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Not just scenery: Viewing nature pictures improves executive attention in older adults

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Abstract

Background/Study Context—Attention Restoration Theory (Kaplan, 1995) suggests that exposure to nature improves attention. Berman, Jonides and Kaplan (2008) showed that simply viewing nature *pictures* improves executive attention in young adults. The present study is the first to investigate this Nature Effect in older adults. We investigated whether executive attention could be improved in healthy older adults following brief exposure to nature pictures.

Methods—Thirty healthy older adults (64–79 years old) and 26 young university students (18–25 years old) participated. They completed the Attention Network Test before and after six minutes of viewing either nature or urban pictures, with random assignment into a picture type. Attention immediately before (most fatigued) and after (most restored) picture viewing was measured, and change in attention was compared between age groups and picture types.

Results—Results showed that viewing nature, but not urban, pictures significantly improved executive attention in both older and young adults as measured by the Attention Network Test, with similar effects seen in the two age groups. Alerting and orienting attention scores were not affected by picture-viewing.

Conclusion—This was the first study to show that viewing nature pictures improves attention in older adults, and to show that it is executive attention, specifically, that is improved. Among a growing number of interventions, nature exposure offers a quick, inexpensive, and enjoyable means to provide a temporary boost in executive attention.

Keywords

Aging; Attention; Cognition; Environment; Intervention

Introduction

Nature has been a means of escape from the stresses of the city for centuries. For example, Frederick Law Olmsted, the landscape architect who designed Central Park, created places of respite in urban areas to induce, “refreshing rest and invigoration to the whole system” (c.f. Kaplan, 1995). Natural environments are not only preferred to more urban environments, but time in nature has psychological benefits, too, such as increasing people’s positive outlook and psychological energy (R. Kaplan & Kaplan, 1989). Research inspired by Kaplan’s Attention Restoration Theory (S. Kaplan, 1995) has shown that brief exposure to nature scenes improves executive attention in young adults (Berman, Jonides, & Kaplan, 2008). The present study is the first to investigate whether this Nature Effect occurs in healthy older adults as well, an important question because executive attention is essential for everyday life and independent living (Banich, 2009).

Building upon the theories of William James, Kaplan posits that there are two kinds of attention, directed and involuntary, and that nature captures our involuntary attention in a bottom-up, stimulus-driven manner (S. Kaplan, 1995). Kaplan’s Attention Restoration Theory proposes further, that in capturing involuntary attention, nature permits fatigued directed attention to rest and be restored. He argues that a natural environment must meet four criteria to be restorative. It must: (1) be *fascinating*, effortlessly capturing attention in a bottom-up manner; (2) provide a feeling of *being away*, allowing the mind to wander from daily stresses; (3) be *extensive*, providing a desire to explore more of the environment; and (4) be *compatible* with one’s desires or needs, providing opportunities to take part in enjoyable activities. An urban environment, according to Kaplan, may also capture our involuntary attention, but does so with less inherently appealing stimuli, such as police sirens, thus requiring people to use effortful top-down, directed attention, to overcome these stimuli and re-focus their attention (S. Kaplan & Berman, 2010).

A range of evidence supports the Attention Restoration Theory. Nature has been shown to reduce stress in participants who have been experimentally stressed (Ulrich, et al., 1991), as well as to reduce recovery time from gall bladder removal surgery (Ulrich, 1984), and to improve attentional capacity in women recovering from breast cancer surgery (Cimprich & Ronis, 2003). The restorative benefits of nature have been found in varied populations, from college students (Tennessen & Cimprich, 1995) to groups suffering from impaired attention, such as women with breast cancer (Cimprich, 1993) and children with Attention Deficit Hyperactivity Disorder (Faber Taylor & Kuo, 2009). Older adults, the target population in the present study, also experience declines in some aspects of executive control or attention (Verhaeghen, 2011), as well as increased fatigue that affects their daily lives and well-being (Yu, Lee, & Man, 2010). Only one other study has looked at the effects of nature on attention in older adults, finding that attention on the Necker Cube Pattern Control, Digit Span Forward and Backward, and the Symbol Digits Modalities Test, improved more after sitting outside for an hour compared to sitting inside for an hour (Ottosson & Grahn, 2005).

Most of the research described above has examined the effects of participants physically being in a natural environment, however, more recent studies have investigated whether simulated forms of nature can have restorative effects, as well. Viewing pictures of natural

scenes has been shown to improve attention when compared to viewing pictures of urban scenes and even geometric shapes (Berto, 2005). A virtual reality version of a natural environment had physiological effects through a reduced skin conductance response and increased positive affect (Valtchanov, Barton, & Ellard, 2010), and stress was reduced in response to both a natural outdoor environment and pictures of a natural environment (Kjellgren & Buhrkall, 2010). Compared to videos of an urban environment, nature videos were shown to improve orienting attention to invalidly cued items and to reduce heart rate (Laumann, Gärling, & Stormark, 2003), and compared to urban pictures, nature pictures increased heart rate variability, suggesting a change in autonomic activity interpreted as relaxation (Gladwell, et al., 2012). An eye-tracking study also showed that people have fewer fixations and more exploration of urban compared to nature scenes; the authors suggest this indicates that more effortful attention is required to view urban scenes than more fascinating nature pictures (Berto, Massaccesi, & Pasini, 2008).

Despite a number of studies that have looked at effects of more simulated forms of nature, none of them used this more controlled nature exposure to investigate the specific type of cognitive improvement that occurs. Berman et al. (2008) recently showed that mere exposure to a series of pictures of natural, as opposed to urban scenes, improved *executive* attention, specifically, as assessed by the Attention Network Test (ANT). The advantage of the ANT is that it simultaneously measures three types of attention: alerting, orienting, and executive (Fan, McCandliss, Sommer, Raz, & Posner, 2002), thereby offering more precise assessments of specific types of attention that reflect contemporary cognitive theories. Thus, Berman and colleagues (Experiment 2) were able to replicate the above “real world” findings of improved attention, in a more controlled laboratory paradigm. They established the specificity of the Nature Effect to one component of attention, and showed that it occurs even when the only contact with nature is via pictures.

This study had two aims: first, to replicate the findings of Berman et al. (2008, Experiment 2) in young adults, and second, to determine whether the Nature Effect, i.e., improvement of executive attention through exposure to nature, also occurs for older adults who experience cognitive fatigue more easily than young adults (Hess & Ennis, 2011). Because the only aging study testing Kaplan’s theory (Ottoosson & Grahn, 2005) did not report the cognitive health of the older adults, the present study is the first to not only test cognitively healthy older adults, but to do so using pictures, and to specifically measure effects on executive attention. We used the protocol from Berman and colleagues to test college-aged and healthy older adults, and predicted that exposure to nature pictures would improve executive attention in both age groups.

Design and Methods

Participants

Participants were 26 college-aged ($M = 20.54$, $SD = 1.24$) and 30 older adults ($M = 69.10$, $SD = 3.92$). Young participants were from Georgetown University and received class credit or monetary compensation, while older adults were recruited via an advertisement in the *Washington Post* and were paid for their participation. All procedures were approved by the Georgetown University Institutional Review Board. Participant demographics and

neuropsychological scores can be seen in Table 1. Educational attainment was high for both older ($M = 16.2$, $SD = 3.66$) and younger adults ($M = 14.2$, $SD = 0.95$). As is typical, young adults had significantly higher scores than older adults in the WAIS-III Digit Symbol tests of processing speed (Old: $M = 64.90$, $SD = 10.78$, Young: $M = 92.77$, $SD = 10.70$, $t(54) = -9.68$, $p < .001$, $d = 2.59$), and cued recall (Old: $M = 11.00$, $SD = 4.74$, Young: $M = 14.85$, $SD = 3.55$, $t(54) = -3.55$, $p = .001$, $d = 0.92$). These scores did not significantly differ by Picture Type within either age group. All older adults were cognitively healthy as measured via the Mini Mental State Examination, with all scores ≥ 27 , and had an average self-report of 4.45 ($SD = 0.57$) for overall health on a 5 point scale, with 5 denoting “excellent” health.

Design

This was a 2 (Age: Young, Old) $\times$ 2 (Picture Type: Nature, Urban) $\times$ 2 (Session: Pre-, Post-picture viewing) design. Age and Picture Type varied between subjects, and Session varied within subjects. All participants completed the Attention Network Test before and after viewing a given set of pictures. Half of the participants in each age group were randomly assigned to see pictures of nature scenes, and the other half to see pictures of urban environments.

Tasks

Attention Network Test—The Attention Network Test (ANT) measures three types of attention: executive, alerting, and orienting, in one (approximately) 20-minute session (Fan et al., 2002). Alerting and orienting attention occur when a cue directs attention in either a temporal (alerting) or orienting manner, while executive attention, in the context of the ANT, requires cognitive control to inhibit interfering stimuli when making a judgment about a target (Fan et al., 2002). All three types of attention were measured according to methods from Fan et al. (2002), as described below.

In the ANT task used here, each trial began with a central fixation, followed by a target appearing either above or below the fixation. The target was an arrow pointing to either the left or the right, and it was always flanked by two arrows on each side, which appeared in the following three possible configurations: all facing in the same direction as the target arrow (congruent), all facing in the opposite direction as the target (incongruent), or all being lines with no arrowhead (neutral). Participants were to respond to the direction the target arrow was facing as quickly as possible. *Executive attention* was measured by subtracting reaction time (RT) on congruent trials from that on incongruent trials. The correlations between response times to congruent and incongruent trials were significant in both age groups, both in Block 3 Pre-pictures (Old: $r = .866$, $p < .001$, Young: $r = .787$, $p < .001$) and in Block 1 Post-pictures (Old: $r = .857$, $p < .001$, Young: $r = .794$, $p < .001$), suggesting that individuals responded similarly to the two trial types, and that this did not change after picture viewing.

In addition, attention to the location of the target in relation to the central fixation was sometimes cued by an asterisk. The target stimulus occurred at varied inter-stimulus intervals (ISIs), so the appearance of an asterisk *alerted* participants that the target would appear soon (alerting attention). *Alerting attention* was measured by subtracting the RT on

trials where an asterisk, or alerting cue, was in the center of the screen in place of the central fixation, from the RT on trials where there was no alerting cue. The asterisk could appear in the same location as the central fixation, above or below the central fixation, or two asterisks could appear, one above and one below. When a single asterisk appeared above or below the central fixation point, it *oriented* participants to where the target would appear, i.e., above or below fixation (orienting attention). *Orienting attention* was measured by subtracting the RT on trials where an asterisk, or an orienting cue, was above or below the central fixation, from trials where the orienting cue was in the same location as the central fixation.

The ANT began with a short training block, which was identical to the subsequent blocks with two exceptions. First, for training, the ISI was not random, with the target occurring at uniform times after the alerting or orienting stimuli, or simply after the fixation. Second, feedback was provided after each trial in the training block, giving participants a cumulative percent correct across all training trials. No feedback was given in the subsequent three test blocks. Training consisted of 24 trials, and the three test blocks in a session were 96 trials each.

Positive and Negative Affect Scale—The Positive and Negative Affect Scale (PANAS) is a 20-item survey containing ten positive and ten negative adjectives (Watson, Clark, & Tellegen, 1988). Using a 5-point Likert scale, participants rated the extent to which they were experiencing each emotion at that current time, with ratings from 1 for “not at all,” to 5 for “extremely.” A person’s positive affect score was determined by summing the ratings on all ten positive words, with the possible score ranging from 10–50. Scores were calculated in the same way for negative affect using the negative adjectives.

Backward Digit Span—The WAIS-III Backward Digit Span (DSB) is a measure of working memory, which Berman et al. (2008) also included. In this task, participants are read a string of numbers and told to repeat them back to the experimenter, but in a backward direction from how they were heard. The first string read was made up of two numbers, and string length increased up to eight numbers, with two strings of each length. Participants received one point for each string they correctly repeated backward, and thus could earn up to 14 points. Two different versions were used for Pre- and Post-picture viewing.

Picture viewing—In the picture viewing task, participants viewed 50 pictures of scenes from either nature or urban environments. Procedures were based on, and stimuli were taken from, Berman, Jonides and Kaplan (2008, Experiment 2). Each set of stimuli contained 50 pictures of one type of environment (nature or urban), with each picture shown once for seven seconds. Pictures were viewed in the same, pre-determined randomized order for all participants within each group (i.e., nature versus urban). After each picture, participants rated how much they liked that picture on a 3-point scale, with 1 denoting the least, and 3 the most, liking.

Procedure

Participants provided informed consent and were administered biographical and health questionnaires. They were then led into the testing room, and completed the PANAS and DSB, and were then read instructions explaining the ANT.

For the ANT, participants held the computer mouse in their hands, placing their thumbs over the two mouse keys. They were told to respond to the center target arrow as quickly as possible, pressing either the left or right key, depending on the direction in which the target arrow was facing. They were also instructed regarding the purpose of the alerting and orienting cues, which were referred to as 'asterisks.' The researcher stayed in the testing room during the training block to ensure that they understood the task. Following training, participants were informed that they would no longer receive feedback to their responses, but were to continue to respond to the direction of the target arrow as they had in the training block. There were then three test blocks; participants could take a break between blocks, but were encouraged to remain in the testing room until the third block was complete. Upon completing the third block, the program prompted participants to inform the researcher of task completion.

After this first session of the ANT, participants completed the picture viewing. They were told that they would see a series of pictures, and after each, there would be a screen asking them to rate how much they liked that picture. Participants viewed 50 pictures, images of either nature or urban scenes, depending on the condition to which they had been assigned.

Following picture viewing, participants completed the PANAS and the DSB a second time, followed by a second session of the ANT. After the ANT, participants completed a series of neuropsychological tests including, for older adults, the Mini Mental State Examination. Participants were then debriefed and compensated for their participation.

Results

A 2 (Age: Old and Young) $\times$ 2 (Picture Type: Nature and Urban) $\times$ 2 (Session: Pre- and Post-picture viewing) mixed design analysis of variance (ANOVA) was run for all of the below analyses, except where noted.

Backward Digit Span

We first examined whether viewing nature versus urban pictures improved working memory as assessed by Backward Digit Span. We found significant main effects of Age, $F(1,52) = 6.72$, $p = .01$, and Session, $F(1,52) = 25.80$, $p < .001$. Overall, older adults ($M = 6.90$, $SD = 2.58$) had lower Backward Digit Spans than young ($M = 8.64$, $SD = 2.58$), and Digit Span was higher Post-picture viewing ($M = 8.14$, $SD = 2.72$) than Pre-picture viewing ($M = 7.27$, $SD = 2.66$). The interaction of Age $\times$ Session was not significant, $p = .72$, and there were no significant effects involving Picture Type. Thus, all four groups, regardless of Age or Picture Type, showed practice effects, which were uninfluenced by Picture Type. Our results are consistent with Berman et al. (2008; Experiment 2) in not finding a significant interaction of Picture Type and Session. However, their follow-up analyses showed that Digit Span significantly improved after viewing Nature, but not after viewing Urban pictures, whereas

in the present study, Digit Span significantly improved after both picture types (Nature: $t(27) = -3.20, p = .004$, Urban: $t(27) = -3.99, p < .001$).

Attention Network Test

Before examining the measures of the three types of attention, all of which are based on RT of correct responses, we first examined accuracy on the ANT to make sure that there were no age differences that would complicate age group comparisons. An ANOVA yielded no significant main effects or interactions; proportion correct was uniformly high in all blocks for both Age groups and Picture Types; overall mean accuracy = 0.96 ($SD = 0.06$).

Most important, to determine whether viewing Nature versus Urban pictures influenced attention, we calculated executive attention scores for each block of the ANT, both before and after picture viewing, by subtracting RT of Congruent trials from RT of Incongruent trials (Fan et al., 2002). Thus, a high score signals worse executive attention. To examine the most acute effects of picture viewing on executive attention, we compared executive attention scores on the last block of the ANT Pre-pictures and the first block of the ANT Post-pictures. There was a significant main effect of Session, $F(1,52) = 12.01, p = .001$, observed power = 0.93, but not of Age. This lack of an overall age difference in the executive attention component of the ANT is consistent with earlier findings with a comparable older adult group, when general age-related slowing was accounted for (Fernandez-Duque & Black, 2006; Gamboz, Zamarian, & Cavallero, 2010; Jennings, Dagenbach, Engle, & Funke, 2007).

Most important, there was a significant interaction between Session and Picture Type, $F(1,52) = 6.88, p = .01$, observed power = 0.73, suggesting a difference in how the picture types affected executive attention scores. Post-hoc paired comparison t-tests revealed that executive attention significantly improved from Pre- ($M = 139.17, SD = 50.26$) to Post- ($M = 102.77, SD = 45.04$) Nature pictures, $t(27) = 5.27, p < .001, d = 0.76$, but there was no significant improvement from Pre- ($M = 104.47, SD = 50.09$) to Post- ($M = 99.31, SD = 47.48$) Urban pictures, $t(27) = 0.55, p = .59, d = 0.11$. The magnitude of the Nature Effect for each age group can be seen in Figure 1, which shows the improvement in executive attention, with executive attention difference scores calculated by subtracting the executive attention score from the first block of the Post-pictures ANT from the score on the last block of the Pre-pictures ANT. There were no interactions with Age, indicating that executive attention can be improved via nature exposure for both young and older adults.

Unexpectedly, the Pre-pictures results suggest that the Urban groups tended to have higher executive attention scores than the Nature groups before picture viewing (Table 2). It is clear that the lack of Post-pictures improvement in the Urban groups cannot be due to a ceiling effect, as there was room for improvement based on the executive attention scores reported by Berman et al. (2008). However, to ensure that our results were not an artifact of Pre-pictures group differences in executive attention, we analyzed a subset of the data with outlier subjects removed. To do this, we determined the minimum and maximum Pre-picture executive attention scores for each of the four groups. The highest minimum was 72.79, and the lowest maximum was 178.71. We then re-analyzed the above analyses using only the 40 subjects (of the original 56) who had Pre-picture executive attention scores falling within

this truncated range. This resulted in the four subgroups having similar Pre-picture executive attention scores, which can be seen in Table 3. Although power was reduced, the pattern of results remained the same as in the full group. That is, for the older groups, executive attention scores improved significantly after Nature (M difference score = 44.15, SD = 48.19, $t(8) = 2.75$, $p = .03$, $d = 1.14$) but not after urban pictures ($M = 22.26$, $SD = 63.72$, $t(10) = 1.16$, $p = .27$, $d = 0.58$). The same was true for the young groups, where executive attention scores improved significantly after nature (M difference score = 23.63, $SD = 19.57$, $t(10) = 4.01$, $p = .003$, $d = 0.88$) but not urban pictures ($M = 2.75$, $SD = 37.50$, $t(7) = 0.21$, $p = .84$, $d = 0.08$).

In contrast to the significant Nature Effect seen in executive attention, ANOVAs on the measures of alerting and orienting attention did not yield significant interactions between Picture Type and Session (all p 's > 0.10), consistent with Berman et al.'s (2008) findings that the Nature Effect occurred only for the executive component of attention in the ANT.

Positive and Negative Affect Scale

We examined the changes in mood from Pre- to Post-picture viewing to be sure that changes in cognition were not due to changes in mood. For positive affect, there were significant main effects of Age, $F(1,52) = 39.43$, $p < .001$, and Session, $F(1,52) = 10.33$, $p = .002$, and a significant interaction between Age and Session, $F(1,52) = 6.19$, $p = .02$. Positive affect did not significantly change in older adults from before ($M = 35.5$, $SD = 7.02$) to after ($M = 35.0$, $SD = 8.93$) picture viewing, whereas younger adults had higher positive affect before ($M = 24.85$, $SD = 7.47$) than after ($M = 20.92$, $SD = 7.12$) viewing pictures. For negative affect, there was only a significant main effect of Session, $F(1,52) = 13.60$, $p < .001$, such that negative affect was greater before ($M = 11.96$, $SD = 2.54$) than after ($M = 11.29$, $SD = 2.21$) picture viewing. There were no main effects or interactions with Picture Type for either positive or negative affect, suggesting that Picture Type did not influence affective state in either old or young adults. There was also no significant correlation between changes in positive or negative affect and changes in executive attention from Pre- to Post-picture viewing in either young (Positive: $r = .019$, $p = .928$, Negative: $r = .165$, $p = .426$) or older adults (Positive: $r = -.205$, $p = .279$, Negative: $r = .206$, $p = .278$), suggesting that mood did not have an effect on executive attention changes. These results are consistent with those of Berman et al. (2008).

Picture viewing and rating

Participants had rated how much they liked each picture on a scale of 1–3. The main reason for requiring picture ratings was to ensure that participants remained engaged during picture viewing; this task was easy enough that it would not have caused participants cognitive or attentional fatigue during viewing. A 2 (Age: Old and Young) $\times$ 2 (Picture Type: Nature and Urban) ANOVA on these ratings revealed significant main effects of Age, $F(1,52) = 10.48$, $p = .002$, and Picture Type, $F(1,52) = 51.23$, $p < .001$, and a significant interaction of Age $\times$ Picture Type, $F(1,52) = 4.12$, $p = .05$. Both older and younger adults liked Nature pictures more than Urban pictures, but this preference was greater for older than younger adults (Old: Nature, $M = 2.53$, $SD = 0.39$, Urban, $M = 1.78$, $SD = 0.25$; Young: Nature, $M =$

2.10, $SD = 0.32$, Urban, $M = 1.68$, $SD = 0.21$). The findings with young adults, again, support the findings from Berman and colleagues (2008).

Discussion

To our knowledge, this study was the first to find that viewing nature, but not urban, pictures significantly improved executive attention as measured via the Attention Network Test (ANT) in older adults. Our findings with young adults replicate those of Berman and colleagues (2008), but we also show that pictures can have a restorative effect on healthy older adults who are typically more easily fatigued (Hess & Ennis, 2011). This Nature Effect occurred only for executive attention, and not for alerting or orienting attention, a dissociation originally reported by Berman et al. for young adults. These results are in line with studies showing positive effects of nature on concentration (Faber Taylor & Kuo, 2009) and symptoms of attention deficit (Kuo & Faber Taylor, 2004) in children with Attention Deficit Hyperactivity Disorder. Also consistent with Berman, we found that although participants liked nature better than urban pictures, nature pictures did not improve mood more than urban pictures. Thus, the beneficial effects of nature pictures on executive attention can likely not be attributed to changes in mood.

Research has demonstrated ways to ameliorate cognitive declines via behavioral interventions, such as physical exercise (Kramer & Erickson, 2007), video games (Basak, Boot, Voss, & Kramer, 2008), and multi-modal interventions of social and cognitive engagement (Stine-Morrow, Parisi, Morrow, & Park, 2008). These interventions often seek to establish long-term improvement, and thus may require extended training to see effects (Voss, et al., 2010). Effects of lifestyle on aging have also been investigated using correlational methods, including measures of leisure activities such as gardening (Akbaraly, et al., 2009). Although the benefits of gardening may be attributed to its physical component (Akbaraly et al., 2009; Small, Dixon, McArdle, & Gimm, 2011), it may also have social and stress-reducing benefits, as suggested by self-report from older adults (Milligan, Gatrell, & Bingley, 2004). Caffeine is another means of enhancing cognition in older adults, temporarily improving their memory performance in the afternoon when memory is typically worse than in the morning (Ryan, Hatfield, & Hofstetter, 2002). Nature exposure, similar to caffeine, provides a fast and temporary boost in executive attention. Although it is likely that the effect of nature picture viewing is short-lived, a walk through or exposure to a natural *outdoor* environment may have longer lasting, and perhaps larger benefits and provide greater levels of restoration.

The underlying neural bases of how nature or urban scenes can differentially affect cognitive performance have not been examined. However, one functional neuroimaging study found differences in activation in young adults while viewing nature versus urban pictures, which was interpreted as differential emotional responsiveness to the two picture types (Kim, et al., 2010). Another recent study found that, compared to more rural areas, current city living and urban upbringing are each related to distinct patterns of brain activity during social stress processing (Lederbogen, et al., 2011), suggesting that long-term exposure to natural versus urban environments may affect brain function differently, though the correlational nature of this study does not establish the direction of cause. Of course, it is likely that long-term

exposure has different effects, both functionally and behaviorally, than the short-term picture viewing studied here. Nonetheless, the present findings, together with those of Berman et al. (2008), suggest that picture viewing can be used to examine causal effects of exposure to nature on both cognitive and brain function.

It is not clear exactly what differences between nature and urban pictures lead to this Nature Effect. For example, we do not know if improvement occurs because nature pictures are pleasing, are more brightly colored, conjure up fond memories, or if urban settings are actually harmful, and nature settings are only beneficial in contrast. However, one study found that viewing nature pictures significantly improved attention compared to viewing geometric shapes, suggesting that nature shows improvement even with a presumably neutral, non-urban comparison (Berto, 2005). Future studies should investigate specific characteristics of a natural environment that are restorative. For example, might nature scenes be less beneficial to people who were raised in an urban environment, and who may therefore find urban spaces more familiar and relaxing than natural ones? Lederbogen et al. (2011) found that the brains of people who grew up in different types of environments, such as a rural or an urban area, responded differently to a stressful task.

It is also not known if this Nature Effect is generalizable to all of nature, or if there are urban environments that could fit Kaplan's criteria (S. Kaplan, 1995) and be restorative. For example, one study investigated nature and urban pictures that were either high or low on fascination as defined by Kaplan, and found that Kaplan's fascination criterion may play a large role in improved attention across both picture types (Berto, Baroni, Zainaghi, & Bettella, 2010). Future studies could investigate whether some urban environments may in fact be restorative, meeting some or all of Kaplan's criteria, and if some natural areas may not be as restorative, if they meet Kaplan's criteria to a lesser degree, or not at all.

Although we found significantly improved executive attention in old and young adults following nature picture viewing compared to urban picture viewing, these results may not be generalizable to all older or college-aged adults. Participants in both age groups are a convenience sample, and are homogenous in terms of education and neuropsychological scores, and older adults are high-functioning, as based on their Mini Mental State Examination and Vocabulary scores. In addition, our sample size, though similar to that of other studies of the Nature Effect (Berman et al., 2008; Berto, 2005), is relatively small. In general, it would be useful to replicate these findings in a larger population-based sample.

In conclusion, this study shows that viewing pictures of nature for as few as six minutes can boost executive attention for both old and young adults. This supports the statement of Kaplan and Kaplan (1989), that "wilderness is not the only setting for experiencing such restorative experiences." Nonetheless, a number of questions remain. It is not yet known how long this effect lasts; the effect is likely short-lived after brief exposures of the sort used here, but the Lederbogen et al. (2011) study above, suggests that more extended exposure to nature might have longer-term effects. Despite these and the above limits, the present study suggests that brief viewing of nature pictures offers an inexpensive and enjoyable way to temporarily boost cognitive function in both young and older adults. Given the important role that executive attention plays in other cognitive abilities, such as memory and reasoning,

and in everyday activities, taking advantage of the Nature Effect may help people to better focus on relevant tasks and avoid unwanted distractions. These benefits are particularly important for older adults who experience more fatigue and may not be able to recover as quickly from it as young adults (Yu et al., 2010).

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Figure 1. Improvement in Executive Attention

Executive Attention Difference Scores (Pre-pictures Executive Attention score (in msec) minus Post-pictures Executive Attention score) for older and young adults, showing Executive Attention improvement following Nature compared to Urban picture viewing. Executive attention improved following Nature picture viewing compared to Urban picture viewing in both age groups, with no differences between older and younger adults.

Participant demographics and neuropsychological scores.

	Older adults				Young adults			
	Nature	Urban	t-value	p-value	Nature	Urban	t-value	p-value
Education	17.57 (3.42)	15.87 (3.82)	1.29	0.21	13.69 (0.95)	14.54 (0.78)	-2.49	0.02
Processing speed	67.40 (10.14)	62.40 (11.15)	1.29	0.21	91.33 (10.89)	93.85 (11.21)	-0.57	0.58
Cued recall	7.33 (1.45)	7.80 (0.86)	-1.07	0.29	7.75 (1.06)	8.23 (0.83)	-1.27	0.22

Education levels, processing speed, and cued recall scores for older and younger adults, compared between picture-viewing groups. (Mean scores with standard deviation in parentheses.)

Table 2

Executive attention scores for Pre- and Post-picture viewing for full sample

	Older adults		Young adults	
	Nature	Urban	Nature	Urban
n	15	15	13	13
Block 3 Pre-pictures	146.77 (59.53)	103.07 (47.45)	130.40 (37.33)	106.07 (54.88)
Block 1 Post-pictures	101.65 (51.74)	95.22 (41.87)	104.05 (37.93)	104.03 (54.61)

Mean executive attention scores for the full sample (Incongruent – Congruent trials) for Block 3, pre-picture viewing and Block 1, post-picture viewing, separated by Age group and Picture type. Standard deviation is in parentheses.

Table 3

Executive attention scores for Pre- and Post-picture viewing for truncated sample

	Older adults		Young adults	
	Nature	Urban	Nature	Urban
n	9	11	11	9
Block 3 Pre-pictures	135.33 (32.47)	125.01 (33.82)	120.06 (30.05)	115.80 (29.74)
Block 1 Post-pictures	91.17 (44.23)	102.74 (42.73)	93.99 (29.46)	111.53 (36.76)

Truncated sample of 40 participants: Mean executive attention scores (Incongruent – Congruent trials) for Block 3, prepicture viewing and Block 1, post-picture viewing, separated by Age group and Picture type. Standard deviation is in parentheses.