Trees and Traffic:

Restorative Environments and Children's Executive Functioning

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Abstract

Kaplan’s Attention Restoration Theory (1995) suggests that exposure to nature, even in the form of pictures, helps to restore depleted attention. Previous studies have found that adults’ executive functions (attention, inhibitory control, and working memory) often improve after viewing nature scenes, but not after viewing urban scenes. The current study assessed whether pictures of nature also facilitate the recovery of young children’s ($M = 66.10$ months) executive functions. Results indicated that there was no effect of viewing nature or urban pictures on young children’s executive functions, suggesting that children may respond differently than adults to restorative environments. Learned associations between nature and relaxation may explain this difference.
There are well-established links between executive functioning and many important life outcomes, including academic achievement, problem behaviors, and peer relationships (Hughes & Ensor, 2011; Morgan & Lilienfeld, 2000). Therefore, researchers have begun to focus on environmental factors, such as classroom programs and parenting styles, that contribute to the development of young children’s executive functioning (Diamond, Barnett, Thomas, & Munro, 2007; Schroeder and Kelley, 2009). One potentially important environmental factor is children’s exposure to nature. While the positive association between exposure to nature and executive functioning has been well studied in adults (Berman, Jonides, and Kaplan, 2008; Berto, 2005), little is known about the effects of natural environments on children’s executive functioning. The current study examines this potential relationship.

**Executive Function**

Executive functioning (EF) is often defined as a set of cognitive processes, including attentional flexibility, inhibitory control, and working memory, that enable people to solve problems, plan actions, and exert self-control (Carlson, 2005; Diamond et al., 2007; Kaplan, 1995). How researchers measure EF depends on the context. In the lab, attention, inhibition, and working memory can be assessed individually or as one construct. For example, the Hearts-and-Flowers task (Diamond et al., 2007) requires attentional flexibility, inhibition, and working memory. While playing, children see either a heart or a flower appear on the left or right side of a computer screen. They are instructed to press a button in the same location as the stimulus if they see a heart, but on the opposite side from the stimulus if they see a flower. Both the heart and the flower are red and approximately the same size, so children must carefully attend to the
stimuli in order to discriminate one from the other. Children must also inhibit their initial impulse to press the button on the same side as the stimuli when they see a flower, which is a rule they previously learned about responding to hearts, but which does not apply to flowers. Finally, children must maintain the rules in their working memory while completing the task. Therefore, their performance would reflect a more general EF ability rather than any one of the individual components.

Other tasks measure individual components of EF. For example, the Gift Delay task places demands mainly on inhibition, while the Count and Label task depends largely on working memory. In one version of the Gift Delay task, children receive a wrapped present but are told they must wait to open it until the researcher returns with a bow (which takes three minutes) (Kochanska et al., 2000). In another version, children are told not to peek at the gift while a researcher wraps it behind them (Kochanska et al., 1996). A measure of inhibition is derived from whether children peek and, if so, how long they waited before doing so. In Count and Label, which measures working memory, children are asked to name and assign numbers to different objects (e.g. number one goes with shoe and number two goes with key). After a delay, children are asked to repeat the labels and the numbers for each object (Gordon & Olson, 1998).

In a large-scale study of 18 different executive functioning tasks, Carlson (2005) found that children often perform better on measures that assess individual components of EF than on those that combine multiple components.

Outside of the lab, in everyday contexts, EF is often measured using parent or teacher reports of children’s self-regulation in the home or classroom, which have been linked to many important school-related outcomes (Rimm-Kaufman et al., 2009; Blair & Razza, 2007). Although measures of self-regulation and EF both assess a child’s ability to inhibit inappropriate
responses, stay focused, and remember rules, self-regulation measures generally assess these abilities in more naturalistic contexts. For example, self-regulation is often measured in school settings, while EF is usually measured in labs. Despite the seeming overlap between the two constructs, self-regulation and EF are only moderately correlated (Blair, 2002), which has been attributed to the different behavior demands of the lab and the classroom.

Both lab-based measures of EF and parent- and teacher-reports of self-regulation have unique advantages. Lab-based measures assess EF in carefully controlled settings, producing data that are more easily compared across children, whereas parent- and teacher-reports sacrifice some reliability for the sake of assessing children’s behavior in real-world contexts. However, there are tasks designed to measure EF in both a reliable and more authentic way, such as the Head–Toes–Knees–Shoulders task (HTKS) (McClelland et al., 2007). This task is designed for use in a lab-like setting, but HTKS closely mimics the kinds of EF expectations children face in the classroom, like listening and responding to adult instructions and persevering in the face of difficult adult-led activities.

During the task, a researcher asks children to touch one of four body parts, after instructing them that they should always touch a body part that is different from the one they hear named. For example, they are instructed to touch their heads when they are told to touch their toes and to touch their knees when they told to touch their shoulders. As children progress through HTKS, the instructions change so that previous rules about which body parts go together are switched. Thus, they must pay attention to the directions, inhibit a dominant responses based on previous rules, and maintain four different rules in working memory. Although HTKS is a more holistic measure of EF (Ponitz et al., 2009; Ponitz et al., 2008; Wanless, 2011), it is highly
correlated with tasks that measure attention, working memory, and inhibitory control separately (Ponitz et al., 2009).

**Executive Function and Later Outcomes**

EF predicts many life outcomes whether it is measured in the lab or in everyday settings. In adults, low EF is correlated with higher criminal activity, student dropout rates, antisocial personality disorder, and drug use (for a review, see Morgan & Lilienfeld, 2000). Similarly, EF has been linked to a wide range of outcomes in children (Clark, Prior, & Kinsella, 2002). For example, one study found that children with low levels of EF between the ages of four and six had more dysfunctional peer relationships, conduct problems, hyperactivity, and emotional problems, such as crying or feeling sad, than did children with higher levels of EF (Hughes & Ensor, 2011). Furthermore, low EF has been linked to several developmental psychopathologies. For instance, children with attention deficit hyperactivity disorder, phenylketonuria, and autism all typically score lower on EF measures (Pennington & Ozonoff, 1996), although different disorders seem to impair different EF components. Children with ADHD often have lower levels of inhibitory control, while children with autism often have impaired verbal working memory.

Conversely, high levels of EF are associated with many positive behavioral outcomes, such as perceived school success and behavioral compliance (Hughes & Ensor, 2011; Kochanska et al., 1996). Kochanska et al. (1996) found that preschoolers with high levels of inhibitory control were more compliant with researchers’ and parents’ rules than were those with lower levels. In their study, preschoolers with high levels of EF were more likely to continue to follow the rules even when they believed researchers were not looking, perhaps suggesting that they are better able to adhere to social norms. Furthermore, the relationship between EF and children’s behavior continues into elementary school. In kindergarten, teacher reports of children’s self-
regulation at the beginning of the year predict their behavioral self-control, cognitive self-control, and work habits at the end of the year after children have completed their transition to school (Rimm-Kaufman et al., 2009). This relationship continues into the later elementary grades. In one study, fourth and fifth grade boys with low EF had more behavioral problems in school. Specifically, they displayed more instances of hostile attribution bias and reactive aggression (Ellis, Weiss, & Lochman, 2009).

EF is also associated with academic achievement throughout the elementary school years. For instance, Bull and Scerif (2001) administered several EF tasks to a sample of kindergartners and found that higher levels of inhibition, attention, and working memory predicted mathematic achievement in kindergarten. In addition, a longitudinal study showed that EF continued to predict mathematics achievement throughout the elementary school years (Mazzocco & Kover, 2007). Blair & Razza (2007) have suggested that EF may be crucial for solving math problems because mathematics requires working memory to represent problems, attention shifting to move from one step to the next, and inhibition to avoid salient but wrong answers. The EF and math association is further supported by fMRI work showing that parietal-frontal cortical circuitry is important for both EF (attention and working memory) and numeracy (Torkel, 2006).

While EF is most strongly associated with math abilities, it is also correlated with reading skills and other academic abilities, which may reflect the attention and persistence required for learning in school (Blair & Razza, 2007). In one study, gains in EF from the start to end of preschool, measured with the HTKS, predicted improvements in mathematics, vocabulary, and early-reading skills (McClelland et al., 2007). In a similar study, both parent reports of better attention and teacher reports of better self-regulation in kindergarten were related to math, literacy, and vocabulary achievement (Ponitz et al., 2009).
Some have argued that the association between EF and academic achievement is attributable to a common underlying factor, such as IQ (Lynam, Moffitt & Stouthamer-Loeber, 1993). However, although EF is highly correlated with fluid intelligence measures, such as problem solving, it is less related to crystallized intelligence measures, such as general knowledge (Blair, 2002). Therefore, the link between EF and academic achievement cannot be wholly attributed to IQ (Diamond et al., 2007). In fact, controlling for general intelligence in a sample of preschoolers, Blair and Razza (2007) found that that inhibitory control was still a significant predictor of young children’s math and reading abilities.

Because of the link between EF and academic outcomes, researchers have begun to design classroom interventions to foster EF development. One example is the Tools of the Mind curriculum (Bodrova & Leong, 2001). Teachers using the curriculum spend about 80% of each day emphasizing memory, attention, and self-regulation skills. In a randomized control trial, children in preschool and kindergarten classrooms who had been assigned to the intervention performed better than controls on both EF and reading skills assessments. The children who benefitted the most were those who had begun with the lowest EF and had engaged in more challenging executive functioning tasks (Diamond et al., 2007).

In another intervention study, Dowsett and Livesey (2000) similarly found that training improved preschoolers’ inhibitory control, attention, and working memory. They had three-year-olds practice the Wisconsin Card Sort Task. Practice on this task improved performance on different measures of attention, working memory, and inhibitory control, suggesting that their intervention produced a general improvement in EF that transferred to other EF intensive tasks.

Work suggesting that EF can be improved by targeted interventions is further supported by EEG findings. Rueda, Rothbart, McCandliss, Saccomanno, and Posner (2005) trained preschool
children for five days over a two-week period on a task similar to the computerized Hearts-and-Flowers task (Diamond et al., 2007). The researchers measured EEG activation as the children completed EF tasks. They observed more EEG activation in the executive attention network of the brain in children who had received the training compared to a control group. They concluded that exposure to EF interventions during the preschool years not only increases EF abilities, but may also change underlying brain networks.

**Restorative Environments**

While much of the work on facilitating the development of EF has focused on classroom settings, there is relatively little research on how environments outside the classroom promote or compromise EF. In fact, one highly relevant environment lies right outside the schoolroom door: the natural world. E.O Wilson (1984) has suggested, in his biophilia hypothesis, that humans are instinctively attracted to nature and that this attraction is likely to have a genetic component. Kaplan’s (1995) Attention Restoration Theory builds on this possibility to propose that experience with the natural world increases directed attention, a component of executive functioning that facilitates purposeful focusing on a task.

Kaplan (1995) distinguishes between directed attention and involuntary attention. Although directed attention requires effort and is necessary for attending to potential threats and detail-oriented tasks, involuntary attention allows the mind to rest and is harnessed by stimuli such as artwork, animals, and nature. Kaplan proposes that directed attention facilitates effective inhibition, problem solving, and selection of stimuli. However, because all these functional domains require effort, directed attention can be fatigued by prolonged mental exertion, leading to compromised performance in these same domains. For example, a person who has spent a long day concentrating on important work-related details may step into a busy street without
monitoring oncoming traffic. In a classroom context, a child’s attention to his or her tenth difficult math problem may begin to falter, leading to mistakes he or she might not otherwise have made.

Conversely, Kaplan suggests that involuntary attention requires little effort and is resistant to fatigue. He places involuntary attention on a continuum from hard fascination to soft fascination, which reflects the extent to which features of the environment capture attention. For example, watching violent movies and athletic events activates hard fascination, which captures attention so fully as not to exclude other thoughts. In contrast, looking at a painting or nature activates soft fascination, which allows for thought and reflection. Kaplan hypothesizes that being in a state of soft fascination facilitates attention restoration because it allows mental space for reflection.

Given this framework, Kaplan has proposed that some environments, and even pictures of those environments, share some characteristics that facilitate soft fascination and thus make it possible for depleted directed attention resources recover. To be restorative, a scene must suggest the idea of being in a restorative place, as if on a vacation. It must also include enough detail to encourage full engagement. Furthermore, the environment must be compatible with individuals’ goals, such that they are able to move, or imagine moving, leisurely or quickly through an area at will.

Natural environments often meet all three criteria. Nature suggests being away, because people often vacation in more natural settings, like going to the beach or camping. Nature also contains many engaging details, such as the intricacies of leaves and flowers and the movements of animals. Moreover, nature is often compatible with people’s goals, because people often choose a natural environment to suit a particular goal, such as hiking, fishing, or gardening.
Therefore, Kaplan suggests that nature and natural scenes should be especially restorative because they effectively engage involuntary attention but not directed attention. In essence, Kaplan (1995) proposes that natural imagery captures one’s attention without requiring mental exertion, allows the mind to rest from problem solving, and promotes the recovery of directed attention resources.

More recently, Kaplan and Berman (2010) have elaborated on why looking at natural scenes should be an effective way of restoring attention resources. They cite work showing that directed and involuntary attention rely on different regions of the brain (Reingold & Stampe, 2002), suggesting that natural scenes may allow directed attention recovery because they engage an attentional network that requires less effortful control. In contrast, Kaplan and Berman suggest that urban environments may do just the opposite. They argue that urban environments do not allow for the restoration of directed attention, because they are over stimulating and require directed attention to navigate. To stay safe in a busy urban setting, one must maintain focus on high-stakes stimuli, such as cars, pedestrians, streetlights, and potentially threatening people. These directed attention expenditures could be depleting without moments of involuntary attention engagement. While natural environments also have their dangers, modern humans rarely interact with truly untamed wilderness.

Because of the theorized restorative effects of natural environments, Kaplan and Berman (2010) argue that exposure to natural environments could be therapeutic, helping people to restore their problem-solving abilities during difficult tasks and facilitating self-reflection during challenging times. For instance, people who have ADHD have difficulty sustaining attention for prolonged periods of time (Barkley, 1997). As such, they might benefit from pausing to look at natural scenes during attention-intensive tasks.
Results from several recent studies with adults support Attention Restoration Theory. For example, Berto (2005) tested, and then depleted, adults’ ability to sustain attention. The participants completed a sustained attention task where they had to press the spacebar on the computer when certain numbers appeared on the screen. Following depletion, participants viewed either high-restorative images (nature scenes) or low-restorative images (urban scenes), and then their ability to sustain attention was retested. The performance of those who had viewed the restorative natural pictures improved, while the performance of those who had viewed the non-restorative urban pictures declined.

The attention-restoring effects of natural environments have also been demonstrated outside of a lab setting. Berman, Jonides, and Kaplan (2008) gave adults a test of executive functioning (backwards digit span) before and after walking through either an urban environment or a tree-lined park. A week later, the participants repeated the same procedure, but this time they walked through the other environment. The participants performed better on the backwards digit span posttest after a walk through the natural environment than after a walk through the urban environment. The results were the same whether participants were assigned to the natural environment during the first session or the second session. Together, these two studies suggest that exposure to a natural environment (whether real or depicted) facilitates the restoration of fatigued attention capabilities in adults.

Although the restorative effects of natural environments on attention have been well studied in adult populations, there has been less work with children. The few studies that have been conducted thus far have provided some evidence that natural environments may have similar restorative effects on children. In one study of children with ADHD, Taylor, Kuo, and Sullivan (2001) had parents fill out questionnaires that asked how severe their child’s attention
problems were after activities in both indoor and outdoor environments. The parents reported more severe attention problems associated with activities in less natural environments, but better attention after participating in activities in natural environments.

In another study of children with ADHD, Taylor & Kuo (2009) had children walk through a park, an urban setting, and a suburban neighborhood over three different days. After each walk, the researchers tested the children’s attention. Children who had walked through the park did significantly better on the posttests than children who had walked through the suburban neighborhood or city. These studies suggest that natural environments may have restorative effects on children similar to those documented with adults, at least for children with ADHD. However, both studies have methodical limitations that weaken the interpretability of their results. Taylor et al. (2001) relied on parent reports, and their findings are correlational, so no causal claims can be made. Taylor & Kuo (2009) used more experimental methods, but they only looked at nature’s effect on attention, ignoring other aspects of EF such as inhibitory control. More experimental work is needed to examine whether natural environments promote attention restoration, and EF more broadly, in children.

The Present Study

The present study was designed to investigate whether natural or urban scenes have a restorative effect on children’s depleted EF. In our procedure, children completed the Hearts-and-Flowers task, adapted from Diamond et al. (2007), both to measure and to deplete EF at multiple time points. This method allowed for a more continuous measure of EF between times when the children viewed high-restorative images (nature scenes) or low-restorative images (urban scenes). This method makes it possible to test whether there is a causal effect of natural environment scenes on attention restoration. For this study, children viewed pictures of natural
and urban environments, rather than being exposed to the actual environments, so that comparisons could be made to the initial adult work on restorative environments. We also administered the Head–Toes–Knees–Shoulders task (McClelland et al., 2007) at the end of the test session to get a measure of children’s EF that is similar to the kinds of tasks children are asked to perform in school. HTKS closely mimics the kinds of EF expectations children face in the classroom, like listening and responding to adult instructions and persevering in the face of difficult adult-led activities.

We hypothesized that children who viewed low-restorative urban pictures between administrations of our EF task would show a steeper decline in correct responses during the Hearts-and-Flowers task and a larger increase in response times across all three test blocks than would children who viewed high-restorative nature pictures. A steeper decline in correct responses and lengthier response times in the urban condition, when compared to the nature condition, would indicate a more pronounced deterioration of EF. We also hypothesized that children exposed to the natural images would perform better overall on the Head–Toes–Knees–Shoulders task than would children exposed to the urban images. This result would suggest that looking at high-restorative natural images helps to restore EF during an attention-taxing task.

Method

Participants

Participants were 33 5-year-olds (16 girls and 17 boys, \( M = 66.1 \) months, range = 60.1 to 72.1 months), who were recruited from a largely middle-class community using a database of families who signed up to participate in studies. One child has no data from the Head-Toes-Knees-Shoulders (HTKS) task because the testing session was cut short.
Design

The study was designed to test the effect of nature and urban images on children’s executive functioning using the Hearts-and-Flowers task administered on a computer and the Head-Toes-Knees-Shoulders (HTKS) task. The between-subjects factor for both tasks was the type of images children viewed (natural or urban). The study utilized a repeated measures design, such that children viewed images in-between the three Hearts-and-Flowers task test blocks. Response times and number of correct responses were recorded for the Hearts-and-Flowers task and correct responses were recorded for the HTKS.

Measures

**Hearts-and-Flowers Task.** Children completed two training blocks of trials and three test blocks of trials during the Hearts-and-Flowers task (Diamond et al., 2007). In Block 1, a heart appeared on either the right or the left side of the computer screen. Children were instructed to press a button on the same side of the screen as where the heart appeared. In Block 2, a flower appeared on either the right or left side of the screen. Children were instructed to press a button on the opposite side from where the flower appeared (see Figure 1). Children were instructed to apply either the rule they learned during Block 1 (press button on same side as heart) or the rule they learned during Block 2 (press button on opposite side of flower), depending on the stimulus. This task has been used to measure EF in children (Diamond et al., 2007), and a similar task has been shown to deplete EF in adults (Lorist, Boksem, & Ridderinkhof, 2005).

The Hearts-and-Flowers task ran on presentation software by Neurobehavioral Systems. Number of correct responses and response times, for incorrect and correct responses, were recorded from the Hearts-and-Flowers task. The first test block served as a baseline measure of
EF. Each subsequent test block was meant to deplete children’s executive functioning and to provide a measure of depletion relative to the preceding trial.

**Head-Toes-Knees-Shoulders Task.** The children also completed the Head-Toes-Knees-Shoulders (HTKS) task, a behavioral measure thought to assess EF as it might be recruited in classroom settings (McClelland et al., 2007). In the first part of the HTKS, the experimenter told the children to touch a specific body part while modeling the correct movement. In second part, the experimenter paired head with toes and told the children to do the opposite of what she said to do. For example, the children were expected to touch their toes when they were told to touch their heads. Once the children demonstrated that they had learned this rule, they were given ten head/toes trials. In the third part, the children were told to touch their shoulders when the experimenter said to touch their knees and to touch their knees when the experimenter told them to touch their shoulders. The fourth part combined the two rules, head/toes and knees/shoulders. After a practice session, the children completed a final ten trials with the combined rules. While completing the task, the children had to pay attention to the directions, inhibit a dominant responses based on previous rules, and maintain four different rules in working memory.

**Procedure**

The children were randomly assigned to one of two conditions, nature or urban. After each of the three Hearts-and-Flowers test blocks, the children in the nature condition viewed nature pictures and the children in urban condition viewed urban pictures (adapted from Berto, 2005). All children completed the Hearts-and-Flowers task first, followed by the HTKS.

For the Hearts-and-Flowers task, the children sat in front of a touch-screen computer while the researcher explained the rules for each block of trials. They learned the rules of the game during the first two training blocks, which were all hearts followed by all flowers. They
were reminded of the rules before the three test blocks. The three test blocks each consisted of 33 trials during which either a heart or a flower could appear on the left or right side of the screen. After each test block, the children watched a slideshow of either urban or natural images, depending on which condition they had been assigned to. Each slideshow lasted 90 seconds and contained 10 images presented for 9 seconds each. The children never saw the same picture twice. After viewing the last slideshow of either natural or urban images, they immediately completed the Head-Toes-Knees-Shoulders task.

Results

Compared to the children in the urban condition, the children in the nature condition were expected to have both faster response times and more correct responses in the two Hearts-and-Flowers test blocks following nature/urban slideshows. We also hypothesized that the children in the nature condition would score higher on the Head-Toes-Knees-Shoulders task. Mean response times and number of correct responses for both the Hearts-and-Flowers task and the HTKS are presented in Table 1.

Performance on the Hearts-and-Flowers Computer Task

We compared response times for correct responses by condition. For this analysis, we combined the last two test blocks, because these were the only blocks that differed by condition. There was no significant effect of condition, $F(1,30) = 1.22, p = .279, \eta_p^2 = .04$. The mean response time in both the nature and urban conditions was 1.1 sec (SD = 45 ms).

There were no differences in response times for correct responses by condition in any of the blocks (see Figure 2). Similarly, there were no differences in response times by condition across the three blocks.
We also examined the combined number of correct responses in test blocks two and three by condition. There was no significant difference between the nature and urban conditions, $F(1,31) = .44, p = .512, (M_{\text{nature}} = 22.79, SD = 1.82, M_{\text{urban}} = 24.53, SD = 1.88)$. Similarly, there were no differences in the number of correct responses by condition across the three blocks (see Figure 3).

We then compared the number of incorrect responses in each condition by block. There were no significant differences in the number of incorrect responses in each test block by condition. These results indicate that the nature and urban pictures did not differ in their effects on the children’s Hearts-and-Flowers performance.

**Performance on the Head-Toes-Knees-Shoulders Task**

We conducted an independent sample t-test to compare scores on HTKS in the nature condition and urban condition. There was no difference in scores on HTKS between the nature condition ($M = 35.44, SD = 17.686$) and urban condition ($M = 37.50, SD = 15.887$), $t(30) = -.35, p = .731$ (see Figure 4).

**Discussion**

Our hypothesis that the children who viewed nature pictures between test blocks of the Hearts-and-Flowers task would respond faster and respond correctly more often than would children who viewed urban pictures was not supported. The children in both conditions performed equally well on the task. Furthermore, the hypothesis that children who viewed nature pictures would score higher on the HTKS task than those who viewed urban pictures was also not supported.

These findings are surprising, because previous work with adults suggests that nature pictures should facilitate performance on EF tasks (Berto, 2005), and the current study utilizes a
paradigm similar to those used with adults. In both the present study and those with adults, participants viewed comparable pictures for approximately the same length of time. Despite these similarities, the nature and urban images did not have the same restorative EF effects on children that they have been shown to do on adults.

There are several possible reasons why children and adults may respond differently to nature and urban pictures. For one, children may not associate natural and urban environments with the same situations and feelings that adults do. For example, adults often associate natural environments, such as beaches and mountains, with relaxing vacations (Berto, 2005). Five-year-olds may not have many vacation experiences or culturally specific knowledge about where people often go (or wish to go) on vacation and how they feel or expect to feel when they are there. Therefore, they may not yet associate nature and relaxation.

It is even possible that children think about vacations in exactly the opposite way. They may experience, or wish to experience, their vacations as more exhilarating than relaxing. Without associating nature with relaxation and rejuvenation, children may not have access to the restorative effects often reported in adult studies. Similarly, young children may not associate urban environments with stress and danger, either because they lack experience in these environments or because their parents monitor threatening environments for them. Without this association in place, children may not expend EF resources monitoring for threats when viewing pictures of urban environments.

The one experimental study that supports a link between nature and attention restoration in children found that the children who walked through a park performed better on an EF task than those who had walked along a busy street (Taylor & Kuo, 2009). There are several important differences between that study and ours that may account for the different findings.
First, Taylor and Kuo (2009) conducted their study with children diagnosed with ADHD, while no children in our sample had this diagnosis. It is possible that those children who already struggle with attention and inhibition may benefit more from exposure to nature than those children who do not. Second, Taylor and Kuo (2009) tested children between 7-years-old and 12-years-old. All of the children in our study were 5-years-old. Older children may have more vacation experiences and more knowledge about vacations than younger children. Accordingly, they may respond to nature more like adults because they have more adult-like associations between nature and relaxation. Finally, Taylor and Kuo had the children walk through actual environments rather than just viewing images. For children, navigating through an unfamiliar urban environment, especially without their parents, may be sufficiently depleting to affect performance on an EF task.

Although both E. O. Wilson (1984) and Kaplan (1995) suggest that nature is inherently fascinating to humans and therefore restorative, is it possible that young children find every novel environmental image fascinating no matter the content. The children in our study may have been just as captivated by the busy urban streets as they were by the dense forest. Our findings may have been different if there had been animals in the nature pictures rather than just landscapes, since other research has shown that children are more fascinated by animals than man-made objects (DeLoache, Bloom-Pickard, & LoBue, 2010). Alternatively, the children may have been bored with both sets of unpopulated images. Children accustomed to videogames and fast-paced cartoons may be bored by a slideshow of still images. Whatever the explanation, images of nature and urban environments do not seem to promote nor compromise young children’s EF.
Despite the null result, the present study is a valuable contribution to restorative environment research, because the findings suggest that children respond differently than adults to nature and urban pictures. While the identification of the mechanism underlying this difference is beyond the scope of this research, it should be an important focus for future research. For example, future studies should investigate whether walking through actual nature and urban environments has restorative effects on young children. Furthermore, researchers should test a wide age range of children to establish when the restorative effects of natural environments are first experienced.

The current study is one of the first experimental studies on the effects of natural and urban environments on children's executive functioning. Although our results indicate that young children may respond differently than adults to pictures of these environments, more rigorous experimental work must be conducted outside of the lab and with a wider age range of children. Because more than 80 percent of Americans live in cities—a percentage that continues to grow as people move to cities from rural areas (U.S. Census, 2012)—it is important to examine the relation between urban environments and the development of executive functioning and the possibility that exposure to natural environments could mitigate any negative effects.
References


Table 1

*Mean Response Times (RT) in Milliseconds and Number of Correct Responses for Hearts-and-Flowers and HTKS by Condition*

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<th>Urban Condition</th>
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“When you see a heart, press the button on the same side as the heart.”

“When you see a flower, press the button on the other side of the flower.”

Figure 1. Still frames from Hearts-and-Flowers computer task depicting the rule for the Hearts game and the rule for the Flowers game.
Figure 2. Mean response time for correct responses in each test block by condition.
Figure 3. Mean number of correct responses in each test block by condition.
Figure 4. Mean number of correct responses on HTKS by condition.