaces will help individuals function at higher levels than if they had only barren spaces around their homes, work places, or schools.

Second, although the availability of green environments is important, it is not enough. Given that using an electronic device in a restorative setting mitigates the benefits on attention of that setting, individuals would be wise to put away their laptops and other electronic devices in restorative settings to restore their capacity to pay attention.

Future Directions

This is the first study to demonstrate that the use of portable electronic devices mitigates the attention enhancing effects of taking a break in a green setting. Certainly, these findings must be replicated in a variety of conditions before we are convinced of their generalizability. Given that electronic devices are nearly ubiquitous and that many people have easy access to smart phones and tablets, this study should be replicated with participants using a variety of mobile electronic devices because screen size (de Kort, Meijnders, Sponselee, & Ijsselsteijn, 2006) and content used may be confounding factors. Based on the existing literature, our findings suggest that the relationship between laptop use and attention enhancement may be similar for individuals in different age categories. Just as we know that exposure to green settings improves attentional functioning for adolescents (Li & Sullivan, 2016), adults (Berto, 2005; Roe & Aspinall, 2011), and seniors (Gamble, Howard, & Howard, 2014), we expect the findings of the current study will generalize to people across the age spectrum too—from school children to older adults. In addition, we suggest future researchers will examine this research question by using other measures of attention functioning (Ohly et al., 2016).

Although the results of this study are best applied to individual behavior, there are some implications for planners and designers. At first glance, the findings here suggest that a good design of physical spaces can hardly support attention enhancement if people engage with their electronic devices. But perhaps that notion underestimates the power of design. If we were to challenge designers to create settings that encouraged engagement of bottom-up attention in a more compelling fashion than did the spaces we put our participants in, would such spaces pull users' attention away from their electronic devices for long enough periods that their top-down attention would improve? The findings here pose questions for future research about the design of restorative settings (Sullivan et al., 2014).

What might spaces that draw more heavily on bottom-up attention be like? We propose they would contain elements from nature that grab and hold bottom-up attention more than a typical green space on a campus. These settings might include moving water, wildlife, fire, or other natural elements that move and change. The advent of augmented reality—a technology that superimposes a computer-generated image on a user's view of the real world, thus providing a composite view—might also be a way of creating such places (Marques, Cladera, & Tenedório, 2017). But that, of course, would require the use of electronic devices.

In this study, 10 min of cognitive tasks did not yield a significant decrease in participants' attentional performance. We see two possible explanations regarding why attention scores did not diminish after the 10-min tasks. On the one hand, it is possible that participants were mentally fatigued when they arrived for the experiment. This possibility seems reasonable because, during the summer semester, participants were likely taking courses or were involved in research that put considerable demands on their attention. In addition, pervious research using a 5-min Sustained Attention Response Task (SART) has been shown to degrade attention (Berto, 2005). That 10-min of cognitive tasks did not reduce attention scores suggests that participants were fatigued when they began the experiment.

On the other hand, it is possible that the 10-min session was not long enough to produce measurable declines in attentional functioning. Although we cannot rule this out as a possibility, it seems less likely than that the participants arrived in a fatigued state.

Although the task designed to fatigue participants' attention did not result in lower attention scores, the treatments did produce significant differences. The only group to have a significant increase in attentional functioning at the end of the treatment period was the Green-no laptop condition. These findings beg the question, "To whom do these findings generalize? Are they applicable to people who are mentally fatigued, or to people who are not mentally fatigued?" At this moment, we cannot say; this is clearly an area that deserves further study.

Future research might also examine the extent to which esthetic value or other attributes of a place influence visitors' preference and behavior (Gobster, Nassauer, Daniel, & Fry, 2007; Nassauer, 2011). To what extent can settings be designed to promote walking or sitting in a fashion that is engaging enough that people are not drawn to use their electronic devices?

Conclusion

In this study, using an electronic device substantially counteracted the attention enhancing benefits of being in a green space. These findings suggest that a common assumption people have about taking a break by using an electronic device may be counterproductive. Individuals in this study who were randomly assigned to take a break while using an electronic device showed no improvement in their attentional performance after a 15-min break. To reap the benefits of being in a restorative green space, it appears that one needs to take in the softly fascinating objects in the landscape. Perhaps the most important lesson from this study is that to enhance your attention functioning it is not enough to go to a green space; the evidence here suggests you have to put aside your electronic devices in that space.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This work was supported by the USDA Forst Service Northern Research Station and with laboratory seed funding from the Faculty of Architecture at the University of Hong Kong.

References

Ai, M. (2012). How computer and Internet use influences mental health: A five-wave latent growth model. *Asian Journal of Communication*, *23*, 175-190. doi:10.1080/01292986.2012.725179

Attia, N. A., Baig, L., Marzouk, Y. I., & Khan, A. (2017). The potential effect of technology and distractions on undergraduate students' concentration. *Pakistan Journal of Medical Sciences*, *33*, 860-865. doi:10.12669/pjms.334.12560

Beil, K., & Hanes, D. (2013). The influence of urban natural and built environments on physiological and psychological measures of stress-A pilot study. *International Journal of Environmental Research and Public Health*, *10*, 1250-1267. doi:10.3390/ijerph10041250

Berman, M. G., Jonides, J., & Kaplan, S. (2008). The cognitive benefits of interacting with nature. *Psychological Science*, *19*, 1207-1212. doi:10.1111/j.1467-9280.2008.02225.x

Berto, R. (2005). Exposure to restorative environments helps restore attentional capacity. *Journal of Environmental Psychology*, *25*, 249-259. doi:10.1016/j.jenvp.2005.07.001

Chang, C. Y., & Chen, P. K. (2005). Human response to window views and indoor plants in the workplace. *HortScience*, *40*, 1354-1359.

Cheever, N. A., Rosen, L. D., Carrier, L. M., & Chavez, A. (2014). Out of sight is not out of mind: The impact of restricting wireless mobile device use on anxiety levels among low, moderate and high users. *Computers in Human Behavior*, *37*, 290-297. doi:10.1016/j.chb.2014.05.002

Chi, H.-L., Kang, S.-C., & Wang, X. (2013). Research trends and opportunities of augmented reality applications in architecture, engineering, and construction. *Automation in Construction*, *33*, 116-122. doi:10.1016/j.autcon.2012.12.017

Chicchi Giglioli, I. A., Chirico, A., Cipresso, P., Serino, S., Pedroli, E., Pallavicini, F., & Riva, G. (2016). Feeling ghost food as real one: Psychometric assessment of presence engagement exposing to food in augmented reality. In S. Serino, A. Matic, D. Giakoumis, G. Lopez, & P. Cipresso (Eds.), *Communications in computer and information science* (Vol. 604. pp. 99-109). Pervasive computing paradigms for mental health. MindCare 2015. Springer. Cham. 6330 doi:10.1007/978-3-319-32270-4_10 de Kort, Y. A. W., Meijnders, A. L., Sponselee, A. A. G., & Ijsselsteijn, W. A. (2006). What's wrong with virtual trees? Restoring from stress in a mediated environment. *Journal of Environmental Psychology*, *26*, 309-320. doi:10.1016/j.jenvp.2006.09.001

Frumkin, H., Bratman, G. H., Breslow, S. J., Cochran, B., Kahn, P. H., Lawler, J. L., & Wood, S. A. (2017). Nature contact and human health: A research agenda. *Environmental Health Perspectives*, *125*(7), 075001. doi:10.1289/EHP1663

Gamble, K. R., Howard, J. H., Jr., & Howard, D. V. (2014). Not just scenery: Viewing nature pictures improves executive attention in older adults. *Experimental Aging Research*, *40*, 513-530. doi:10.1080/0361073x.2014.956618

Gobster, P. H., Nassauer, J. I., Daniel, T. C., & Fry, G. (2007). The shared landscape: What does aesthetics have to do with ecology? *Landscape Ecology*, *22*, 959-972. doi:10.1007/s10980-007-9110-x

Jiang, B., Chang, C.-Y., & Sullivan, W. C. (2014). A dose of nature: Tree cover, stress reduction, and gender differences. *Landscape and Urban Planning*, *132*, 26-36. doi:10.1016/j.landurbplan.2014.08.005

Jiang, B., Larsen, L., Deal, B., & Sullivan, W. C. (2015). A dose–response curve describing the relationship between tree cover density and landscape preference. *Landscape and Urban Planning*, *139*, 16-25. doi:10.1016/j.landurbplan.2015.02.018

Jiang, B., Li, D., Larsen, L., & Sullivan, W. C. (2016). A dose-response curve describing the relationship between urban tree cover density and self-reported stress recovery. *Environment and Behavior*, *48*, 607-629. doi:10.1177/0013916514552321

Jiang, B., Zhang, T., & Sullivan, W. C. (2015). Healthy cities: Mechanisms and research questions regarding the impacts of urban green landscapes on public health and well-being. *Landscape Architecture Frontiers*, *3*, 24-35.

Kaplan, R., & Kaplan, S. (1989). *The experience of nature: A psychological perspective*. New York, NY: Cambridge University Press.

Kaplan, S. (1995). The restorative benefits of nature—Toward an integrative framework. *Journal of Environmental Psychology*, *15*, 169-182.

Kaplan, S., & Berman, M. G. (2010). Directed attention as a common resource for executive functioning and self-regulation. *Perspectives on Psychological Science*, *5*, 43-57. doi:10.1177/1745691609356784

Kaplan, S., & Kaplan, R. (2003). Health, supportive environments, and the reasonable person model. *American Journal of Public Health*, *93*, 1484-1489.

Kemp, S. (2018). *Digital in 2018: World's Internet users pass the 4 billion mark*. Available from https://wearesocial.com/

Korpela, K. M., Ylen, M., Tyrvainen, L., & Silvennoinen, H. (2010). Favorite green, waterside and urban environments, restorative experiences and perceived health in Finland. *Health Promotion International*, *25*, 200-209. doi:10.1093/heapro/daq007

Kuo, F. E., & Sullivan, W. C. (2001). Aggression and violence in the inner city—Effects of environment via mental fatigue. *Environment and Behavior*, *33*, 543-571.

Kuo, F. E., & Taylor, A. F. (2004). A potential natural treatment for attention-deficit/hyperactivity disorder: Evidence from a national study. *American Journal of Public Health*, *94*, 1580-1586.

Kweon, B.-S., Ellis, C. D., Lee, J., & Jacobs, K. (2017). The link between school environments and student academic performance. *Urban Forestry & Urban Greening*, *23*, 35-43. doi:10.1016/j.ufug.2017.02.002

Laumann, K., Garling, T., & Stormark, K. M. (2003). Selective attention and heart rate responses to natural and urban environments. *Journal of Environmental Psychology*, *23*, 125-134. doi:10.1016/s0272-4944(02)00110-x

Lee, Y. S., Han, D. H., Kim, S. M., & Renshaw, P. F. (2013). Substance abuse precedes Internet addiction. *Addictive Behaviors*, *38*, 2022-2025. doi:10.1016/j.addbeh.2012.12.024

Li, D., & Sullivan, W. C. (2016). Impact of views to school landscapes on recovery from stress and mental fatigue. *Landscape and Urban Planning*, *148*, 149-158. doi:10.1016/j.landurbplan.2015.12.015

Marques, L., Cladera, J. R., & Tenedório, J. A. (2017, October). *Valorisation of urban elements through 3D models generated from image matching point clouds and augmented reality visualization based in mobile platforms*. Paper presented at the SPIE Remote Sensing.

Matsuoka, R. H. (2010). Student performance and high school landscapes: Examining the links. *Landscape and Urban Planning*, *97*, 273-282. doi:10.1016/j.landurbplan.2010.06.011

Mobile Fact Sheet. (2017). Retrieved from http://www.pewinternet.org/fact-sheet/mobile/

Nassauer, J. I. (2011). Care and stewardship: From home to planet. *Landscape and Urban Planning*, *100*, 321-323. doi:10.1016/j.landurbplan.2011.02.022

Ohly, H., White, M. P., Wheeler, B. W., Bethel, A., Ukoumunne, O. C., Nikolaou, V., & Garside, R. (2016). Attention restoration theory: A systematic review of the attention restoration potential of exposure to natural environments. *Journal of Toxicology and Environmental Health, Part B*, *19*, 305-343. doi:10.1080/10937404.2016.1196155

Perlow, L. A. (2012). *Sleeping with your smartphone: How to break the 24/7 habit and change the way you work*. Boston, MA: Harvard Business Press.

Poon, K.-T., Teng, F., Wong, W.-Y., & Chen, Z. (2016). When nature heals: Nature exposure moderates the relationship between ostracism and aggression. *Journal of Environmental Psychology*, *48*, 159-168. doi:10.1016/j.jenvp.2016.10.002

Pretty, J., Peacock, J., Sellens, M., & Griffin, M. (2005). The mental and physical health outcomes of green exercise. *International Journal of Environmental Health Research*, *15*, 319-337. doi:10.1080/09603120500155963

Roe, J., & Aspinall, P. (2011). The restorative benefits of walking in urban and rural settings in adults with good and poor mental health. *Health & Place*, *17*, 103-113. doi:10.1016/j.healthplace.2010.09.003

Sahin, C. (2011). An analysis of Internet addiction levels of individuals according to various variables. *Turkish Online Journal of Educational Technology*, *10*(4), 60-66.

Short, J. E. (2013). *Paying attention: How concurrent media exposure, cross media viewership and multitasking are forever changing traditional media behaviors*. San Diego, CA: Marshall School of Business.

Sparrow, B., Liu, J., & Wegner, D. M. (2011). Google effects on memory: Cognitive consequences of having information at our fingertips. *Science*, *333*, 776-778. doi:10.1126/science.1207745

Sullivan, W. C. (2015). In search of a clear head. In R. K. A. Basu (Ed.), *Fostering reasonableness: Supportive environments for bringing out our best* (pp. 54-69). Ann Arbor: University of Michigan Press.

Sullivan, W. C., & Chang, C. Y. (2011). Mental health and the built environment. In A. L. Dannenberg, H. Frumkin, & R. J. Jackson (Eds.), *Making healthy places: Designing and building for health, well-being, and sustainability* (pp. 106-116). Washington, DC: Island Press.

Sullivan, W. C., Frumkin, H., Jackson, R. J., & Chang, C.-Y. (2014). Gaia meets Asclepius: Creating healthy places. *Landscape and Urban Planning*, *127*, 182-184. doi:10.1016/j.landurbplan.2014.03.005

Sullivan, W. C., & Kaplan, R. (2015). Nature! Small steps that can make a big difference. *HERD: Health Environments Research & Design Journal*, *9*(2), 6-10. doi:10.1177/1937586715623664

Suppakittpaisarn, P., Jiang, B., Slavenas, M., & Sullivan, W. C. (2018). Does density of green infrastructure predict preference? *Urban Forestry & Urban Greening*. Advance online publication. doi:10.1016/j.ufug.2018.02.007

Swing, E. L. (2012). *Plugged in: The effects of electronic media use on attention problems, cognitive control, visual attention, and aggression* (Doctoral dissertation). Iowa State University. Retrieved from https://lib.dr.iastate.edu/cgi/viewcontent.cgi?article=3607&context=etd

Taylor, A. F., Kuo, F., & Sullivan, W. C. (2001). Coping with ADD: The surprising connection to green play settings. *Environment and Behavior*, *33*, 54-77. doi:10.1177/00139160121972864

Tennessen, C. M., & Cimprich, B. (1995). Views to nature—Effects on attention. *Journal of Environmental Psychology*, *15*, 77-85.

UCLA Institute for Digital Research and Education. (n.d.). *Power analysis for paired sample t test | G*power data analysis examples*. UCLA: Statistical Consulting Group. Retrieved from https://stats.idre.ucla.edu/other/gpower/power-analysis-for-paired-sample-t-test/

van der Aa, N., Overbeek, G., Engels, R. C. M. E., Scholte, R. H. J., Meerkerk, G.-J., & Van den Eijnden, R. J. (2009). Daily and compulsive Internet use and well-being in adolescence: A diathesis-stress model based on big five personality traits. *Journal of Youth and Adolescence*, *38*, 765-776. doi:10.1007/s10964-008-9298-3

Wang, X., Rodiek, S., Wu, C., Chen, Y., & Li, Y. (2016). Stress recovery and restorative effects of viewing different urban park scenes in Shanghai, China. *Urban Forestry & Urban Greening*, *15*, 112-122. doi:10.1016/j.ufug.2015.12.003

Weiss, M. D., Baer, S., Allan, B. A., Saran, K., & Schibuk, H. (2011). The screens culture: Impact on ADHD. *Attention Deficit and Hyperactivity Disorders*, *3*, 327-334. doi:10.1007/s12402-011-0065-z

World Health Organization. (2015). *Public health implications of excessive use of the Internet, computers, smartphones and similar electronic device: Meeting report*. Report of the meeting conducted at Main Meeting Hall, Foundation for Promotion of Cancer Research, National Cancer Research Centre, Tokyo, Japan, 27-29 August 2014.

Author Biographies

Bin Jiang is an assistant professor in the Department of Architecture and a lab director at the University of Hong Kong. He is a cochair of research and methods track in the Council of Educators in Landscape Architecture (CELA). He holds a PhD in landscape architecture from the University of Illinois at Urbana–Champaign. His research work examines the impacts of the built environment on human health, environmental justice, environmental safety and criminology, and virtual reality technology.

Rose Schmillen is a freelance designer and consultant in Trinidad and Tobago. She holds a master of landscape architecture from the University of Illinois at Urbana–Champaign. Her research focuses on environment, human health, and human behavior.

William C. Sullivan is professor and head of landscape architecture at the University of Illinois at Urbana–Champaign. He examines the health impacts of having regular contact with urban green infrastructure.