Time Grows on Trees: The Effect of Nature Settings on Time Perception

by

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A thesis submitted to the Faculty of Graduate and Postdoctoral Affairs

in partial fulfillment of the requirements for the degree of

Master of Arts

in

Psychology

Carleton University

Ottawa, Ontario

Abstract

Time perception may vary depending on one's surroundings. Four studies examined whether time feels slower in nature compared to urban settings. Participants viewed images of nature or urban settings (Study 1), viewed a video of a walk through a forest or city via virtual reality headsets (Study 2), imagined themselves walking down a forest path or a city street (Study 3), and actually walked by a river or through campus tunnels (Study 4). Time perception was measured through subjective duration estimates (Study 1, 2, 3, 4) and objective duration estimates in minutes/seconds (Study 1, 2, 4). Across studies, the surroundings affected time estimates. Participants estimated the objective duration (Study 4) and subjective duration (Study 2, 3, 4) of the nature stimuli as significantly longer than urban stimuli. This research contributes to both time perception and environmental literature and may be applied in everyday time management.

Keywords: time perception, nature, stress

Acknowledgments

Firstly, I would like to thank Dr. Johanna Peetz for her excellent guidance and mentorship. Her support and dedication is a sign of her academic professionalism and generous nature. I am very grateful for the knowledge and advice she has given throughout my M.A. degree and I am eager to continue my Ph.D. research with Dr. Peetz.

Secondly, I would like to thank my parents, Mykola and Natalya Davydenko. I would not be given the opportunities I have now without their struggles and sacrifices. I am eternally indebted for their support and devotion.

Finally, I would like to thank Timour Ibrahim and my dear friends for always being there for me and keeping me sane. I want to thank all the participants who participated in my research studies.

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Time Grows on Trees: The Effect of Nature Settings on Time Perception

Time is in every aspect of human existence. It shapes how we perceive the world and organize our life. Time is crucial for remembering the past (e.g., reliving childhood memories), living the present (e.g., experiencing the thrill of skydiving), or planning the future (e.g., saving for retirement). How we perceive time is malleable and may be influenced by internal (e.g., mood, thoughts) and external (e.g., surroundings) factors. As Albert Einstein stated, "Put your hand on a hot stove for a minute, and it seems like an hour. Sit with a pretty girl for an hour, and it seems like a minute. That's relativity." (Goodreads Inc., 2011). Personal experience of time perception fluctuations while hiking (i.e., consistently overestimated hike duration – two hours felt like four hours) motivated the research to examine whether a natural surrounding effects time perception differently than an urban surrounding. Do settings – nature vs. urban environments - change how we experience time?

Time perception

Perceiving "time" in the psychological literature can refer to perceiving temporal distance to past or future events, remembering the temporal order of events, or forecasting or tracking time during an experience. Time perception can be studied in various ways. For example, one may research how people perceive distance to the past (e.g., Pennington & Roese, 2003) or to the future (e.g., Wilson et al. 2012), whether people focus more on past or future events (e.g., D'Argembeau, Lardi, & Van, 2012; Wilson & Ross, 2000), and how people date events (e.g., Shum, 1998). Of particular concern in this research were differences in time perception conceptualized as *duration*. Time duration focuses on the sense of time *in the moment* and how we 'feel' time pass. A set time duration (e.g., one hour) is the same across people, yet how it is perceived can vary. Referring back to the Albert Einstein quote, it is interesting and important to

know whether manipulations in time duration can potentially make “one hour on a hot stove” feel like one minute. Psychological research into how or why people perceive the duration of a time period differently is at times inconsistent (Hogan, 1978). Although time perception may include numerous experiences of time, the present research focused on duration, thus the term ‘time perception’ refers to perceived duration.

Objective and subjective time perception. Time perception can be quantified into both objective and subjective measures. Objective time refers to the universally agreed upon measurement of time (i.e., seconds, hours, weeks). This form of time perception is quantifiable, for example, one minute is equal to 60 seconds and three hours is three times longer than one hour. Subjective time is the phenomenal experience of time passing; it can vary between and even within individuals. Subjective duration, for example, is defined as judgements about the length (i.e., how long a stimulus was presented) or speed (i.e., how fast a stimulus was presented) of stimuli passing (Wearden, O'Donoghue, Ogden, & Montgomery, 2014). Subjective time is comprised of these judgements on duration and the passage of time, respectively. The two can be connected whereby if the duration feels long, it is assumed time passes slowly and likewise if the duration feels short, time passes quickly. For example, being in traffic for 30 minutes can ‘feel’ like a lifetime, but 30 minutes watching an interesting TV-show can seem to fly by. Although the objective time is the same in both scenarios (i.e., 30 minutes), the subjective time is quite different. Estimates of subjective duration can also be broken down into prospective and retrospective timing (Wearden et al., 2014). Prospective timing refers to estimating duration of time as it occurs (e.g., turn this page after one minute has passed); here, the element of time is made salient from the beginning. Retrospective timing refers to thinking back and judging how

long a duration of time lasted (e.g., how did it take to read the last page); the time judgement is unexpected, as it is not explicitly mentioned to keep track of time in the beginning.

While the distinction into objective and subjective duration is important, they remain interconnected. The subjective experience of time passing influences one's objective time estimates, and objective time units (i.e., minutes and seconds) are often used to measure subjective perception. In my research, I examine both objective and subjective time measures, being well aware that the objective time measure is in nature a subjective estimate. Although the objective measurement of time is ubiquitous in everyday life, and ostensibly quantifiable, the estimation of objective time - just like the experience of subjective time - can vary between people and situations.

Conceptual foundations of time perception. Researchers propose individuals use internal clocks to perceive time. The most common models of time perception suggest an internal clock consisting of a pacemaker and an attentional gate (Kramer, Weger, & Sharma, 2013). These models refer to the subjective duration experience of time (i.e., how we feel time pass in the moment). The pacemaker of the internal clock releases a steady pulse that fluctuates in speed depending on levels of arousal, such that highly arousing moments result in more frequent pulses (Church, 1984; Herbst, van der Meer, & Busch, 2012). The rhythm of pulses is compared to previous rhythms stored in memory to form an estimate of time duration (Kramer, Weger, & Sharma, 2013). Moments with high arousal, and frequent pulses, result in an overestimation of time duration because typically such a high number of pulses occur across a lengthy period of time (Herbst, van der Meer, & Busch, 2012; Kramer, Weger, & Sharma, 2013). The attentional demands of a task also contribute to time perception. If a task or stimulus requires high levels of attention, less attention can be given to temporal processing and errors in

time perception occur (Zakay, & Block, 1997). Ornstein (1970) also suggested a "storage-synthesis hypothesis" stating time perception is associated with the demands of memory storage; the more things there are to remember given a certain period, the longer the time judgement of that period. Perceiving time is a complex process that involves the collaboration of various cognitive systems, such as attention and memory, to form a time judgement. In the present research I do not examine the biological foundations of perceived time but focus on self-reported subjective and objective duration.

Factors affecting time perception

People's perceptions and estimations of time can shift depending on both internal (e.g., personality and arousal) and external (e.g., environmental surrounding) factors.

Internal factors. Time duration can be experienced differently depending on internal states. For example, differences in personality and perception of stimulus characteristics, such as the experiencer's arousal and enjoyment, can alter the experience of time in the moment and shape retrospective duration judgements.

Emotions accompanying an event influence how an individual perceives time. Wearden et al. (2014) showed highly arousing and exciting stimuli are associated with an underestimation of time duration (i.e., time feels faster); participants who judged videos as more exciting perceived time passing faster than videos judged to be boring. However, if the arousing qualities of a stimulus are too high (e.g., as in a near death experience), an individual perceives time to slow down (Hammond, 2012; Loftus, Schooler, Boone, & Kline, 1987). Negative events are regarded as being more arousing than positive events (Angrilli, Cherubini, Pavese, & Manfredini, 1997; Mereu, & Lleras, 2013). When experiencing a negative or fearful event an

individual's internal clock emits pulses frequently and one overestimates time passage based on previous memories of pulse frequency and time duration (Zakay, & Block, 1997).

Enjoyment can matter. The fluctuation in how time is experienced does not go unnoticed by people. Individuals are aware of the relationship between internal experiences and time perception, so much so that the feeling of time passing quickly in pleasant moments has become a common saying, 'time flies when you're having fun'. Researchers have demonstrated when individuals are happy and enjoying an experience, time feels to pass faster (Angrilli, et al., 1997; Gable, & Poole, 2012; Wearden et al., 2014). Furthermore, researchers have tested the directionality of the relationship between enjoyment of a task and quickened time perception. Sackett, Meyvis, Nelson, Converse, and Sackett (2010) showed that individuals give a more positive evaluation of experiences if they perceived the experience to pass quickly. While completing an activity participants were told more time passed than actually did (i.e., after 10 minutes were told 20 minutes elapsed), thereby making it feel time passed surprisingly quick, participants rated the activity as more enjoyable, fun, engaging, and were more likely to do the activity again. Thus, awareness of changes in the passage of time can influence hedonic judgements of an experience.

Individual differences, such as personality traits, shape how people perceive time. Hogan (1978) suggested the extraversion-introversion dimension of personality relates to time perception through differing preferences for stimulus complexity (i.e., irregular, difficult, energy-demanding, or detailed stimuli) between the two traits. He proposed extraverts prefer high levels of complexity and this relates to the feeling of time passing faster for extraverts than for introverts in highly complex situations. Introverts prefer less complex stimuli and are overwhelmed with the high complexity craved by extraverts, and as such, introverts perceive

highly complex stimuli as slowing time. According to this theory, extraverts are bored with less complex stimuli and will perceive time to pass slower than introverts in such situations. Introverts perceive time passes faster than extraverts when there is less complex stimuli because the low levels of complexity bore the extraverts and slow down their time perception. Such a relationship proposed by Hogan (1978) slightly alters the U-shape relationship between stimulus complexity and time perception discussed previously.

Chronic or temporary anxiety levels can affect different aspects of time perception, such as duration and distance estimates. On such example pertains to one's anxiety level. Bar-Haim, Kerem, Lamy, & Zakay (2010) demonstrated that when naturally anxious individuals are exposed to a threat, they experience time passing slower than non-anxious individuals exposed to the same threat. A similar trend of slowing time is seen in children with Attention Deficit Hyperactivity Disorder (ADHD) and may serve to explain why children with ADHD behave what appears to be impulsively for non-ADHD individuals, because the perception of time is greatly slowed down with ADHD (Hammond, 2012). Other examples of internal factors influencing time perception include one's physiological response whereby the speeding up of time is associated with a rise in body temperature (Baddeley, 1966; Hammond, 2012). Also, certain substances are associated with time perception changes. Wearden et al. (2014) analyzed participant descriptions of experiences where time either slowed or quickened. The researchers found alcohol and cocaine were related to time passing more quickly and the majority of participants agreed time distortions occur more frequently with substance use. Using the same descriptions, these researchers found participants reported a slowing of time associated with negative emotions, such as sadness, tiredness, and boredom. The valence of an emotion greatly

impacts how people perceive time in a given moment, but changes in time perception can also feedback onto the individual's emotions, thereby creating an interconnected relationship.

Chronic and temporary states of mindfulness can also change how individuals 'feel' time, as much as anxiety may influence time perception. Mindfulness is a state of awareness and attention of present internal and external sensory stimuli (Kramer, Weger, & Sharma, 2013). Mindfulness increases metacognitive awareness and attention, as well as decreases rumination (Davis & Hayes, 2011). It is a useful technique to reduce stress and arousal (Chang et al., 2004). Mindfulness meditation manipulates time perception by altering both attention and arousal levels; attention is internally focused on feeling of the present moment and arousal levels decrease resulting in an increase in perceived time duration (Kramer, Weger, & Sharma, 2013). During mindfulness meditation, the internal pacemaker model emits infrequent pulses giving the illusion that time is passing slowly (Kramer, Weger, & Sharma, 2013). Overall, it appears time perception is a dynamic process that is influenced by various internal characteristics and perceptions (e.g., emotions, individual differences, mindfulness, etc.).

External factors. Time perception may further vary depending on external stimuli and the environmental surroundings of an individual. For example, stimuli complexity and natural or urban settings can alter perceived duration.

Stimulus complexity, like arousal, is also associated with changes in time perception. An experience with a novel or complex stimuli usually leads to an overestimation of time duration and a specified time interval is felt to be longer (Hogan, 1978). A complex stimulus requires more cognitive resources to be processed than a less complex stimulus and this increased demand in processing is associated with longer time estimation (Hogan, 1978). Flaherty (1991) analyzed narratives and interviews describing temporal experiences and concluded stimulus

complexity in either extreme (i.e., very low or very high levels) is associated with a slowing of time and moderate complexity with a quickening of time. This proposes a U-shaped relationship between stimulus complexity and time perception (Flaherty, 1991; Hogan, 1978).

External sources, such as the surroundings in which a person finds themselves while making time estimates, should further influence time perception. However, a literature search of external sources of influence on time perception, in particular natural vs. urban settings, resulted in only one previous study. Berry, Repke, Nickerson, Conway, Odum, and Jordan (2015) showed images of natural and built settings to participants and asked them to estimate time duration since arriving to the lab and estimate the speed of time passing. The main interest of the researchers was the relationship between nature, impulsivity, and time perception. These researchers demonstrated that those participants exposed to images of natural settings estimated more time had passed in the experiment than those who viewed images of urban settings. While this study provides initial evidence that surroundings can affect time perception, many aspects of this link remain unclear. These studies will attempt to provide more information on the relationship between external influences (specifically, nature vs. urban settings) on time perception.

Nature

Before specifically examining the relationship between time perception and nature settings, the following section will examine the broad effects of nature. Surrounding environments greatly influence and shape how an individual feels, thinks, and behaves. Natural vs. human-built (urban) settings is one potential influence of the surroundings on an individual. People have an intrinsic connection to natural over urban settings and associate more with natural than urban settings (Verges & Duffy, 2010). Natural settings are “areas containing elements of living systems that include plants and nonhuman animals across a range of scales

and degrees of human management" (Bratman, Hamilton, & Daily, 2012, p. 120). This definition includes varying levels of natural and urban association and human involvement, varying from landscaped yards to wild forests. Typically, natural settings provide quiet and open atmospheres when compared to urban settings, which are usually noisy and confined (Bratman, Hamilton, & Daily, 2012). Evolutionary hypotheses suggest humans may prefer and value natural settings, such as grasslands, because this where our early ancestors evolved; urban environments are relatively new to humanity and are 'unnatural' when examining the course of our specie evolution (Ulrich, 1986).

With such an instinctive connection to nature, psychologists extensively study the affective and cognitive benefits of nature. It is important to study and understand the benefits of nature as it is associates to various aspects of psychological health (Bratman, Hamilton, & Daily, 2012; Wolsko & Hoyt, 2012), such as attention (Lee, Williams, Sargent, Williams, & Johnson, 2015), emotion regulation (Johnsen, 2013), stress relief (Bratman, Daily, Levy, & Gross, 2015), life satisfaction (Korpela & Kinnunen, 2011), and mindfulness (Howell, Dopko, Passmore, & Buro, 2011). Nature could be a potential method of preventing depression, anxiety, and stress (Bratman, Hamilton, & Daily, 2012). However, some research suggests people may underestimate the effects of nature exposure on mood (Bratman, Daily, Levy, & Gross, 2015). Research and awareness about the psychological benefits of nature is needed.

Influencing affect. Natural environments evoke various emotional responses in individuals. Overall, nature promotes positive states while decreasing negative states (Mayer, Frantz, Bruehlman-Senecal, & Dolliver, 2009). After exposure to nature-related stimuli, individuals experience an increase in positive affect (Bratman, Daily, Levy, & Gross, 2015; Saroglou, Buxant, & Tilquin, 2008). Furthermore, nature experience decreases anxiety,

rumination, and negative affect (Bratman, Daily, Levy, & Gross, 2015). It is proposed that nature may even serve as a buffer against the effects of negative emotions (Johnsen, 2013). Bratman, Daily, Levy, and Gross (2015) suggest nature may offer negative affect repair and restore feelings of positive affect. Beyond positive affect, nature also evokes feelings of awe (Shiota, Keltner, & Mossman, 2007). Nature settings are considered fascinating and extensive (Lee, Williams, Sargent, Williams, & Johnson, 2015), potentially adding to increases in positive affect. Once again, these nature benefits may come because of an evolutionary basis in more nature than urban settings (Johnsen, 2013).

Although the relationship between nature and positive affect is well established, yet little research attempts to clarify why this relationship exists. Potential mediators include connectedness to nature (Mayer, Frantz, Bruehlman-Senecal, & Dolliver, 2009), recovery from stress (Hartig, Evans, Jamner, Davis, & Gärling, 2003), and attentional fatigue (Kaplan, 1995). However, the research is sometimes inconsistent and needs more investigation.

Beyond changes in emotion, nature may also be used as a tool for emotion regulation. Research by Johnsen (2011) demonstrated individuals spend time in nature to increase positive affect or decrease negative affect. Furthermore, Korpela (2003) showed that individual differences may influence preference for nature settings. Those individuals who rated higher in negative mood were more likely to select a natural setting as their favourite place, potentially as a method to regulate their negative emotions. Nature experiences may be used to maintain emotional stability (Johnsen, 2013). This is interesting to note because not only does nature implicitly increase positive affect, it is also explicitly sought out as a resource to regulate emotions.

Influencing physical benefits. Beyond psychological effects, nature also promotes physical changes. Research by Pretty, Peacock, Sellens, and Griffin (2005) demonstrated exercising in nature settings offered a greater decrease in blood pressure than exercising in urban settings. Furthermore, nature experiences, such as walking through a forest, show a decrease in heart rate variability, adrenaline and noradrenaline (neurotransmitters activated during stress), as well as an increase in immune functioning (Korpela & Kinnunen, 2011; Li, 2010). These physical benefits interact with the psychological benefits to create an overall sense of well-being following exposure to nature.

Stress. The Stress Reduction Theory suggests nature evokes an unconscious, automatic response that reduces stress (Bratman, Hamilton, & Daily, 2012; Bratman, Daily, Levy, & Gross, 2015). Based on previously mentioned evolutionary hypotheses, Ulrich (1979) suggests natural settings (e.g., water bodies, vegetation) were most beneficial for survival of the species, and as such are associated with decreased stress. Following a nature experience, self-reported stress levels decrease, as well as physical signs of stress (e.g., skin conductance, heart rate, and cortisol levels) decrease, complementing research on the physical benefits of nature discussed earlier (Bratman, Hamilton, & Daily, 2012; Bratman, Daily, Levy, & Gross, 2015). Furthermore, nature settings allow for faster recovery from stress than urban settings (Ulrich et al., 1991) and functional magnetic resonance imaging research has shown urban settings may tax neural circuitry designed to deal with stress (Lederbogen et al., 2011). It is suggested that nature is particularly beneficial for those dealing with a crisis, such that the greater the stress level pre-nature experience, the greater the difference in stress post-nature (Ottosson & Grahn, 2008). This reduction in stress levels allows for greater psychological well-being.

Similar to the use of nature experiences to regulate emotions, nature may also be sought after in times of high stress to aid in regulating well-being. Gulwadi (2006) demonstrated that elementary school teachers who reported high levels of work stress mentioned natural settings as being more restorative than those with low work stress. This relates back to Ulrich's four criteria for restorative environments, whereby nature distances the teachers from the source of the stressor allowing for stress reduction and restoration. Furthermore, there is an inverse relationship between time spent in nature and need for recovery from work stress, such that the longer the duration of time spent in nature, the less need for recovery from stress (Korpela and Kinnunen, 2011). This suggests the effects of nature experiences on stress may be long lasting and used to lessen future stress and in turn aid cognitive functioning.

Korpela and Kinnunen (2011) demonstrated nature experiences were assessed as the most effective way to recover from work stress, and time spent in nature correlated to life satisfaction and relaxation. These researchers also examined whether the type of activity in nature influenced stress reduction. When in nature settings, many activities have an element of physical activity (e.g., walking, hiking, gardening, etc.) and the physical activity may be influencing the effects of nature on stress. Korpela and Kinnunen (2011) compared time spent in nature exercising and non-exercising and found that although physical exercise in nature does relate to relaxation, the relaxing effects of nature hold without physical exercise. Even minimal interaction with nature (i.e., potted plants in an office without a window) can offer benefits to stress reduction and are recommended in office spaces to boost worker mood, cognition, and reduce stress (Augustin, 2009). Nature settings in and themselves offer a unique element for relaxation and stress relief.

Influencing cognition. Following the affective and physical benefits, nature experience also influences one's cognition. The effects of nature on cognition are well established and even

small exposures to nature, such as a window with a nature view, aid cognitive functioning (Bratman, Hamilton, & Daily, 2012). In addition, children who move to a nature focused area vs. an urban focused area show increased cognitive capacity (Taylor, Kuo, & Sullivan, 2002; Wells, 2000). Bratman, Daily, Levy, and Gross (2015) demonstrated better working memory functioning following a 50-minute nature walk. The benefits of nature on cognition are numerous with special focus on attention restoration and mindfulness.

Attention. One method of increasing cognitive functioning is by restoring depleted attention resources. Attention Restoration Theory posits that nature replenishes attentional levels through effortless, unconscious processes by reducing demands on limited attention resources, while urban settings deplete attention by tiring voluntary attentional control that filters relevant information (Bratman, Hamilton, & Daily, 2012; Bratman, Daily, Levy, & Gross, 2015; Johnsen, 2013; Kaplan, 1995; Mayer, Frantz, Bruehlman-Senecal, & Dolliver, 2009). Nature provides a sense of fascination and restores attention with the feeling of being away from the source of depletion, urban settings (Bratman, Daily, Levy, & Gross, 2015). Voluntary attention requires individuals to focus on select stimulus, while ignoring irrelevant stimuli; after prolonged use, this resource becomes depleted (Kaplan, 1995). Involuntary attention occurs when stimuli is inherently interesting and does not require forceful concentration (Kaplan, 1995). Nature is considered inherently intriguing and experiences with nature allow voluntary directed attentional resources to rest and restore. Natural settings exercise cognitive resources without causing mental fatigue (Kaplan, 1995).

There are four criteria for restorative environments set out by Kaplan (1995): extent (immersion with environment), being away (distance from habitual environment), fascination (capture attention effortlessly), and compatibility (match between individual's intentions and

environment). Nature settings consistently fulfill each of these criteria for a restorative environment. As most people live in cities, urban settings do not fulfill the criteria of being away. Furthermore, urban settings frequently require effortful attention, failing to fulfill the third criteria.

Research on attention and nature use various methodologies to test the minimal interaction with nature required to restore attention. Researchers have demonstrated going for a 50 minute walk (Berman, Jonides, & Kaplan, 2008), a 20 minute bus ride through a nature preserve (Mayer, Frantz, Bruehlman-Senecal, & Dolliver, 2009), and viewing a photograph of a green roof for a mere 40 seconds (Lee, Williams, Sargent, Williams, & Johnson, 2015) can restore attention levels. Further research examines the effects of different types of nature (e.g., urban green, water bodies, forests, farmland), effects of different duration exposures in nature (e.g., minutes to hours, days, years), and different methods of presenting nature (e.g., images, window views, virtual reality, physical presence). Physical presence appears to provide stronger effects in terms of cognitive restoration than other forms, even if they are immersive, such as virtual reality (Mayer, Frantz, Bruehlman-Senecal, & Dolliver, 2009). The fourth study will examine how taking a brief walk by a river influences one's perceptions.

Mindfulness. Nature exposure allows for the clearing of negative thoughts, restoring depleted attention, and reducing stress leading to cognitive tranquility (Kaplan, 1995). This state of mental calmness may be akin to mindfulness and may encourage reflection on life (Johnsen, 2013; Mayer, Frantz, Bruehlman-Senecal, & Dolliver, 2009). Indeed, mindfulness is also associated to exposure to natural environments. Howell, Dopko, Passmore, and Buro (2011) demonstrated a positive correlation between nature connectedness and well-being, as well as nature connectedness and mindfulness. Individuals with greater connection to nature also score

higher on trait levels of mindfulness (Wolsko & Lindberg, 2013). As such, there seems to be evidence for a connection between nature and mindfulness.

Influencing time perception. One additional, understudied, effect of natural environments may be a shift in time perception. Two potential predictions arise based on past research.

On the one hand, natural settings (vs. urban settings) might be linked to perceiving time to pass faster. Time perception research demonstrates enjoyment of an activity is associated with the feeling of time passing faster (Angrilli, et al., 1997; Gable, & Poole, 2012; Wearden et al., 2014). The common saying, 'time flies when you're having fun' encapsulates this idea. Nature exposure is typically regarded as an enjoyable and pleasant experience (Verges & Duffy, 2010). As a result, it would be reasonable to assume that in nature settings the passage of time feels faster than in other settings.

On the one hand, natural settings (vs. urban settings) might be linked to perceiving time to pass slower. Time feels to pass slower when an individual is in a meditative/mindful state (Kramer, Weger, & Sharma, 2013). Nature settings arouse feelings of mindfulness and relaxation (Howell, Dopko, Passmore, & Buro, 2011; Johnsen, 2013; Korpela and Kinnunen, 2011). Spending time in nature decreases stress levels (e.g., Bratman, Hamilton, & Daily, 2012; Korpela and Kinnunen, 2011) and restores attention (e.g., Johnsen, 2013; Kaplan, 1995). These benefits of nature create a sense of calm and relaxation within the individual (Korpela and Kinnunen, 2011). Such a state allows for reduced arousal levels and the feeling of a slower passage of time (e.g., Herbst, van der Meer, & Busch, 2012; Kramer, Weger, & Sharma, 2013). Finally, the limited empirical evidence available on nature and time perception also supports this prediction (Berry et al., 2015).

The study by Berry et al. (2015) is the only study that has examined time duration estimates and nature. The purpose of this study was to examine whether natural vs. built environments influence impulsivity, but also time perception. The researchers operationalized time perception as speed of time passage since the participant arrived to the study and signed the informed consent (i.e., subjective duration estimate). Also, the participants estimated in minutes how much time passed since they arrived and completed the informed consent (i.e., objective duration estimate). The researchers found a significant difference in objective duration estimates by condition, with those in the natural condition reporting more minutes had elapsed than those in the built condition. Subjective duration estimates showed marginally significant differences by condition following the same trend of perceiving slowed time in the nature condition vs. built condition.

However, there are a few limitations with the design and methods of this study by Berry et al. (2015), which separates it from my studies. Firstly, Berry et al. (2015) were primarily concerned with impulsivity and used time perception as a method of explaining differences in impulsivity. The main purpose of my studies is first to establish the relationship between time perception and nature, and then explore how other factors, such as stress, may be related.

Secondly, Berry et al. (2015) did not analyze characteristics of the natural (e.g., mountains, forests, lakes) and built (e.g., buildings, cities, roads) images used in the study. This may be problematic if the images chosen vary in appeal, pleasantness, and complexity. Typically, images of natural environments are more awe-inspiring, pleasant, colourful, interesting, and feature large open spaces. If the natural and built images significantly differ in their features, the differences between conditions may be due to aspects of the image beyond the nature or built content, such colour or complexity. My studies will ask participants to rate their

experience while being exposed to the nature or urban setting to ensure both settings are equal in key attributes and allow fair comparison.

Finally, the way in which time perception was operationalized in the study by Berry et al. (2015), namely measuring time since arrival to lab, may introduce variability in the results. There was no measure or comparison of the *actual* time elapsed since arrival and participation perceptions of time since arrival. This lack of comparison is a point of concern because the time since arrival or completion of informed consent may vary between participants and so differences in time estimation may reflect differences in the actual time it took to run the experiment. Without measuring the actual duration, Berry et al. (2015) could not control for actual duration when testing differences in time estimates between the nature and urban conditions. In my research, I used a stopwatch to track duration and participant estimates, so that a fair comparison can be made across all participants; differences in the actual durations were controlled when analyzing how time perception differs for natural vs. urban settings.

The Present Research

Although everyone is affected by time and can feel its passage, many aspects of time perception remain unstudied. The present research may provide a potential explanation for why nature relates to increased mindfulness and reduced stress. The feeling of mindfulness in nature settings may come as a result of the feeling of time passing slower when in nature. The slowed sense of time in nature allows for moments of relaxation and reflection leading to a greater state of mindfulness. I hypothesize time perception will slow down and lead to an overestimation of duration when exposed to natural settings vs. urban settings. Furthermore, being exposed to nature settings will result in greater positive affect and reduced stress than in urban settings, presumably because of the shift in time perception. I will explore whether time perception

mediates the relationship between nature and stress relief. Three initial studies examined how nature vs. urban settings influence time duration estimates, as well as other factors (e.g., nature connectedness, stress, mood), using increasingly immersive methodologies. These studies allowed for initial testing of this effect, since the relationship of interest is not previously documented.

Study 1: Effects of Surroundings on Time Perception

The purpose of this study was to test differences in subjective duration estimates after being exposed to nature or urban images. This study also explored differences in nature connectedness, experience in nature vs. urban settings, and stress by condition. Time perception was operationalized as 'objective' (i.e., estimate time in seconds) and subjective (i.e., estimate speed and length of time passage) time duration.

Method

Participants

One hundred and thirty nine participants (85 males and 54 females; M_{age} = 37.50, SD_{age} = 13.76) from across the United States of America and Canada completed this study using Crowd Flower. Participants received $0.50 in compensation. Only one participant was excluded from the analysis for being aware of how much time passed while the images were displayed.

Procedure

Using Crowd Flower, participants signed up for an online study titled "Effect of Surroundings on Perception". After completing the informed consent and a brief demographics questionnaire, participants were randomly assigned to the nature or urban condition and were presented with four images pertaining to their condition. After each image participants completed time duration and experience in nature/urban setting scales. Pre- and post-

manipulation stress levels were also reported. Participants next completed the Nature Connectedness Scale (Mayer & Frantz, 2004). For all study materials see Appendix A. Finally, participants were presented with the debriefing form and received compensation. The measures are listed as follows.

Demographics. Participants reported their age, gender, current occupation, and population size of place of residence. Current occupation was asked to control for anyone who may have worked in a natural setting and had higher than average exposure to nature. Population size was likewise assessed to examine differences between rural and urban places of residence.

Pre-manipulation stress. Two items (i.e., in general how stressed are you, in general how strained for time are you) assessed participant stress levels using a five point Likert scale (1 = *Not at all stressed/strained;* 5 = *Very stressed/strained*). Participant mood was also reported using one item with a five point scale (1 = *Sad*; 5 = *Happy*).

Nature vs. urban condition. Participants were randomly assigned to the nature or urban condition. The nature condition displayed four images of nature settings with increasingly less maintained nature (i.e., balcony with potted flower, landscaped backyard, urban park, and forest). The urban condition images were representations of common urban areas the participants might frequent (i.e., athletics facility, office buildings, shopping centre, and downtown centre). All images were the same size and each image was presented for exactly 30 seconds. After 30 seconds, the screen automatically progressed to the Time Duration Scale and the Experience in Nature/Urban Setting Scale, followed by the next image and so on. Participants were asked to look at the image and imagine him/herself in that setting.

Time duration scale. The scale consisted of three items assessing participant perceptions of how long each image was presented. Participants were asked to think about the image they

just saw and report how they felt. Participates rated subjective duration with two items (i.e., how short/long did it feel, how fast/slow did it feel) using a slider (0 = *very short/fast*; 100 = *very long/slow*). Participants rated objective duration by typing in seconds how long they estimated the image was presented.

Experience in nature/urban setting scale. Participants were instructed to think about their experiences when they are actually in the setting that was depicted in the image. Next, they rated how often they are in this setting using a five point Likert scale (1 = *Never*; 5 = *Always*). If the participant selected "Never", they were asked to skip the following questions and continue to the next page. Participants then estimated the number of hours and minutes they spend on average per visit in the setting that was previously depicted in the image. Also, they reported using a five point Likert scale their physical exertion (1 = *Very physically relaxed*; 5 = *Very physically exerted*), mood (1 = *Sad*; 5 = *Happy*), awareness (1 = *Not at all aware*; 5 = *Very aware*), and mental stimulation (1 = *Not at all stimulated*; 5 = *Very stimulated*) while in that setting.

Post-manipulation stress. Similar to the Pre-manipulation Stress items, participants reported how stressed and strained for time they felt right now using a five point Likert scale (1 = *Not at all stressed/strained;* 5 = *Very stressed/strained*). They also rated their mood using a five point scale (1 = *Sad*; 5 = *Happy*). Next, participants were asked whether they looked at a clock when the images were displayed; if they answered "yes", they were asked if they were aware of how much time had passed. Those participants who were aware of how much time passed (n = 1) were excluded from the analysis.

Nature connectedness scale. This 14-item measure assessed how connected to nature participants felt after looking at either four nature or urban setting images (Mayer & Frantz,

2004). Using a five point Likert scale (1 = *Strongly disagree*; 5 = *Strongly agree*), participants answered how much they agree with items such as "I often feel part of the web of life" and "I often feel a kinship with animals and plants". The ratings were averaged to create a nature connectedness score. The scale had a Cronbach's reliability alpha of 0.85.

Results and Discussion

This study hypothesized individuals in the nature condition will overestimate how long they look at the image (objective duration) and the time felt longer (subjective duration) than in the urban condition. Furthermore, we predicted individuals would feel happier and less stressed after looking at the nature images than the urban images.

To analyze the data, an independent samples t-test was used. Each nature setting image was compared to the respective urban setting image and mean differences were compared. There were no significant differences in mean objective duration for any of the four pairs of nature and urban images, or when averaging across all nature and all urban images (see Table 1). However, there was evidence of a potential trend in overestimating length in seconds when looking at nature images compared to urban images. This possible effect may have diminished through practice effects. Since all images were shown for 30 seconds, with each estimate participant responses may have become more accurate and decreased the effect of the manipulation.

Table 1. Mean objective duration estimates (in seconds) by image condition.

	Urban		Nature				
	M	*SD*	*M*	*SD*	*t*	*p*	*d*
Balcony/office	32.78	20.943	39.03	30.33	-1.40	0.16	-0.24
Backyard/gym	31.12	15.93	29.65	15.57	0.55	0.59	0.10
Park/downtown	29.38	15.01	30.26	15.43	-0.34	0.74	-0.06
Forest/shopping	29.06	18.37	30.16	17.09	-0.36	0.71	-0.06
Across all nature/urban	30.50	15.36	33.04	19.12	-0.86	0.39	-0.15

Analysis of subjective duration estimates yields interesting results. Two items assessed subjective duration, “how short/long did it feel” and “how fast/slow did it feel”; they were averaged together to create a mean subjective duration score. Higher ratings represented a long/slow subjective duration estimate. See results in Table 2. There was a significant difference between the nature (backyard) and urban (gym) condition in subjective duration estimates. Also, the difference between the balcony and office settings, as well as the overall mean across all nature and all urban images were approaching significance. However, it is interesting to note the relationship is contrary to what is predicted. Those individuals who viewed urban settings reported time passing slower and feeling longer than those in the nature condition. This is also contrary to the results of the objective duration estimates; the participants estimated the nature images to be displayed longer, but time passage felt shorter and faster. A possible explanation of this result may be the type of pictures chosen. The urban images were typically less colourful and less visually interesting; participants may have felt bored looking at them, resulting in a feeling of slowed time.

Table 2. Mean subjective duration estimates by image condition.

	Urban		Nature				
	M	*SD*	*M*	*SD*	*t*	*p*	*d*
Balcony/office	63.89	16.24	58.69	17.14	1.83	0.07	0.31
Backyard/gym	55.54	18.83	47.57	16.73	2.63	0.01	0.45
Park/downtown	52.47	16.65	52.43	18.22	0.01	0.99	0.002
Forest/shopping	52.94	16.91	49.72	18.80	1.06	0.29	0.18
Across all nature/urban	56.22	12.73	52.37	14.08	1.69	0.09	0.29

There were no significant differences in participant feelings of stress, time strain, or mood before looking at their respective nature or urban images (see Table 3). Examining the means within each condition before and after viewing the images shows all participants, irrespective of their condition, felt less stressed, less strained for time, and happier after looking at the images. Post-manipulation, there were no significant differences in stress or time strain between the nature and urban conditions. There was a marginally significant difference in ratings of mood, whereby participants who viewed nature images were happier than those who viewed urban images. For mood, higher ratings represented feeling happy, while low ratings represented feeling sad. The manipulation may not have been as strong for detecting differences in time perception. Previous researchers demonstrated looking at an image for merely 40 seconds could restore attention resources (Lee, et al., 2015), and thus, for the first study we predicted 30 seconds may be enough to induce differences between the conditions. This manipulation (i.e., looking at a nature or urban image on a computer screen for 30 seconds) is not nearly as

immersive as being in the setting or even watching a video of the same setting, yet it still provides some evidence that merely looking at a nature themed image increases positive mood.

Table 3. Stress and mood ratings before and after manipulation.

	Urban		Nature				
	M	*SD*	*M*	*SD*	*t*	*p*	*d*
Pre-Stress	2.83	1.03	2.91	1.00	0.49	0.62	0.12
Pre-Time Strain	2.75	1.02	2.81	1.00	0.38	0.71	0.09
Pre-Mood	3.39	0.94	3.46	0.79	0.45	0.66	0.11
Post-Stress	2.10	1.10	1.96	0.94	-0.84	0.40	-0.21
Post-Time Strain	2.16	1.13	2.07	0.97	-0.49	0.63	-0.12
Post-Mood	3.40	0.78	3.66	0.80	1.90	0.06	0.47

The results of this first study give some evidence on a possible relationship between time perception and nature settings, as well as the affective benefits of nature settings. Study 2 addresses the limitations of this first study, in particular making the manipulation more immersive, to examine this relationship between time perception and nature with more externally valid methods.

Study 2: Take a Virtual Reality Walk

The second study builds on the methods and results of the first study. The purpose of this study was to test differences in feelings and estimates of durations after being exposed to nature or urban videos. This study makes the nature and urban experience more immersive by

introducing virtual reality videos. Time perception is operationalized the same way as the first study.

Method

Participants

One hundred and two participants (58 males, 42 females, 1 other; M_{age} = 21.21, SD_{age} = 3.87) were recruited on university campus. Participants received a snack (e.g., chocolate bar or rice crispy square) as compensation for their participation. No participants were excluded from the analysis. A sample size of 102 participants allows for 80% power of detecting a medium effect size (d = 0.40).

Procedure

Participants signed up to participate in the study in the tunnels of the university. The experimenter was set up at a table with the virtual reality headset (Sony HMZ-T2) and a computer. Virtual reality headsets have been previously used by researchers to compare nature and urban settings (Jiang, Li, Larsen, & Sullivan, 2016; Valtchanov & Ellard, 2010), but not for examining differences in time perception. Some research assistants helped in recruiting participants by approaching people in the nearby area. Anyone who was interested in participating in a study titled “Take a Virtual Reality Walk” was asked to approach the experimenter for more information. Those participants who agreed to participate completed an informed consent and were asked to put on the virtual reality headset and headphones. The experimenter randomly assigned participants to watch a nature or urban video. Immediately after watching the video, participants completed a brief questionnaire on time perception, video features, demographics, stress and mood, and experience in nature/urban settings. For all study

materials see Appendix B. Finally, participants were given the debriefing form and the choice of a snack. The measures are listed as follows.

Videos. The videos used in this study did not contain any inappropriate or sensitive material. They reflected the typical experiences people have while walking in a large city or in a forest. The researcher edited the videos to be of equal time duration, 1 minute and 50 seconds. The nature video showed a slow walk through a forest with a soundtrack of birds chirping. The urban video showed a walk through popular destinations in New York City with a soundtrack of general city noises (e.g., traffic, people talking, etc.). The virtual reality headset was used to create as much immersion as possible into the setting without being physically present in the environment. Also, the virtual reality allowed for maximal focus on the video as it was the only thing participants could see, unlike watching a video on a computer screen.

Time perception. Participants judged objective duration by estimating in minutes and seconds the duration of the video they watched. All answers were coded into seconds for the analysis. Subjective duration asked participants to place a mark along a line (similar to a slider in an online survey) to judge "how short/long the video felt" and "how fast/slow the video felt" (0 = *very short/fast*; 100 = *very long/slow*). These ratings were averaged to create a subjective duration score.

Video characteristics. Participants were asked to rate their experiences while watching the video on a seven point Likert scale (1 = *Not at all*; 7 = *Very*). They were asked how immersive, fun, awe-inspiring, pleasant, mentally stimulating, fast moving the video was, and how distracted by other thoughts they were during the video. Next participants were asked to list as many details as they can that they noticed in the video. This open-ended question was coded

by a research assistant for the number of things remembered by participants to examine whether the nature and urban videos had similar levels of complexity.

Demographics. Participants reported their age in years and gender.

Stress and mood. Similarly to the first study, participants reported their stress and mood post-manipulation. Participants were asked to rate how happy, strained for time, relaxed, sad, stressed, and busy they felt on a seven point Likert scale (1 = *Not at all*; 7 = *Very*). Participants also rated their connection to nature in a single item using the same Likert scale.

Experience in nature/urban settings. Participants were asked their frequency of visit to nature and urban areas. They were asked to estimate how many times per week or per month they walk or drive in a forest or in a city. Also, they estimated how much time per week in hours and minutes they spend waking, sitting, or driving in nature or urban settings. These items were not used in the analysis because most participants did not understand how to report their estimates and excluding the participants from the analysis would result in a small sample size. Instead, the wording of these questions and way of reporting will be improved in the further studies. Participants were also asked to rate their familiarity with the setting shown in the video on a seven point Likert scale (1 = *Not at all*; 7 = *Very*).

Results and Discussion

Preliminary analysis examined video characteristics to ensure both video were equal in feelings of immersion, pleasantness, enjoyment, awe, and mental stimulation to allow for a fair comparison between the conditions. There were no significant differences between the nature setting (i.e., forest) and urban (i.e., New York city) videos for the aforementioned characteristics, except video speed (see Table 4). Furthermore, participants remembered a similar number of details for both videos, as such the nature video, although less diverse and slower paced than the

urban video, did not lack detail or complexity. These results demonstrate that the video characteristics were equal across the conditions; this allows for comparison of conditions based on video content with video characteristics held constant.

Table 4. Participant ratings of video characteristics

	Nature		Urban				
	M	*SD*	*M*	*SD*	*t*	*p*	*d*
Immersion	4.42	1.28	4.80	1.40	-1.44	.15	-0.29
Enjoyment	4.67	1.67	4.90	1.29	-0.80	.43	-0.16
Awe-inspiring	4.31	1.52	4.71	1.72	-1.22	.23	-0.24
Pleasant experience	5.49	1.14	5.35	1.13	0.61	.54	0.12
Mentally stimulated	4.78	1.29	4.92	1.47	-0.50	.62	-0.10
Video Speed	3.00	1.25	3.96	1.08	-4.16	<.001	-0.83
Number of details	3.39	1.77	3.55	2.27	-0.39	.70	-0.08

This study hypothesized participants who watched a nature setting video in the virtual reality headset would report longer duration estimates and feelings of time passing slower than those who watched an urban setting video. To test this initial hypothesis, independent samples t-tests examined mean estimate differences between the conditions. The results show no significant differences in objective duration estimates (i.e., estimate video length in minutes) between the nature (M = 193.04 seconds, SD = 77.16) and urban (M = 181.50 seconds, SD = 64.91) conditions ($t(99) = 0.81$, $p = 0.42$, $d = 0.16$). The video length for both conditions was 110 seconds. Participants in both conditions overestimated the length of the video. It is interesting to

note that the means, although not significant, follow the hypothesized trend with the nature video estimated to be longer on average. Subjective duration estimates (i.e., how short/fast and long/slow did the video feel) were averaged to create a single subjective duration estimate. There was a significant difference in subjective duration estimates between the nature (M = 56.10, SD = 16.45) and urban (M = 50.10, SD = 14.28) conditions, whereby those who watched the nature video perceived a longer/slower passage of time ($t(99) = 1.96$, $p = 0.05$, $d = 0.39$). Unlike in the first study, this study establishes a consistent direction for both objective and subjective estimates.

We also hypothesized that participants who watched the nature setting video would feel happier and less stressed than those who watched the urban setting video. There was no significant difference in participant emotions for happiness or sadness between the nature and urban conditions (see Table 5). However, it is interesting to note that for both the happiness and sadness ratings, participants reported feelings in a consistent direction with the nature video evoking more positive and less negative feelings. There was no significant difference in participant stress, relaxation, or time strain ratings (see Table 5). A possible explanation of these non-significant findings is that the experience of using a virtual reality headset, for most participants for the first time, was an overall pleasant and exciting experience and the use of the headset may have overshadowed some of the effects of the manipulation.

Table 5. Participant emotion and stress ratings post-video

	Nature		Urban				
	M	*SD*	*M*	*SD*	*t*	*p*	*d*
Happy	5.41	0.94	5.20	0.97	1.11	0.27	0.22
Sad	1.92	1.07	2.04	1.36	-0.49	0.63	-0.10
Time strain	3.27	1.54	3.86	1.95	-1.66	0.10	-0.34
Relaxed	4.88	1.23	4.46	1.46	1.58	0.12	0.32
Stressed	3.10	1.66	3.20	1.79	-0.31	0.76	-0.06

Exploratory analysis used a multiple regression model to investigate whether the relationship between nature settings and feelings of time strain depends on time duration estimates. Using MODPROBE, a regression macro designed by Hayes and Matthes (2009), objective duration was selected as a moderator for the relationship between time strain (dependent variable) and study condition (independent variable). Previous research has demonstrated the relationship between nature and stress relief to be well-established and this analysis investigated whether time perception is involved in this relationship. In this analysis, stress was operationalized as feelings of being strained for time. In a university sample, such feelings of time strain are common with frequent deadlines and time-sensitive obligations. Results indicated that the interaction between video condition and objective duration was significant ($b = 0.01$, $SEb = 0.005$, $t(96) = 2.44$, $p = 0.02$, $d = 0.50$), suggesting that the effect of video setting on time strain was moderated by objective duration estimates. Simple slopes for the relationship between video setting and time strain were tested for short (1 SD below the mean), moderate (mean), and long (1 SD above the mean) estimates of objective duration. The simple

slopes test did not reveal a significant relationship between video setting and time strain for short (b = -0.27, SEb = 0.49, $t(96)$ = -0.56, p = 0.58, d = -0.11) or moderate (b = 0.59, SEb = 0.34, $t(96)$ = 1.70, p = 0.09, d = 0.35) estimates of objective duration. However, there was a significant relationship between video setting and time strain for long estimates of objective duration (b = 1.45, SEb = 0.50, $t(96)$ = 2.91, p = 0.005, d = 0.59), suggesting a strong relationship between video setting and time strain only for those participants who estimated above average video duration estimates.

This study demonstrated the relationship between nature settings and stress relief may depend on feelings of time passage. This model will be further investigated in study 4.

Study 3: Time Orientation and Natural Settings

This third study builds the link between time perception and nature settings. The purpose of this study is to test differences in subjective estimates of duration after being exposed to nature or urban setting images. Time perception is operationalized as subjective duration estimates of one minute, whereby participants are asked to count to a minute while viewing an image. By counting to one minute in the moment, any effects of time feeling slower or longer can be captured as they occur. In the previous studies, subjective duration estimates were measured retrospectively and relied on participant memory of how time felt.

Method

Participants

Two hundred and eighteen participants (115 males, 103 females; M_{age} = 36.17, SD_{age} = 13.05) from across the United States of America and Canada were recruited using Crowd Flower. Participants received $0.50 as compensation for participation. Ten participants were excluded from analyses for not following instructions (i.e., did not look at given image for

specified duration), resulting in a sample size of 208. Such a sample size allows for 0.80 power for detecting a medium effect size.

Procedure

Interested participants signed up for a study titled "Time Orientation and Nature Settings" using Crowd flower. After completing the informed consent, participants completed a brief demographics questionnaire regarding their age and gender. Next, participants were randomly assigned to a nature (forest trail or flower path) or urban (modern street or Brownstone townhouses) condition and were shown their corresponding image. Participants were instructed to look at the image for exactly one minute and imagine themselves in this setting as they walked down the path/ street. Once the participant felt a minute had passed, they were instructed to continue to the following pages where they were given a Temporal Focus Scale (Shipp, Edwards, & Lambert, 2009), a long-term time orientation scale, a Nostalgia (Wildschut, Sedikides, Arndt, & Routledge, 2006) and hopefulness scale, a Nature Connectedness Scale (3 items from Mayer & Frantz, 2004), and an Incremental Lay Theories scale (Dweck, 2000). Finally, participants completed a few questions as a brief manipulation check and were presented the debriefing form and given compensation. For all study materials see Appendix C. The measures are listed as follows.

Demographics. Participants reported their age in years and their gender.

Temporal focus scale. This 12- item scale measures what people focus on when their mind wanders. It consists of three subscales: past focus (e.g., "I replay memories of the past in my mind."), current focus ("I think about where I am today."), and future focus ("I imagine what tomorrow will bring for me.") with four items in each subscale. Participants used a five point Likert scale (1 = *Not at all*; 7 = *All of the time*) to rate their focus on each period of time.

Participant ratings were averaged to create total scores for each subscale. Scale reliability using Cronbach's alpha are as follows: past focus (0.90), current focus (0.86), and future focus (0.94).

Long-term time orientation scale. Using this self-constructed scale, participants were asked to indicate on a slider their perceived temporal distance to the year 2030. Next participants were asked two items for how far temporally their mind wanders when thinking about the past and future (*minutes* / *hours* / *days* / *weeks* / *months* / *years* / *decades* / *centuries* / *millennia*).

Nostalgia and hopefulness scale. This 4-item scale assessed participant agreement with statements regarding feelings of nostalgia (e.g., "Right now, I am having nostalgic thoughts.") and hopefulness ("I feel hope at the moment.") using a 6-point Likert scale (1 = *Strongly Disagree*; 6 = *Strongly Agree*). Ratings were averaged to create nostalgia (Cronbach's alpha 0.96) and hopefulness (Cronbach's alpha 0.93) scores.

Nature connectedness scale. This scale consists of 14 items, but was modified to include only three items in this study. The following items were used, "I feel connected with nature.", "I feel a kinship with animals and plants.", and "I feel a sense of oneness with the natural world." Nature connectedness was not a primary concern of this study, and as such there was no need for the full scale. These three items most succinctly address nature connectedness. Using a 5-point Likert scale (1 = *Strongly disagree*; 5 = *Strongly agree*), participants answered how much they agree with items. This scale had a Cronbach alpha of 0.91.

Incremental lay theories scale. This 8-item scale assesses lay theories people have about change by asking participants to rate their agreement with each statement using a 7-point Likert scale (1 = *Strongly disagree*; 7 = *Strongly agree*). Example items include: "People can always substantially change the kind of person they are." and "The kind of person someone is, is something very basic about them, and it can't be changed very much." Items 1, 2, 4, and 6 were

reverse coded and all ratings were averaged to create a composite participant score. This scale had a Cronbach's alpha of 0.86.

Manipulation check. Participants were asked whether they looked at a clock while looking at the picture and to provide a keyword describing the picture they were shown. The purpose of these manipulation checks was to find any participants who did not follow instructions during the survey to ensure data quality.

Results and Discussion

Preliminary analysis revealed that 10 participants did not follow the instruction and did look at the image for a reasonable amount of time (i.e., either only a few seconds or over an hour). These participants were excluded from the analysis.

The purpose of this study was to test differences in perceived minute length after viewing nature or urban setting image. Both conditions were instructed to look at the image for minute and proceed to the next page of the survey when they believed a minute had passed. We hypothesized those participants who viewed a nature setting image would look longer at the image than those who viewed an urban setting image. Other aspects of this study (i.e., nostalgia, incremental lay theory, and time orientation) are not relevant to this specific hypothesis and were not analyzed.

A one-way ANOVA was conducted to test the hypothesis. Results showed there was a significant difference between the nature (M = 58.91 seconds, SD = 66.74) and urban (M = 42.56 seconds, SD = 48.15) conditions for subjective minute duration estimates ($F(1, 206) = 3.975$, $p = 0.05$, $\eta_p^2 = 0.02$). Participants who viewed the nature images believed one minute took longer than those who viewed urban images. This method of assessing subjective duration (i.e., asking participants to count to one minute) provided larger differences between the two conditions than

asking participants to retrospectively assess speed and length of time passage; this method of measuring subjective duration will be incorporated in the fourth study. Beyond momentary duration estimates, participants who viewed nature setting images ($M = 55.24$, $SD = 24.73$) perceived a greater temporal distance to the year 2030 than those who viewed urban setting images ($M = 46.19$, $SD = 27.82$), ($F(1, 206) = 6.14$, $p = 0.01$, $\eta_p^2 = 0.03$). Although these results are outside the scope of the hypothesis, it is an interesting way to examine the effects of nature on time perception. By combining the results of the second and third study, the fourth study examined the full relationship between time perception, nature settings, and stress relief.

Study 4: Campus Walk Perceptions

The fourth study built on the three previous studies and tested the main hypotheses by taking participants for a walk in actual nature or urban settings. In this study, time perception was operationalized as objective (i.e., estimate walk and break duration) and subjective (i.e., estimate one minute) time duration. Furthermore, stress was assessed to investigate the relationship between nature and reduced stress, as well as any influences time perception may have on this relationship. I predict participants who went on the nature walk would overestimate the walk and break duration compared to participants who went on the urban walk. Also, participants would take longer to count to one-minute after the nature (vs. urban) walk, signifying a feeling of time passing subjectively slower.

Methods

Participants

A sample of 161 university students (109 female (67.7%); $M_{age} = 22.97$, $SD_{age} = 6.86$) were recruited using an online database (SONA). Five participants were excluded for the analysis due to unfavourable weather (i.e., rain), leading to a usable sample of 156. A priori

power analysis required a sample size of 156 to have 0.80 power for detecting a medium (*d* = 0.40) effect size. Participants received course credit as compensation. To be eligible to participate, participants must have been able to sustain a brief walk across campus without any assistance.

Procedure

Interested participants signed up to participate using the online Carleton University psychology experiment sign-up system (SONA). No more than two participants were allowed to sign up per timeslot (37.18% of the sample participated in groups of two). The researcher recorded the weather conditions (e.g., air temperature and precipitation) prior to meeting with participants; this was useful in examining any potential weather effects on mood. On days with unfavourable weather for a walk (i.e., rain), only urban walks were conducted, but this data was not be used in the analysis (n = 5). Participants were asked to meet the researcher in the Social Science Research Building. Posters with directions to the building were posted in the tunnels. The researcher randomly assigned participants to the nature (n = 78) or urban (n = 78) condition and record in a log their condition, along with participant ID numbers. The participants were given an informed consent to sign before starting the study. Once the informed consent was completed, the researcher gave participants a pre-mood and pre-stress set of items. This same set was given after the walk to measure post-mood and post-stress levels. Once the pre-mood and pre-stress measure was completed, the researcher and participants started the campus walk.

The ‘nature walk’ consisted of exiting the Social Science Research Building and walking along the river until Colonel By Drive and then returning to Loeb Building (approx. 600 meter). Participants were then seated in the outside Loeb Café area facing the river to complete the questionnaire. The ‘urban walk’ consisted of exiting the Social Science Research Building and

walking in the tunnels to Tory Building and returning to Loeb Building tunnel level (approx. 600 meter) to complete the questionnaire inside. Both walks were equally easy walks without obstacles. Each walk took approximately 10 minutes to complete. Walk start and end time was recorded by the researcher for accuracy. During the walk, participants were instructed to not talk with the researcher or each other and to focus on their surroundings (see Appendix D for researcher script).

During the walk, the researcher measured participant time perception in three different ways. First, about half way through the walk, the researcher asked the participant to take a break and observe his/her surroundings. Meanwhile, the researcher used a timer to count to one-minute. Once one minute had passed the researcher asked participants to estimate the duration of the break. Second, after the walk, the researcher asked the participant to estimate the total walk duration (including the break). Finally, the researcher asked the participant to estimate one minute (as in Study 3) at the end of the walk; after a given signal, the participant was supposed to stop the researcher when they thought one minute had passed. The researcher used a stopwatch to track participant estimates and recorded the estimates in the log.

Participants then completed the questionnaire. The questionnaires consisted of a series of items measuring stress, walk characteristics, mood, time perception, temporal focus, nature relatedness, and demographics. These study materials are described in brief below, for verbatim copies of the scale, please see Appendix D. Once the participants completed the questionnaire, they were given the debriefing form and received compensation.

Pre-stress and pre-mood. Participants reported their stress and mood (as in Study 1). Participants were asked to rate how happy, strained for time, relaxed, sad, stressed, and busy they feel right now on a seven point Likert scale (1 = *Not at all*; 7 = *Very*). Participants also rated their

connection to nature in a single item using the same Likert scale. The sad and relaxed items were reverse coded. The happy and sad (reverse scored) items were averaged into a mood score. The strained for time, relaxed (reverse scored), stressed, and busy items were averaged into a stress score.

Time perception. Three measures of time perception were taken regarding both objective and subjective duration estimates. During the walk, participants estimated objective duration of a one-minute break. At the end of the walk, participants estimated the walk duration; this objective walk duration estimate was compared to the true walk duration recorded by the researcher. After estimating the walk duration, participants were instructed by the researcher to observe their surroundings and count to a minute; this provided a measure of subjective duration because it is assumed that if time feels to pass subjectively slower in that moment, then participants will take longer to count to one minute. All answers were coded into minutes for the analysis.

Post-stress and post-mood. Participants reported their stress and mood. Participants were asked to rate how happy, strained for time, relaxed, sad, stressed, and busy they felt during the walk on a seven point Likert scale (1 = *Not at all*; 7 = *Very*). Participants also rated their connection to nature in a single item using the same Likert scale. The sad and relaxed items were reverse coded. The happy and sad (reverse scored) items were averaged into a mood score. The strained for time, relaxed (reverse scored), stressed, and busy items were averaged into a stress score.

Walk characteristics. Participants were asked to rate their experiences while walking on a seven point Likert scale (1 = *Not at all*; 7 = *Very*). They were asked how fun, awe-inspiring, pleasant, mentally stimulating, aware, and how distracted by other thoughts they were during the

walk. They also rated how pleasant was the weather; this allowed weather to be a controlled factor in the analyses. Next participants were asked to list as many details as they can that they noticed during the walk. This open-ended question will be coded for the number of things remembered by participants to examine whether the nature and urban walks had similar levels of detail complexity.

Perceived stress scale. The Perceived Stress Scale (PSS) is a 14-item scale that measures on a 5-point Likert scale (1 = *never*; 5 = *very often*) how stressful an individual appraises life situations (Cohen, Kamarck, & Mermelstein, 1983). Appropriate items are reverse scored (i.e., 4, 5, 6, 7, 9, 10, 13) and the scale items (e.g., "How often have you felt that things were going your way?", "How often have you dealt successfully with irritating life hassles?") were summed to create a total stress score. Scale reliability tests revealed a Cronbach's alpha of 0.52.

Long-term time orientation scale. Using this self-constructed scale from Study 3, participants were asked to indicate on a slider their perceived temporal distance to the year 2030. Next participants were asked two items for how far temporally their mind wanders when thinking about the past and future (*minutes* / *hours* / *days* / *weeks* / *months* / *years* / *decades* / *centuries* / *millennia*). This scale was used for exploratory purposes.

Temporal focus scale. This 12-item scale measures how much attention an individual devotes to thinking about the past, present, or future (Shipp, Edwards, & Lambert, 2009). The scale consists of three subscales: past focus (e.g., "I think back to my earlier days"), present focus (e.g., "I live my life in the present"), and future focus (e.g., "I think about times to come") using a 5-point Likert scale (1 = *Not at all*, 5 = *All the time*). The average score for each subscale was computed. The reliability of the past, present, and future focus subscales was 0.84, 0.68, and 0.77, respectively.

Nature relatedness scale. This 21-item scale measures an individual's connection with nature by asking participants to rate on a 7-point Likert scale (1 = *Strongly Disagree*; 7 = *Strongly Agree*) their agreement with each statement (Nisbet, Zelenski, & Murphy, 2008). The scale consists of three subscales: NR-self (e.g., "I am very aware of environmental issues."), NR-perspective (e.g., "Animals, birds and plants have fewer rights than humans."), and NR-experience (e.g., "I enjoy being outdoors, even in unpleasant weather."). Appropriate items were reverse coded and full scale, as well as, subscale mean scores were computed. A Cronbach's alpha of .83 for the full scale, .82 for NR-self, .49 for NR-perspective, and .79 for NR-experience was calculated.

Demographics. Participants reported their age in years and their gender (male/female/other).

Results and Discussion

Preliminary Analysis

Preliminary analyses were conducted to assess any potential outliers (±3 standard deviations). Nine outliers were present in the three measures of objective and subjective duration. These individuals were not excluded from the analysis because although they represent extremes, those participants are still vital to representing and understanding the various perceptions people experience when in nature or urban settings. Also, preliminary analysis of pre-mood and pre-stress measures showed no significant difference in mood or stress by condition (see Table 6). Since there were no differences in participant stress levels before the walk, and the researcher used random assignment to generate the urban and nature groups, it is presumed any differences post-walk are as a result of the walk condition.

Table 6. Pre-mood and Pre-stress – Individual items and aggregates

	Urban		Nature				
	M	*SD*	*M*	*SD*	*t*	*p*	*d*
Happy	4.94	1.13	4.96	1.04	-0.15	.88	-0.02
Strained for time	4.00	1.65	3.78	1.58	0.85	.40	0.14
Relaxed	4.33	1.46	4.51	1.48	-0.77	.45	-0.12
Sad	2.00	1.27	2.14	1.27	-0.70	.49	-0.11
Stress	3.68	1.65	3.54	1.79	0.51	.61	0.08
Busy	4.63	1.63	4.60	1.66	0.10	.92	0.02
Pre-mood	5.47	0.99	5.39	0.98	0.49	.63	0.08
Pre-stress	3.99	1.22	3.85	1.26	0.73	.47	0.12

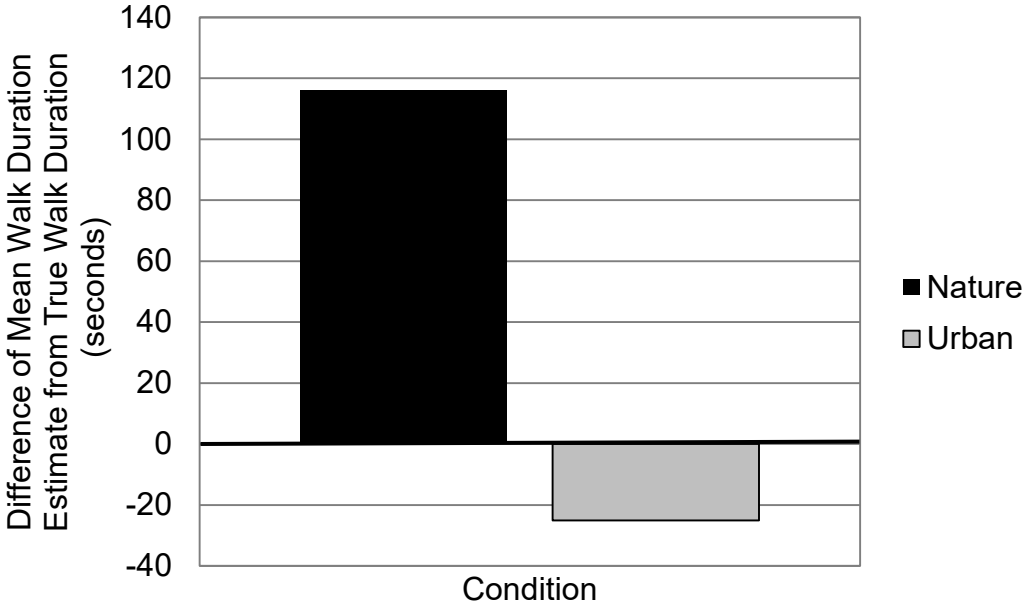
Objective and Subjective Estimates

Firstly, an independent samples t-test was used to analyze any differences in the actual walk duration by condition. The test revealed there was a significant difference in true walk duration between the nature (*M* = 10:13 minutes, *SD* = 0:53) and urban (*M* = 9:43 minutes, *SD* = 0:38) condition, with the nature condition walk being 30 seconds longer on average than the urban condition walk, $t(154) = 4.02$, $p < .001$, $d = 0.65$. As a result, actual walk duration was controlled for in future tests of objective and subjective duration estimates.

An analysis of covariance (ANCOVA) test analyzed the relationship between walk duration estimates and condition, controlling for true walk duration. The test showed a significant difference in walk duration estimates between nature and urban conditions. Those participants who went on the nature walk estimated a significantly longer walk duration (*M* = 12:09 minutes, *SD* = 4:49) than those who went on the urban walk (*M* = 9:18 minutes, *SD* =

3:52), while controlling for the true walk duration, $F(1, 153) = 10.99$, $p = .001$, $R^2 = .12$, $\eta^2_p = 0.07$). The condition accounted for 12% of the variance in walk duration estimates and the relationship between condition and estimate had a medium effect size. Participants in the urban conditions tended to underestimate the walk duration by 0:25 seconds, while the participants in the nature conditions overestimated the walk duration by 1:56 minutes (see Figure 1).

Figure 1. Difference of Mean Walk Duration Estimate from True Walk Duration



The second objective measure (i.e., asking participants to give a duration estimate for the minute break during the walk) was analyzed with an independent samples t-test. The difference in this objective duration estimate by nature (M = 2:04, SD = 5:34) and urban (M = 1:27, SD = 0:50) condition was not significant, $t(154) = 0.96$, $p = .38$, $d = 0.15$).

An independent samples t-test examined the subjective estimate (i.e., asking participants to state when they feel a minute passed). The test revealed a significant difference in the estimates by condition with participants who went on a nature walk counting longer (M = 1:10,

SD = 0:53) to a minute than participants who went on an urban walk (*M* = 0:55, *SD* = 0:15), *t*(154) = 2.36, *p* = .20, *d* = 0.38). Once again, participants who went on the urban walk underestimated one- minute by 0:05 seconds, while the participants on the nature walk overestimated one-minute by 0:10 seconds.

Pre-Post Measures

To examine participant mood and stress levels after the walk, pre and post measures were collected. The preliminary analysis revealed no significant differences in how happy, time strained, relaxed, sad, stressed, or busy the participants felt before the walk (see Table 6). An independent samples t-test was used to test whether there significant difference by condition after going on the walk. There were significant differences in participant feelings of happiness, relaxation, stress, and business by condition after the walk (see Table 7). There were no significant differences by condition for feelings of time strain or sadness after the walk.

Table 7. Post-mood and Post-stress

	Urban		Nature				
	M	*SD*	*M*	*SD*	*t*	*p*	*d*
Happy	4.50	1.36	5.12	1.04	-3.16	.002	-0.51
Strained for time	3.29	1.65	3.08	1.48	0.83	.407	0.13
Relaxed	4.40	1.60	5.37	1.22	-4.28	<.001	-0.69
Sad	2.14	1.37	2.06	1.72	0.31	.757	0.05
Stress	3.40	1.73	2.69	1.44	2.79	.006	0.45
Busy	3.81	1.76	3.17	1.69	2.32	.021	0.37
Post-mood	5.18	1.13	5.60	0.84	-2.65	.009	-0.43
Post-stress	3.52	1.22	2.89	1.09	3.40	.001	0.55

After computing the mood (i.e., happy and sad) and stress (i.e., time strain, relax, stress, and busy) subscales, a paired samples t-test was used to examine how mood and stress levels changed before and after going on the nature or urban walk. There was a significant difference in pre-post mood and stress levels for the nature and urban condition (see Table 8). In both conditions, participants experienced a decrease in stress. In the nature condition, participants experienced a significant increase in positive mood, while participants in the urban condition experienced a significant decrease in positive mood from pre- to post-walk comparisons. Although the urban walk also relieved stress ($d = 0.82$; mean difference = 0.47), the nature walk had a larger effect size ($d = 1.77$) and double the reduction of stress from pre-stress levels (mean difference = 0.96). Changes in mood (pre-mood vs. post-mood) were comparable across the conditions.

Table 8. Pre-post Differences in Mood and Stress

	Urban					Nature				
	M	*SD*	*t*	*p*	*d*	*M*	*SD*	*t*	*p*	*d*
Pre-Mood	5.47	0.99	2.64	.010	0.60	5.39	0.98	-2.58	.012	-0.59
Post-Mood	5.18	1.13				5.60	0.84			
Pre-Stress	3.99	1.22	3.59	.001	0.82	3.85	1.26	7.76	<.001	1.77
Post-stress	3.52	1.22				2.89	1.09			

Walk Characteristics

An independent samples t-test analyzed the differences in the nature and urban walk characteristics. The test revealed participants perceived the nature walk as more fun, awe-inspiring, pleasant, mentally stimulating, and awareness provoking than the urban walk (see

Table 9). There were no significant differences in how distracted by other thoughts participants felt during either of the walks. The participants were also asked to recall what details they remember from their walk and later the researcher coded the number of details each participant recalled. There was a significant difference in recall, whereby participants in the nature condition remembered more details about the walk than those in the urban condition. This greater recall may be attributed to a greater awareness of surroundings and mental stimulation during the nature walk.

Table 9. Walk Characteristics

	Urban		Nature				
	M	*SD*	*M*	*SD*	*t*	*p*	*d*
Fun	3.68	1.53	5.03	1.19	-6.19	<.001	-1.00
Awe	2.13	1.35	4.76	1.38	-11.98	<.001	-1.93
Distracted by thoughts	3.77	1.81	3.65	1.76	0.41	.677	0.07
Pleasant	3.81	1.46	5.51	1.29	-7.74	<.001	-1.25
Mentally stimulated	3.72	1.73	4.55	1.31	-3.35	.001	-0.54
Weather	3.31	1.81	5.74	1.57	-8.96	<.001	-1.44
Aware of surroundings	5.31	1.58	5.83	1.02	-2.46	.015	-0.40
Number of details	4.19	2.09	5.18	2.95	-2.41	.017	-0.39

Thus, the walk conditions were not comparable in terms of fun, awe, pleasantness, mental stimulation, awareness of surroundings, and number of details recalled. To control for their potential influence on the outcome of interest, an ANCOVA revealed none of these

characteristics influenced differences in walk duration estimates across the nature and urban conditions [fun: $F(1, 153) = 12.79$, $p < .001$; awe: $F(1, 152) = 9.58$, $p = .002$; pleasantness: $F(1, 153) = 14.07$, $p < .001$; mental stimulation: $F(1, 151) = 16.71$, $p < .001$; awareness: $F(1, 153) = 15.85$, $p < .001$; number of details: $F(1, 151) = 15.21$, $p < .001$].

There was a significant difference in weather pleasantness as rated by participants depending on condition. The researcher recorded weather log revealed no significant differences in temperature between nature ($M = 23.36$, $SD = 4.96$) and urban ($M = 23.92$, $SD = 5.60$) walk conditions, $t(154) = 0.67$, $p = .51$, $d = 0.15$). The data used for analysis was collected only on days without rain, and therefore, precipitation could not influence differences in participant ratings of the weather. Potentially, participants who went on the nature walk had a chance to interact with the outdoor environment and were more aware of the weather conditions than those who participated in the urban condition and remained indoors. ANCOVA revealed weather pleasantness did not influence the walk duration estimates differences between the conditions, $F(1, 153) = 10.53$, $p = .001$).

Perceived Stress

The Perceived Stress Scale was analyzed with an independent samples t-test. The test showed no significant differences in stress in participants between the nature ($M = 38.82$, $SD = 5.09$) and urban ($M = 38.83$, $SD = 5.93$) conditions, $t(154) = 0.01$, $p = .988$, $d = 0.002$. This is quite surprising considering the pre-post stress measure revealed significant differences between the conditions. A potential explanation may be the low reliability of the scale (i.e., Cronbach's alpha = 0.52). We expected a Cronbach's alpha of 0.85 and a scale mean of approximately 23, as was described in the scale developer's paper (Cohen et al., 1983). As a result of the poor reliability, the data collected with this scale should be viewed with skepticism.

Temporal Orientation

An independent samples t-test revealed no significant differences between the nature and urban conditions in terms of temporal orientation. Participants did not differ in how far away the year 2030 felt (nature: $M = 81.72$, $SD = 38.04$; urban: $M = 78.55$, $SD = 34.61$; $t(154) = 0.49$, $p = .628$, $d = 0.09$) or how long ago the start of 2016 felt (nature: $M = 49.83$, $SD = 28.27$; urban: $M = 44.18$, $SD = 28.19$; $t(154) = 1.17$, $p = .242$, $d = 0.21$) depending on their walk condition. To assess differences in the temporal direction participants' mind wandered depending on the condition, a chi-square test was used. There were no significant differences between the conditions for future (χ^2 (8, $N = 156$) = 9.12, $p = .332$) or past (χ^2 (7, $N = 156$) = 3.79, $p = .806$) mind wandering during the walk.

Temporal Focus

An independent samples t-test was used to analyze the temporal direction of participant thoughts during the nature or urban walk. There was a significant difference between the nature ($M = 3.45$, $SD = 0.83$) and urban ($M = 3.73$, $SD = 0.85$) conditions only in the future subscale, $t(154) = 2.16$, $p = .036$, $d = 0.35$. Meaning participants who took the urban walk thought more about future events and plans than past or current ones compared to participants who went on the nature walk. There were no significant differences between the conditions for the present or past subscales (see Table 10). This result was the opposite to what was expected since the same scale in study 4 showed participants who looked at nature images thought more about the future than those who looked at urban images.

Table 10. Temporal Focus

	Urban		Nature				
	M	*SD*	*M*	*SD*	*t*	*p*	*d*
Future	3.73	0.85	3.45	0.83	2.16	.036	0.35
Present	3.61	0.72	3.48	0.68	1.08	.284	0.17
Past	2.64	1.00	2.80	0.97	-0.96	.339	-0.15

Nature Relatedness

The Nature Relatedness Scale consists of 3 subscales: self, perspective, and experience. Each of these subscales was analyzed with an independent samples t-test, as well as the overall mean of the scale, to test for differences between conditions. There was a marginally significant difference only in the perspective subscale between the nature (M = 3.75, SD = 0.64) and urban (M = 3.55, SD = 0.63) conditions, $t(154) = 1.94$, $p = .054$, $d = 0.31$. The perspective subscale measures how much of an impact an individual believes he/she has on nature and their nature related worldviews. There were no significant differences between the conditions for the self subscale, experience subscale, or overall scale score (see Table 11).

Table 11. Nature Relatedness

	Urban		Nature				
	M	*SD*	*M*	*SD*	*t*	*p*	*d*
Self	3.29	0.78	3.34	0.64	-0.41	.682	-0.07
Perspective	3.55	0.63	3.75	0.64	-1.94	.054	-0.31
Experience	3.26	0.87	3.28	0.87	-0.11	.915	-0.02
Mean	3.36	0.58	3.44	0.53	-0.85	.399	-0.14

Exploratory Mediation Model

Finally, a mediation model was run to examine whether the effect of nature on stress changes depending on duration estimates. This mediation model was exploratory and not the main focus of the study. It was anticipated that participants would feel less stressed after a nature walk because they have a slowed sense of time. The perception of time was hypothesized to be a potential explanation as to why nature walks were associated with greater stress relief than urban walks. A linear regression showed that walk condition affected duration estimates ($\beta = 0.31$, $t(154) = 4.06$, $p < .001$, $R^2 = .10$), and reported post-stress ($\beta = -0.26$, $t(154) = -3.40$, $p = .001$, $R^2 = .07$). Duration estimate was added to the model as a potential mediator between nature and stress relief. There was no significant effect of duration estimate on stress relief, controlling for walk condition, $\beta = 0.05$, $t(153) = 0.56$, $p = .58$, $R^2 = .07$. The indirect effect, as tested with bootstrapping (1000 samples; MacKinnon, Lockwood, & Williams, 2004), was not significant, 95% CI [-0.08; 0.15]. The indirect effect was also not significant when controlling for pre-stress. The same mediation model was run using the one-minute estimate as the mediator. The linear regression showed that walk condition significantly predicted the minute estimate, ($\beta = 0.19$, $t(154) = 2.36$, $p = .02$, $R^2 = .04$). There was no significant effect of minute estimate on stress relief, controlling for walk condition, $\beta = -0.06$, $t(153) = -0.73$, $p = .47$, $R^2 = .07$. The indirect effect, as tested with bootstrapping (1000 samples; MacKinnon et al., 2004), was not significant, 95% CI [-0.09; 0.04]. The break duration estimate was not tested as a mediator because there was no significant difference in the estimate between the conditions. As a result, I conclude that the effects between nature exposure and stress, and nature exposure and time perception are parallel effects; time perception does not seem to mediate the relationship between nature and stress.

Discussion

This research examined the influence of environmental surroundings – specifically, nature vs. urban surroundings – on time perception. Does time feel like it passes slower or faster depending on the environment? Each of the four studies reveals interesting information regarding how environmental settings influence how we perceive time passage.

In Study 1 participants differed in the subjective time that passed while looking at pictures of nature rather than pictures of built environments, although they estimated a similar time in seconds. One of the limitations of Study 1 was the potential influence of practice effects for estimating time. All images were displayed for 30 seconds and in the same order for everyone. The most differences were seen only in the first image displayed. Afterwards, participants' estimates regressed to a mean of 30 seconds.

In Study 2 the realism of the manipulation of surroundings was strengthened by introducing a video displayed through a virtual reality headset. The participants were also exposed to the stimuli for a longer duration (i.e., 1 minute). Participants who watched the nature video felt the video was significantly longer in duration than participants who watched the urban video, although again although they estimated a similar time in seconds. Although more realistic in simulating different surroundings, the second study was also limited in several ways. Specifically, the videos differed on more than just the environmental setting: The video in the nature condition (i.e., walk along a forest trail) was less variant and had fewer scene changes. The urban video (i.e., scenes of New York city) featured different angles and scenes had more movement.

Study 3 focused on testing a new approach to measuring subjective duration estimate: participants estimated one minute while looking at a single nature or urban setting image and

imagining themselves in that setting. The results of this study showed participants estimated one minute to be longer while imagining themselves in a nature setting than an urban image – again an indicator that time was passing subjectively slower when in "nature".

Thus, three studies showed that virtual settings (as represented by videos and images) could change the subjective passing of time, leading to time passing slower in nature environments than urban environments. The final study provided the strongest test of this effect by actually taking participants out for walks in a nature or urban setting. In line with the results from the three virtual environment studies, participants who went on the nature walk felt the walk was longer in duration and they also estimated one minute to last longer than participants who went on the urban walk.

Measurement of Time

Across the studies time perception was measured using different methods. As discussed earlier, there are many different ways in which time perception can be examined, such as temporal distance (e.g., Pennington & Roese, 2003; Wilson et al. 2012) and temporal focus (e.g., D'Argembeau, Lardi, & Van, 2012; Wilson & Ross, 2000). The present studies focused specifically on objective and subjective aspects of time perception. We operationalized objective time perception to mean an estimate of duration. Objective duration estimates were measured in minutes and seconds and asked participants to estimate the temporal length of a certain period in these conventional units of measurement. Subjective time perception was operationalized as the *feeling* of how quickly or slowly time passed. Subjective estimates were measured using ordinal scales of perceived felt speed of time passage and by asking participants to estimate when a certain amount of time had passed.

The objective measure in study 1, 2, and part of 4 (estimating stimuli that were actually 30 seconds, 2 minutes, and 1 minute, respectively) did not did not show significant differences across different stimuli, whereas in the same studies the subjective measures were significant or trending towards significance. This may demonstrate that objective duration estimates require a longer exposure to different settings than subjective measures to detect differences between settings. Subjective measures may be more sensitive at detecting differences during shorter exposure durations. Participants may *feel* that there is a change in how they perceive time passing after a few minutes, but may not be able to quantify that feeling into a duration estimate until they are exposed to the setting for a longer period of time (Ross & Wilson, 2001).

Regarding subjective duration estimates, it appears that prospective subjective estimates (e.g., looking at the image and estimating one minute) may better encompass a change in how quickly or slowly time seems to pass than retrospective subjective estimates (e.g., how fast or slow did [one minute] feel while you looked at the image). Unless the participant is aware that time feels faster or slower in a given moment, when asked to report on it later, he or she may not be able to recall accurately how they perceived time. The prospective subjective estimate can measure how fast/slow time passed by how quickly/slowly an individual estimates the duration. If he/she feels a minute has passed after only 30 seconds, then in that moment he/she feels time is passing faster.

Overall, the different methods of time perception measurement used in this study reveals that objective duration estimates may be better at detecting time perception differences when the true objective duration is longer. Subjective duration estimates appear to be more sensitive and equally adequate at detecting differences in time perception for both short and long stimuli

exposure durations. Finally, prospective subjective duration estimates can be a more perceptive approach to subjective duration estimates.

Immersion in the Environment

The four studies reported here differed in the extent of immersion in the environment, from looking at pictures, over videos, to an actual immersion in the environment by taking a walk. Another result of the present research is that the immersion in an environment matters (Baños, Botella, Alcañiz, Liano, Guerrero, & Rey, 2004; Blascovich et al., 2002; De Kort & Ijsselsteijn, 2006) – one will not get the same results on a dependent measure with images of a walk as when actually taking a walk. Indeed, time perception may only change once an individual gets the chance to interact with nature and be encompassed by the sensations (e.g., smell, wind, sunlight). However, alternative ways to increase immersion might be to lengthen the exposure to mages (Study 1, 3) and videos (Study 2). A two-minute exposure (Study 2) may not be enough to perceive a change in how time passes differently in nature or urban settings. Referencing the results of Study 4, it may be that 10 minutes are a sufficiently long interval to influence time perception – even in virtual environments.

The varying degrees of immersion across the studies facilitated for examining the effect nature may have on time perception from different angles. The studies where only images were displayed allowed for greater control over the stimuli. Although low in immersion, the images were consistent for all participants and featured specific aspects of nature (e.g., river, forest) and urban (e.g., downtown centre, large crowds) settings. The final study was the most immersive by taking participants into the nature or urban setting for a walk, but it also reduced how much control the researchers had over the setting. However, this compromise between experimental

control and environment immersion may be needed when studying nature to maintain ecological validity and replicate the typical experiences people have in those settings.

Stress and Other Potential Downstream Effects of Time Perception

The relationship between nature settings and stress relief is well-established by previous research (Bratman, Hamilton, & Daily, 2012; Korpela and Kinnunen, 2011; Lederbogen et al., 2011; Ulrich et al., 1991). However, no known research examined the influence of time perception in this relationship. Could a slowed sense of time be responsible for what makes nature experiences relaxing? Throughout the studies, stress was measured in order to replicate previous findings and examine how it interacted with time perception and nature vs. urban settings. The studies were successful in replicating the stress relieving qualities of nature settings, whereby participants felt less stressed and happier after nature setting exposure.

While discussing stress, it is important to note the non-significant result of the Perceived Stress Scale (Study 4). This scale was towards the end of the questionnaire set, as it was not the main outcome of interest in this study. Participant fatigue may have influenced ratings and resulted in the non-significant finding. The reliability alpha of the Perceived Stress Scale was unexpectedly low, and as such, the scale results should be regarded with caution. The pre-post measures of stress, which appeared earlier in the questionnaire set, showed participants felt less stressed after the nature walk than after the urban walk. It is important to note that these changes in stress in the nature condition occurred regardless of changes in stress level for the urban condition, meaning nature does not reduce stress because urban settings increase stress.

This research suggests that visiting a nature setting can be helpful for dealing with stress. The uniqueness of this method is in its passivity. Minimal effort is required to feel less stressed when in nature. Just by taking a walk in the nature setting, individuals reported feeling less busy

and more relaxed than an urban setting. Other methods of stress relief, such as meditation (Winzelberg, & Luskin, 1999; Taren, et al., 2015), may be difficult for some individuals to achieve due to lifestyle constraints (Lomas, Cartwright, Edginton, & Ridge, 2015). Kramer et al., (2013) demonstrated that time perception slows down when individuals engage in mindful meditation, while other researchers associated nature exposure to increased mindfulness (Howell, Dopko, Passmore, & Buro, 2011; Wolsko, & Lindberg, 2013). Thus, nature exposure could be useful for such individuals, whereby they will slow down their sense of time, reduce their stress, and increase feelings of mindfulness after a walk in a park or other nature areas. Future research can examine full mediation models to test whether the slowed sense of time is parallel to other effects of nature, such as stress relief, or whether the slowed time predicts stress relief in nature.

Theoretical Implications

These studies provide a new avenue of research in time perception, stress, and nature literature. This research is the first to identify external factors (nature vs. urban settings) that might affect objective and subjective duration estimates can vary between external factors rather than aspects about the person or the stimulus. Future research may examine how other external factors influence time perception. This study focused primarily on natural vs. human-built settings because of anecdotal experience. Similar research may examine how a room's colour, temperature, or use (e.g., work office vs. home office) can influence time perception. Furthermore, research may want to test how the restorative qualities of an environment influence time perception. Nature settings are frequently regarded as restorative (Berto, 2005; Martínez-Soto, Gonzales-Santos, Barrios, & Lena, 2014; Valtchanov & Ellard, 2010), however, some urban settings may also be considered restorative, such as places of worship and spa resorts. Would such restorative urban settings be able to slow down time as a nature settings? If so,

individuals can visit restorative urban settings to help them manage their time and stress when nature settings are inconvenient or not available.

Studying duration estimates is novel in the time perception literature and requires furthers inquiry. The previous study done by Berry et al., (2015) had some methodical and analytic weaknesses, namely duration estimates were unclear (i.e., since participant signed the informed consent) and actual duration was not controlled for in the analyses. These studies built on Berry's research by measuring and controlling for the true duration and making clear to the participants what the estimate entailed, whether asking to estimate duration vs. estimating one minute. The use of images, videos, and walks in the present studies provided varying levels of immersion and allowed for comprehensive analysis of how time perception changes depending on the setting. Further research can examine whether nature exposure influences other aspects of time perception, such as the temporal direction of though, temporal distance to events or planning.

These research studies suggest that time perception does not have to be related to internal processes, such as arousal (Hammond, 2012; Loftus, Schooler, Boone, & Kline, 1987) or personality traits (Bar-Haim, Kerem, Lamy, & Zakay, 2010; Hogan 1978), but that one's external setting can be used to manipulate time perception. Researchers could examine whether incorporating natural features into a workspace, such as potted plants, may help employees slow down their time perception and reduce stress caused by advancing deadlines. The slowed sense of time may help people feel they have more time to complete tasks and time seems fleeting. Through such methods, an individual can surround him/herself with the appropriate setting to achieve the desired sense of time.

Future Directions

Another interesting avenue of this research is examining how changes in time perception following nature exposure influence productivity. If individuals feel they spent more time in a nature setting than they estimated, the overestimated portion is now 'bonus' time that they thought they already used. This 'bonus' time can be help with feelings of time strain and aid in productivity. However, this may only happen after an individual spends an extensive amount of time in a nature setting, since study 4 did not find significant differences in time strain after the nature or urban walk. Further research is needed to examine what factors moderate changes in time perception based on setting and how these changes influence other aspects of one's life. Researchers could recruit office workers to have their lunch break in a predominately nature (e.g., city park) or urban (e.g., downtown café) area. Afterwards, the researchers could examine the participant's time perception, stress, feelings of time strain, and self-reported productivity. The researchers could contrast goal completion between the two groups, after one week of nature or urban lunches.

A different approach to future research could examine what specific elements of nature are needed for the slowed sense of time. Researchers could examine whether the colours, open space, smells, sounds, or other sensations influence how we feel time. Such elements can be examined on a larger scale by categorizing the different types of nature settings. Would mountain ranges evoke similar responses as swamps? Furthermore, it would be interesting to test whether this effect of nature on time perception holds for frequent exposure. If an individual is exposed to nature settings on a regular basis, such as a park ranger, would he/she experience time in nature the same way as the occasional hiker? Researchers could test whether there is an

optimal amount of nature exposure for it to be novel enough to change time perception, but experienced frequently enough to be used as a remedy to relieve time strain.

Further research could also examine whether knowledge or ignorance of the effect nature has on slowed time influences the relationship. Could the effect of slowed time decrease or disappear if the individual is made aware that time feels slower in nature? Researchers could run similar studies as the ones presented here, but make this effect salient to only one-half and measure whether time still feels slower. Knowledge of the effect may change how an individual estimates durations and whether they receive the subjective 'bonus' time discussed above. If nature exposure is a way to trick yourself into thinking you have more time than you do, then being aware of the "trick" may remove the effect.

Applications of This Research

Being strained for time is a common experience in both workplace and academic settings, and having a greater understanding of time perception could be beneficial in alleviating some of the stress caused by time. When individuals feel stressed (i.e., high arousal) time feels to pass faster (Wearden et al., 2014; Zakay, & Block, 1997) and the rapid passage of time may become a stressor in and of itself as the individual may feel he/she has less time to do what is planned. In such a situation, the feeling of time passing slower may be beneficial to create a sense of calm, mindfulness, and the feeling the individual has more time. Knowledge from these studies may eventually lead to workplace interventions or general recommendations about making the most of one's time. Since nature experiences are associated with the slowing of time perception, it may be recommendable to spend time in nature settings to 'slow down' time, as well as experience the numerous benefits of nature (e.g., increased positive affect, restored attention, reduced stress, etc.). This could increase not only psychological health, but also productivity

since time management techniques (Chase, 2013) and nature (Young & Berry, 1979) are separately, and potentially together, important for productivity.

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Appendix A: Study Materials for Study 1

Thank you for deciding to participate in our study!

Demographics

Please answer the following questions.

1) In the box below, state your age in years.
    a. *type age*

2) Please select the gender you identify with.
    a. Male
    b. Female
    c. Other

3) Does your current occupation require you to spend time in natural settings (e.g., in a backyard, park, forest) on a regular basis?
    a. Yes
    b. No
    c. In the box below state your job title.
        i. *type job title*

4) What is the current population of your place of residence?
    a. Less than 1,000
    b. 1,000 to 20,000
    c. 20,000 to 100,000
    d. 100,000 to 300,000
    e. 300,000 to 1,000,000
    f. Greater than 1,000,000

Pre-Manipulation Stress

1) In the past week, how stressed have you felt?
    a. 1 Not all stressed
    b. 2
    c. 3 Somewhat stressed
    d. 4
    e. 5 Very stressed

2) In the past week, how strained for time have you felt?
    a. 1 Not all strained
    b. 2
    c. 3 Somewhat strained
    d. 4
    e. 5 Very strained

3) In the past week, how have you felt?
    a. 1 Sad
    b. 2
    c. 3 Neutral
    d. 4
    e. 5 Happy

In the next section, you will see 4 images of a setting or environment. For each image, imagine yourself in that setting for as long as the picture is shown. Think about how you would feel and what it would be like to be in this setting.

These four images will be presented in random order to participants. After each image, they will complete the Time Duration Scale and the Experience in Nature Scale

Natural Condition: Balcony
Imagine yourself in this setting. Please wait for the picture to disappear and the next question to appear.

Natural Condition: Backyard
Imagine yourself in this setting. Please wait for the picture to disappear and the next question to appear.

Natural Condition: City Park
Imagine yourself in this setting. Please wait for the picture to disappear and the next question to appear.

Natural Condition: Forest
Imagine yourself in this setting. Please wait for the picture to disappear and the next question to appear.

Time Duration Scale

Now, please think of the setting you just imagined yourself in (i.e., a [balcony/backyard/park/forest]) and tell us how you felt while looking at the image of that setting.

1) How long or short did it feel you were looking at the image?
    a. *slider* very short to very long
2) How slow or fast did the time go by while you were looking at the image?
    a. *slider* very fast to very slow
3) Please estimate in seconds how long you looked at the image.
    a. *type in seconds*

Instructions for Experience in Nature Scale

For the following questions, please think of your experiences when you are actually in the depicted setting. Overall, how do you feel and what are your experiences when you are [on a balcony, in a backyard, in a park, in a forest]. The actual setting you are usually in when you are [on a balcony, in a backyard, in a park, in a forest] will differ from the picture, of course (the picture is only an example of that kind of setting).

Experience in Nature Scale

1) Using the picture as an example, think about a [balcony with potted plants/ a backyard / a park / a forest].
    a. How often are you in this kind of setting?
        i. 1 Never
        ii. 2 Rarely
        iii. 3 Sometimes
        iv. 4 Often
        v. 5 Always

    b. [If “Never” is selected, the participant will see this statement.] Since you are never in this setting, please just skip the other questions on this page and hit ">>" at the bottom of the page.

c. What is the typical amount of time you spend in this setting per visit?
   i. *type number of hours**type number of minutes*

d. When you are in this kind of setting, how physically exerted are you?
   i. 1 Very Physically Relaxed
   ii. 2
   iii. 3
   iv. 4
   v. 5 Very Physically Active

e. How do you feel in this kind of setting?
   i. 1 Sad
   ii. 2
   iii. 3 Neutral
   iv. 4
   v. 5 Happy

f. How aware of your surroundings do you feel in this kind of setting?
   i. 1 Not at all aware
   ii. 2
   iii. 3 Somewhat aware
   iv. 4
   v. 5 Very aware

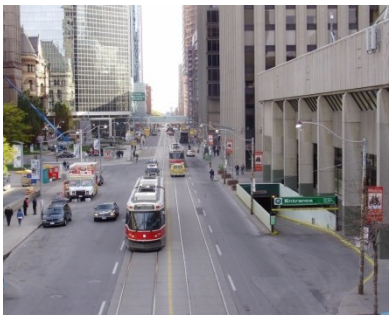
g. How mentally stimulated are you in this kind of setting?
   i. 1 Not at all stimulated
   ii. 2
   iii. 3 Somewhat stimulated
   iv. 4
   v. 5 Very stimulated

Urban Condition: These four images will be presented in random order to participants. After each image, they will complete a Time Duration Scale and an Experience in Urban Settings Scale

Urban Condition: Office Buildings
Imagine yourself in this setting. Please wait for the picture to disappear and the next question to appear.

Urban Condition: Athletics Facility
Imagine yourself in this setting. Please wait for the picture to disappear and the next question to appear.

Urban Condition: Downtown Centre
Imagine yourself in this setting. Please wait for the picture to disappear and the next question to appear.



Urban Condition: Shopping Centre
Imagine yourself in this setting. Please wait for the picture to disappear and the next question to appear.

Time Duration Scale

Now, please think of the setting you just imagined yourself in (i.e., a/an [office building/athletic facility/downtown centre/shopping centre]) and tell us how you felt while looking at the image of that setting.

1) How long or short did it feel you were looking at the image?
    b. *slider* very short to very long
2) How slow or fast did the time go by while you were looking at the image?
    c. *slider* very fast to very slow
3) Please estimate in seconds how long you looked at the image.

d. *type in seconds*

Instructions for Experience in Urban Settings Scale

For the following questions, please think of your experiences when you are actually in the depicted setting. Overall, how do you feel and what are your experiences when you are [office building/athletic facility/downtown centre/shopping centre]. The actual setting you are usually in when you are [office building/athletic facility/downtown centre/shopping centre] will differ from the picture, of course (the picture is only an example of that kind of setting).

Experience in Urban Settings Scale

1) Using the picture as an example, think about a [balcony with potted plants/ a backyard / a park / a forest].
    a. How often are you in this kind of setting?
        i. 1 Never
        ii. 2 Rarely
        iii. 3 Sometimes
        iv. 4 Often
        v. 5 Always

    b. [If “Never” is selected, the participant will see this statement.] Since you are never in this setting, please just skip the other questions on this page and hit ">>" at the bottom of the page.

    c. What is the typical amount of time you spend in this setting per visit?
        i. *type number of hours**type number of minutes*

    d. When you are in this kind of setting, how physically exerted are you?
        i. 1 Very Physically Relaxed
        ii. 2
        iii. 3
        iv. 4
        v. 5 Very Physically Active

    e. How do you feel in this kind of setting?
        i. 1 Sad
        ii. 2
        iii. 3 Neutral
        iv. 4
        v. 5 Happy

    f. How aware of your surroundings do you feel in this kind of setting?
        i. 1 Not at all aware
        ii. 2
        iii. 3 Somewhat aware

iv. 4
v. 5 Very aware

g. How mentally stimulated are you in this kind of setting?
i. 1 Not at all stimulated
ii. 2
iii. 3 Somewhat stimulated
iv. 4
v. 5 Very stimulated

Post-Manipulation Stress

1) Right now, how stressed do you feel?
a. 1 Not all stressed
b. 2
c. 3 Somewhat stressed
d. 4
e. 5 Very stressed

2) Right now, how strained for time do you feel?
a. 1 Not all strained
b. 2
c. 3 Somewhat strained
d. 4
e. 5 Very strained

3) Right now, how do you feel?
a. 1 Sad
b. 2
c. 3 Neutral
d. 4
e. 5 Happy

4) While completing this survey, did you look at a clock when looking at the images?
a. Yes
b. No

5) [Will only appear if participant selects "yes" in above question] If yes, did you know how much time passed?
a. Yes
b. No

Nature Connectedness Scale (Mayer & Frantz, 2004)

Please answer each of these questions in terms of the way you generally feel. There are no right or wrong answers. Use the scale to answer as honestly as you can how much you agree with each statement.

1	2	3	4	5
Strongly disagree		Neutral		Strongly agree

1. I often feel a sense of oneness with the natural world around me.
2. I think of the natural world as a community to which I belong.
3. I recognize and appreciate the intelligence of other living organisms.
4. I often feel disconnected from nature.
5. When I think of my life, I imagine myself to be part of a larger cyclical process of living.
6. I often feel a kinship with animals and plants.
7. I feel as though I belong to the Earth as equally as it belongs to me.
8. I have a deep understanding of how my actions affect the natural world.
9. I often feel part of the web of life.
10. I feel that all inhabitants of Earth, human, and nonhuman, share a common 'life force'.
11. Like a tree can be part of a forest, I feel embedded within the broader natural world.
12. When I think of my place on Earth, I consider myself to be a top member of a hierarchy that exists in nature.
13. I often feel like I am only a small part of the natural world around me, and that I am no more important than the grass on the ground or the birds in the trees.
14. My personal welfare is independent of the welfare of the natural world.

Appendix B: Study Materials for Study 2

Please think of the experience of watching the video.

Please estimate how long the video was: _____ Minutes and _____ Seconds

Sometimes, a time period can feel long or short regardless of the actual time it took. In your subjective experience, how short or long did the video feel to you?
Please mark the line to indicate your answer.

Very ———————————————————————— Very

In your subjective experience, how fast or slow did the video feel to you?
Please mark the line to indicate your answer.

Very fast ———————————————————————— Very

Please answer the following questions about how you felt ***while watching*** the video:
Please circle the number that best represents your response.

	Not at all			Somewhat			Very
How immersed did you feel?	1	2	3	4	5	6	7
How fun was the experience?	1	2	3	4	5	6	7
How awe-inspiring was the video?	1	2	3	4	5	6	7
How distracted were you by other thoughts?	1	2	3	4	5	6	7
How pleasant was the experience?	1	2	3	4	5	6	7
How mentally stimulated were you?	1	2	3	4	5	6	7
How fast moving was the video?	1	2	3	4	5	6	7

In the box below, please list details you noticed in the video.

Finally, we'd like to know a little more about you as a person.

Your age: _____ years

Please circle the gender you identify with: Male Female Other

Please answer the following questions about how you feel ***right now*** in general:

	Not at all			Somewhat			Very
How happy do you feel?	1	2	3	4	5	6	7
How strained for time do you feel?	1	2	3	4	5	6	7
How relaxed do you feel?	1	2	3	4	5	6	7
How sad do you feel?	1	2	3	4	5	6	7
How stressed do you feel?	1	2	3	4	5	6	7
How busy do you feel?	1	2	3	4	5	6	7
How connected do you feel to nature?	1	2	3	4	5	6	7

How often do you walk or drive in a forest (e.g., per week/month)?

_____

How much time per week do you usually spend walking, sitting, or driving in nature?

_____ Hours and _____ Minutes

How often do you walk or drive in a city (e.g., per week/month)?

_____

How much time per week do you usually spend walking, sitting, or driving in urban environments?

_____ Hours and _____ Minutes

	Not at all			Somewhat			Very
How familiar are you with the setting that was shown in the video?	1	2	3	4	5	6	7

Thank you for participating! Please return the questionnaire to the researcher.

The videos used in this study do not contain any inappropriate or sensitive material. They reflect the typical experiences people have while walking in a large city or in a forest. The researcher edited the videos to be of equal time duration, two minutes. Below are the links for the nature and urban videos, respectively.

https://www.youtube.com/watch?v=lxuxS6pi_uE&index=3&list=PLQXaSd2GIj2IZ4JUz3JbAu4C9dxrzZ0za

https://www.youtube.com/watch?v=TmDKbUrSYxQ&list=PLQXaSd2GIj2IZ4JUz3JbAu4C9dxrzZ0za&index=5

Appendix C: Study Materials for Study 3

Thank you for deciding to participate in our study!

Demographics

Your age?: *type age*

Your gender?

a. Male
b. Female
c. Other

Participants will see one of 4 pictures (all show a path / no people, but 2 show nature (long term: trees and short term: flowers) and 2 show urban environments (long term: Brownstones and short term: modern architecture))

In the next section, you will see an image of a setting or environment. Imagine yourself in that setting. Think about how you would feel and what it would be like to be in this setting. Imagine yourself walking down the path.

- Participants will see one of these four pictures-

Please look at this picture for *1 minute before* clicking to the next page. Estimate the time as accurately as possible (no less and no more than 1 minute) [survey measures time until clicking 'next']

Temporal Focus Scale (Shipp, Edwards, & Lambert, 2009)

We are interested in what people focus on when their mind wanders. While you were looking at the picture and right now, what are you thinking about? Scale from (1) not at all; (7) all the time

Past focus
6. I replay memories of the past in my mind.
9. I reflect on what has happened in my life.
1. I think about things from my past.
11. I think back to my earlier days.
Current focus
4. I focus on what is currently happening in my life.
8. My mind is on the here and now.
10. I think about where I am today.
2. I live my life in the present.
Future focus
3. I think about what my future has in store.
12. I think about times to come.
5. I focus on my future.
7. I imagine what tomorrow will bring for me.

Long term time orientation

1. Place the year 2030 on the following timeline:
Today ----------->

2. When thinking of the future, how far ahead does your mind wander?
minutes/ hours/ days/ weeks/ months/ years/decades/centuries/millennia

3. When thinking of the past, how far back does your mind wander?
minutes/ hours/ days/ weeks/ months/ years/decades/centuries/ millennia

Nostalgia (Wildschut, Sedikides, Arndt, & Routledge (2006)) and **hopefulness**

Please rate the extent to which you agree or disagree with the statements below. *Scale: Strongly Disagree (1) - Strongly Agree (6)*

1. Right now, I am feeling quite nostalgic
2. Right now, I am having nostalgic thoughts

3. Right now, I am feeling quite hopeful
4. Right now, I am having hopeful thoughts

Nature Connectedness Scale (3 items from Mayer & Frantz, 2004)

Please answer each of these questions in terms of the way you generally feel. *Scale: Strongly Disagree (1) - Strongly Agree (5)*

1. I feel connected with nature
2. I feel a kinship with animals and plants
3. I feel a sense of oneness with the natural world

Incremental Lay Theories (Dweck, 2000)

Instructions: Please indicate the extent to which the following statements are in line with what you believe about people in general. *Scale: Strongly Disagree (1) - Strongly Agree (7)*

1. The kind of person someone is, is something very basic about them, and it can't be changed very much.
2. People can do things differently, but the important parts of who they are can't really be changed.
3. Everyone, no matter who they are, can significantly change their basic characteristics.
4. As much as I hate to admit it, you can't teach an old dog new tricks. People can't really change their deepest attributes.
5. People can always substantially change the kind of person they are.
6. Everyone is a certain kind of person, and there is not much they can do to really change that.
7. No matter what kind of person someone is, they can always change very much.
8. All people can change even their most basic qualities.

Final checks

1. Did you look at a clock when looking at the picture? (Yes/No)
2. Please write a keyword that describes what you saw in the picture_____

Appendix D: Study Materials for Study 4

[After completing the informed consent, but before beginning the walk participants will complete a pre-mood and pre-stress questionnaire.]

Please answer the following questions about how you feel **right now**:
Please circle the number that best represents your response.

How happy do you feel?	1	2	3	4	5	6	7
How strained for time do you feel?	1	2	3	4	5	6	7
How relaxed do you feel?	1	2	3	4	5	6	7
How sad do you feel?	1	2	3	4	5	6	7
How stressed do you feel?	1	2	3	4	5	6	7
How busy do you feel?	1	2	3	4	5	6	7
How connected do you feel to nature?	1	2	3	4	5	6	7

[Before beginning the walk, participants will be given the following instructions.]

Researcher: For the next part of the study, we will be going on a walk around campus. We will walk only on designated paths. If you feel any discomfort or would like to stop the walk, please let me know. I would also ask that you turn off your cellphone and remove your watch during the walk to minimize distractions. Please refrain from speaking with me or others during the walk. During the walk, observe your surroundings. *[The researcher will record start time of the walk.]*

Urban walk path:

Nature walk path:

[During the walk (approximately 5 minutes into the walk), the researcher will ask the participant to stop and observe his/her surroundings for a certain period of time. The researcher will then measure 1 minute using the stopwatch. Next, the researcher will ask the participant to estimate how long they have been stopped and observing the environment. The researcher will record the response in the log.]

Researcher: "Before continuing the walk, can you please take a moment to stop and observe your surroundings." *[The researcher will measure 1 minute.]* "Can you please estimate how long we have been stopped observing the environment." *[Record the participant estimate in the log.]* "Thank you. We will now continue with the walk."

[After the walk, the researcher will ask participants to estimate the duration of the walk in minutes.]

Researcher: "Please think of your experience while walking. Please estimate how long the walk was in minutes and seconds." *[The researcher will keep track of start and end time of the walk. Walk is expected to be approximately 10 minutes. Researcher will record participant estimate.]*

[Before giving the questionnaire to the participant, the researcher will ask the participant to count to a minute while observing and being in the setting. The participant will be asked to let the researcher know when they feel a minute has passed. The researcher will use a stopwatch to measure the exact time and will record it in seconds in a log.]

Researcher: "Before beginning the questionnaire, can you please take a moment to observe your surroundings for exactly 1 minute. Estimate the time as accurately as possible, meaning no less and no more than 1 minute. When you feel a minute has elapsed, let me know by raising your hand. I will be using a stopwatch to measure your estimate."

Participant: [*Counts to one minute.]*

Researcher: *[Stops the stopwatch precisely when the participant feels a minute has elapsed and records the value in the log.]* "Thank you. Now, please complete this brief questionnaire about your experiences during the walk." *[Give participant the following questionnaire.]*

Perceived Stress Scale

The questions in this scale ask you about your feelings and thoughts **right now**. In each case, you will be asked to indicate how you feel or think a certain way. For each question choose from the following alternatives:

1. not at all
2.
3. somewhat
4.
5. very

1. Do you feel upset because of something that happens unexpectedly?
2. Do you feel you are unable to control the important things in your life?
3. Do you feel nervous?
4. Do you deal successfully with irritating life hassles?
5. Do you feel you effectively cope with important changes that are occurring in your life?
6. Do you feel confident about your ability to handle your personal problems?
7. Do you feel that things are going your way?
8. Do you find you cannot cope with all the things that you have to do?
9. Do you feel you are able to control irritations in your life?
10. Do you feel stressed?
11. Do you feel you are on top of things?
12. Do you feel angry because of things that happen that are outside of your control?
13. Do you find yourself thinking about things that you have to accomplish?
14. Do you feel you are able to control the way you spend your time?
15. Do you feel difficulties are piling up so high that you cannot overcome them?

Please answer the following questions about how you felt **while** walking:
Please circle the number that best represents your response.

	Not at all			Somewhat			Very
How fun was the experience?	1	2	3	4	5	6	7
How awe-inspiring was the setting?	1	2	3	4	5	6	7
How distracted were you by other thoughts?	1	2	3	4	5	6	7
How pleasant was the experience?	1	2	3	4	5	6	7
How mentally stimulated were you?	1	2	3	4	5	6	7
How pleasant was the weather?	1	2	3	4	5	6	7
How aware of your surroundings were you?	1	2	3	4	5	6	7

In the box below, please list details you noticed during the walk.

Please answer the following questions about how you feel **right now**:

	Not at all			Somewhat			Very
How happy do you feel?	1	2	3	4	5	6	7
How strained for time do you feel?	1	2	3	4	5	6	7
How relaxed do you feel?	1	2	3	4	5	6	7
How sad do you feel?	1	2	3	4	5	6	7
How stressed do you feel?	1	2	3	4	5	6	7
How busy do you feel?	1	2	3	4	5	6	7
How connected do you feel to nature?	1	2	3	4	5	6	7

1. How many people did you encounter during the walk? Please circle your response.
   0 1-4 5-9 10+

Long term time orientation

1. Place the year 2030 on the following timeline:

Today ———————————————————————— 2030

2. When thinking of the future, how **far ahead** does your mind wander? Please circle your response.
minutes/ hours/ days/ weeks/ months/ years/decades/centuries/millennia

3. When thinking of the past, how **far back** does your mind wander? Please circle your response.
minutes/ hours/ days/ weeks/ months/ years/decades/centuries/ millennia

4. How short or long ago does the start of the new year feel to you?

Very short ———————————————————————— Very long

Temporal Focus Scale

We are interested in what people focus on when their mind wanders. While you were looking at the picture and right now, what are you thinking about? Scale from (1) not at all; (7) all the time

Past focus
6. I replay memories of the past in my mind.
9. I reflect on what has happened in my life.
1. I think about things from my past.
11. I think back to my earlier days.

Current focus
4. I focus on what is currently happening in my life.
8. My mind is on the here and now.
10. I think about where I am today.
2. I live my life in the present.

Future focus
3. I think about what my future has in store.
12. I think about times to come.
5. I focus on my future.
7. I imagine what tomorrow will bring for me.

Nature Relatedness Scale

Please circle the number that best represents your agreement with each statement.

Strongly Disagree			Neutral			Strongly Agree
1	2	3	4	5	6	7

1. My connection to nature and the environment is a part of my spirituality
2. I am not separate from nature, but a part of nature
3. Even in the middle of the city, I notice nature around me
4. I always think about how my actions affect the environment
5. Some species are just meant to die out or become extinct
6. I enjoy being outdoors, even in unpleasant weather
7. My feelings about nature do not affect how I live my life
8. I am very aware of environmental issues
9. The state of nonhuman species is an indicator of the future for humans
10. My ideal vacation spot would be a remote, wilderness area
11. I feel very connected to all living things and the earth
12. Humans have the right to use natural resources any way we want
13. I think a lot about the suffering of animals
14. Animals, birds and plants have fewer rights than humans
15. I take notice of wildlife wherever I am
16. Nothing I do will change problems in other places on the planet
17. The thought of being deep in the woods, away from civilization, is frightening
18. Conservation is unnecessary because nature is strong enough to recover from any human impact
19. I don’t often go out in nature
20. My relationship to nature is an important part of who I am
21. I enjoy digging in the earth and getting dirt on my hands

Finally, we'd like to know a little more about you as a person.

Your age: _____ years

Please circle the gender you identify with: Male Female Other

Thank you for participating! Please return the questionnaire to the researcher.
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