

Acknowledging and understanding the contributions of nature to human sense of time

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Abstract

1. There is growing evidence that interacting and connecting with nature are essential to maintain human health and well-being. The benefits of specific nature experiences and the cultural ecosystem services they provide are increasingly being recognized, but many others remain to be discovered and explored.
2. In this perspective piece, I argue that there is a need to better explore the pivotal role of nature experiences in shaping human time perception—our *sense of time*. Specifically, I outline the main elements of human time perception and the key factors that shape it, describe recent evidence showing that human time perception changes between urban and natural environments and discuss the potential societal gains from developing a better understanding of this relationship.
3. Human time perception is complex and involves at least three key dimensions related to temporal succession, temporal duration and temporal perspective. Time perception is shaped by various contextual factors, including the contents of the time period and the cognitive, emotional and bodily characteristics of the experiencer.
4. There is growing evidence that nature experiences can influence human sense of time by (i) extending human perception of temporal duration and (ii) shifting time perspectives. People who spend time in nature tend to overestimate the length of that experience and show a more positive outlook of the past, present and future, with less focus on a single-time perspective.
5. In the context of increasing time scarcity in modern urban societies with dire consequences for human health and well-being, I argue we need a better understanding of how nature experiences shape our sense of time and suggest how future research can provide actionable insights to help restore a healthier and more balanced relationship with time and nature.

KEYWORDS

ecosystem services, human–nature interactions, non-material contributions, time perception, time perspective

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1 | INTRODUCTION

Nature provides a diverse range of contributions that are essential for human survival and well-being (Díaz et al., 2018). Nature's contributions include the provision of material goods such as food, fuel and other functional materials and the regulation of soil formation, pollination and ocean acidification (Hill et al., 2021). They also include less tangible but nevertheless crucial contributions, such as learning experiences, creative inspiration, recreational opportunities and other physical and psychological experiences that add value, quality and meaning to people's lives (Chan et al., 2012; Daniel et al., 2012). These non-material contributions, often also referred to as cultural ecosystem services, are shaped by the complex relationships humans establish with nature under specific cultural and ecological contexts (Fish et al., 2016). Cultural ecosystem services underpin the benefits humans derive from nature through their essential role in regulating and maintaining people's physical health, mental health and well-being (Bratman et al., 2019; Huynh et al., 2022) and are considered among the most salient reasons why people protect, restore and sustainably manage natural ecosystems (Chan et al., 2012; Chan & Satterfield, 2017).

While there is now a growing evidence basis about how a broad range of cultural ecosystem services link nature experiences to human well-being, important knowledge gaps remain in their conceptualization, understanding and application (Huynh et al., 2022; Urbina-Cardona et al., 2023). One aspect that has received surprisingly little attention in the cultural ecosystem services literature are the ways in which nature shapes a key dimension of human experience: our *sense of time*. Modern societies are increasingly burdened by the frantic pace of urban living (Rosa, 2013) and growing feelings of 'time scarcity' (Rudd, 2019), denoting the toll placed by contemporary lifestyles on how people experience and process time. In this perspective piece, I propose that nature experiences have the potential to regulate our perception of time and argue that there is a need to better recognize, understand and value this neglected contribution of nature to human well-being. I begin by outlining the key components of human sense of time and how cognitive, emotional and bodily factors influence time processing. I then propose that nature can influence human sense of time by (i) extending human perception of temporal duration and (ii) shifting time perspectives. I conclude by outlining the potential societal gains from developing a better understanding of the relationship between nature experiences and human time processing and future research avenues towards a better understanding of this neglected cultural ecosystem service.

2 | HUMAN SENSE OF TIME

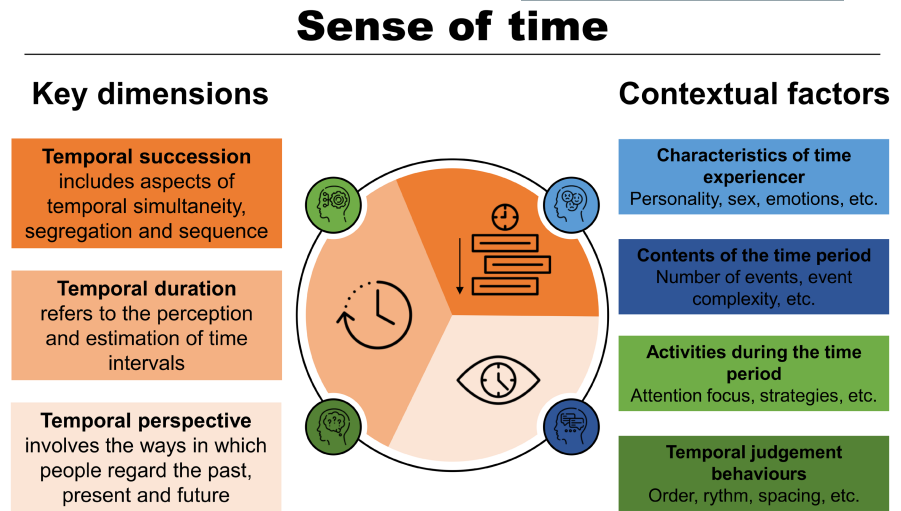
Human sense of time can be described as the set of processes and structures through which humans experience time at multiple scales (Eagleman, 2008; Lloyd & Arstila, 2014). Time perception is an essential component of human experience and plays a defining

role in individual behaviour and survival (Buhusi & Meck, 2005), but it is also highly subjective (Eagleman, 2008; Eagleman et al., 2005). In fact, the accounts of time measured by external mechanical instruments (i.e. 'clock time') and judged, perceived and experienced by humans (i.e. 'subjective or psychological time') can vary widely. This is because time is not a material property of our surrounding environment, and human bodies are therefore not equipped with a dedicated sensory organ to assess the passage of time, at least not in the same way that human eyes and ears have evolved to detect light and sound (Ivry & Schlerf, 2008; Wittmann, 2009).

Human perception of time is regulated by a complex cognitive structure (Allman et al., 2014; Lloyd & Arstila, 2014) and involves at least three key dimensions: (i) temporal succession, (ii) temporal duration and (iii) temporal perspective (Figure 1; Block, 1990; Thönes & Stocker, 2019). Temporal succession refers to the sequential occurrence of events, from which temporal overlap and order may be processed. Events separated by at least 30ms are perceived as temporally segregated and assigned a 'time-tag' in memory, which allows humans to make sense of temporal order (Block, 1990). Temporal duration relates to the perception and estimation of time intervals at multiple timescales. Events lasting up to approximately 3s are directly perceived by humans and processed in the context of the psychological present (Fraisse, 1984), also known as the 'specious present' (James, 1890), but the processing of longer events involves memory and other cognitive processes (Wittmann, 1999). This sometimes leads to biased perceptions of the temporal duration of specific events (Wittmann, 2009, 2013), often reflected in popular expressions such as 'time stood still' or 'time flies when you're having fun'. Temporal perspective characterizes how humans view the past, present and future. Humans have the capacity to develop mental constructs of past and future events, and this capacity to mentally 'time travel' and focus on past, present and future perspectives is considered an evolutionary advantage (Suddendorf & Corballis, 2007) and a sign of psychological well-being (Boniwell & Zimbardo, 2004; Zimbardo & Boyd, 1999). These three components are thought to be hierarchically integrated at different timescales, ranging from a few milliseconds to several decades, to form a broader perception of time (Block, 1990; Pöppel, 1997; Wittmann, 1999).

Some dimensions of temporal judgement are more strongly associated with aspects of experiential perception, while others depend mostly on cognitive processes (Block, 1990). These two different time processing modes are respectively linked to prospective or retrospective time judgement mechanisms (Block & Zakay, 1997). Experimental evidence supports the idea that prospective time judgements are more strongly regulated by attentional effort, whereas memory processes play a more important role in retrospective judgements (Block et al., 2010). For example, deep immersion in an activity through directed attention influences the perceived flow of time (Csikszentmihalyi, 2013). However, both mechanisms are influenced by a broader range of contextual factors (Block, 1990; revised in Block et al., 1996). Other relevant

FIGURE 1 Schematic description of the key dimensions that compose human time perception and the contextual factors that shape it. The icons used in the figure were obtained from flaticon.com.



factors (Figure 1) include the contents of a given period (e.g. number and complexity of stimuli perceived) or temporal judgement behaviours (e.g. order, rhythm and spacing of events). For instance, experimental subjects exposed to more complex stimuli generally tend to overestimate temporal duration (e.g. Brown, 1995; Roseboom et al., 2019). Characteristics of the time experienter, such as age (e.g. Ulbrich et al., 2009; Wittmann & Lehnhoff, 2005), sex (e.g. Rammsayer & Troche, 2010; Wittmann & Szegel, 2003) or internal affective and bodily states (e.g. Droit-Volet & Meck, 2007; Wittmann, 2009; Wittmann & van Wassenhove, 2009), are also known to influence temporal perception. Indeed, multiple studies have demonstrated that people experiencing feelings of boredom, anxiety or awe often overestimate the duration of time intervals and report time passing more slowly (Danckert & Allman, 2005; Rudd et al., 2012; Wittmann et al., 2006). There is also compelling evidence for the existence of links between time perception and bodily states, supported by reports of temporal overestimation in association with increases in body temperature (Wearden & Penton-Voak, 1995), pain intensity (Somov, 2000) or facial mimicking of emotional expressions (Effron et al., 2006).

3 | NATURE'S CONTRIBUTIONS TO HUMAN SENSE OF TIME

Humans interact cognitively, emotionally and physically with nature (Pramova et al., 2022), and the characteristics of nature experiences shape how we benefit from them (Richardson et al., 2021). For example, there is growing evidence that the provision of cultural ecosystem services such as sense of place is deeply shaped by emotional and embodied experiences (Aramoana Waiti & Awatere, 2019; Flood et al., 2021). Given the defining role played by cognitive, emotional and bodily factors in shaping human temporal perception and the large body of evidence confirming the positive influence of nature on these factors (Berman et al., 2008; Bratman et al., 2019), it is plausible that nature experiences can

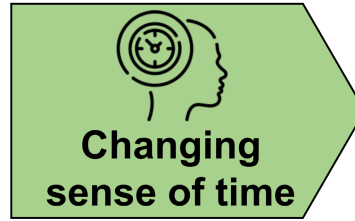
also positively influence human sense of time. I propose that there are at least two relevant pathways through which nature influences human time perception, namely (i) by extending the perception of temporal duration and (ii) by shifting time perspective (Figure 2). I describe supporting evidence for the existence of these links below, but stress that there are other hypothesized pathways with potential relevance and worthy of further investigation, such as helping individuals learn and regulate temporal cognitive structures through experiences in the natural world (Salet et al., 2022).

3.1 | Extending temporal duration perception

There is an emerging body of research indicating that time feels longer when spent in nature compared to the same time spent in urban environments. In one study, 45 undergraduate students were required to complete a set of tasks while randomly exposed to videos depicting natural or urban settings (Berry et al., 2015). Although there were no differences in session duration, individuals exposed to videos of natural settings reported significantly longer estimates of the duration of the session than did those exposed to images of built environments. The authors of the study suggested the observed differences could be due to shifts in attention or arousal between built and natural environments, but highlight the need to discern the underlying mechanisms in future studies (Berry et al., 2015).

A similar result was obtained in another study that compared the perceived duration of a walk in urban and natural settings (Davydenko & Peetz, 2017). When inquired about the duration of the walk they had just experienced, participants tended to accurately report the walk duration when it took place in the urban setting but overestimated the duration of the nature walk. The authors proposed several mechanisms to explain the observed differences, including shifts in attention and mood. The former suggestion aligns well with Attention Restoration Theory, which posits that natural environments can

Urban



Nature

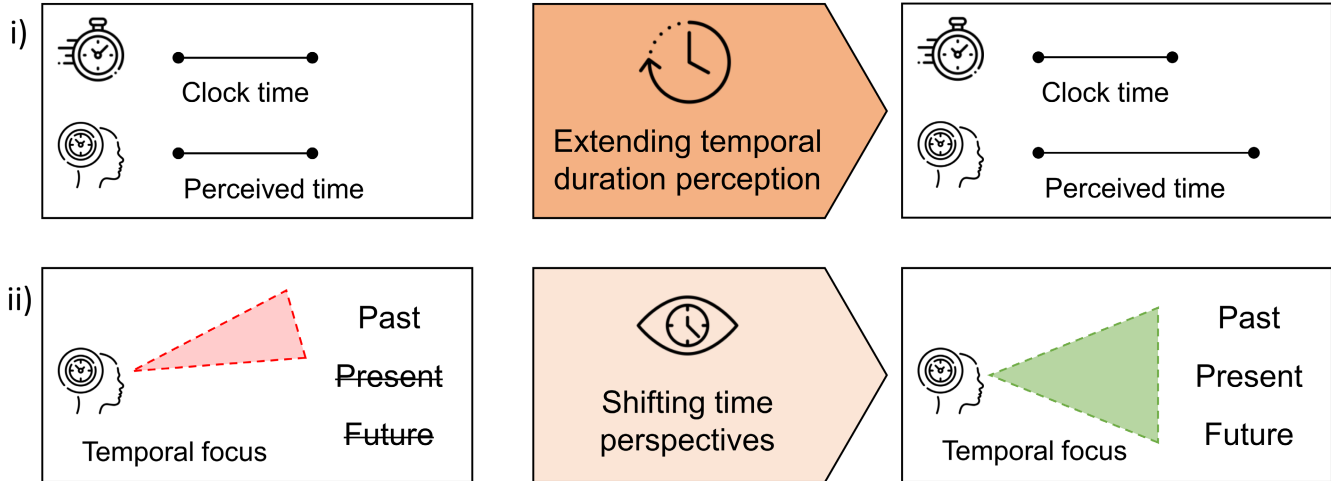


FIGURE 2 Illustrative representation of how exposure to nature environments may positively influence human time perception when compared to urban environments by (i) expanding temporal duration perception and (ii) shifting temporal perspective. The icons used in the figure were obtained from flaticon.com.

have a restorative effect on attention capacity (Berman et al., 2008; Berto, 2005; Kaplan, 1995). Affective changes caused by exposure to nature are also well documented (Mayer et al., 2009; McMahan & Estes, 2015) and could be another plausible explanation for the observed differences in time perception between environments, possibly acting in connection with changes in attention (Lake, 2016). Interestingly, changes in people's affect and temporal perception are restricted or not detected when people are virtually exposed to nature (Mayer et al., 2009; van Elk & Rotteveel, 2020), suggesting that immersion and bodily sensations may also play a role.

A more recent study assessed multiple dimensions of temporal perception, including time awareness, passage of time, felt time and time estimation accuracy, under natural and urban settings and while performing tasks requiring directed and undirected attention (Ehret et al., 2020). Participants exposed to the natural setting reported that time passed more slowly and felt longer in nature when compared to urban environments. They also reported significantly higher attention to time under the natural setting, but only when performing the task that did not require directed attention. The authors of this study also pointed to the attention restoration capacity of nature experiences to justify the observed differences and suggested further studies are needed to explore these mechanisms in detail. Put together, these reports indicate that time is experienced differently and is perceived as longer in nature compared to urban environments.

3.2 | Shifting time perspective

Several studies provide evidence that nature experiences can help people change their temporal perspective. In one experiment, participants were subjected to a short period (six and a half minutes) of silence indoors and outdoors with the aim of assessing how this experience influenced their self-reported relaxation and temporal orientation (Pfeifer et al., 2020). Participants reported a heightened sense of present orientation and a reduced past orientation after a period of silence in a natural setting. The authors proposed that the observed differences may be due to positive emotional changes driven by exposure to natural environments, or to a heightened sense of mindfulness (Pfeifer et al., 2020). Mindfulness is characterized by a sense of being in the present and heightened awareness of the surrounding environment (Langer & Moldoveanu, 2000; Pagnini & Philips, 2015). While the links between mindfulness and attention capacity have been questioned (Prakash et al., 2020), recent research suggests that combining mindfulness practices with attention restoration skills in natural settings contributed to improve psychological functioning (Lymeus et al., 2020, 2022). It is therefore plausible that the restorative effects of nature on attention capacity (Berman et al., 2008; Berto, 2005; Kaplan, 1995) may also contribute to the reported shift in temporal perspective.

Another study assessed the effects of a 90-min walk in nature, compared to a similar-length urban walk, on self-reported

rumination (Bratman et al., 2015). Rumination is strongly linked with a temporal focus on negative aspects of the past (Sailer et al., 2014), and thus with a negative past perspective. The authors reported that the nature walk significantly decreased rumination when compared to the city walk. The suggested mechanisms behind the observed changes are the same as discussed above and include emotional changes and the restoration of cognitive capacity when spending time in nature.

Results from a combined study involving two laboratory experiments and one field test also suggested that nature exposure can help balance present and future time perspectives (van der Wal et al., 2013). Participants in the laboratory study were exposed to photographs of either natural or urban environments (or not exposed to any priming for the control group in the second experiment) before completing a temporal discounting game, which tests the degree to which present goods or benefits are preferred over future ones (Wilson & Daly, 2004). Those participating in the field experiment were asked to complete a 5-min walk in either a natural or urban environment before also participating in a temporal discounting game. In all three cases, participants exposed to the nature setting cared more about the future and showed less tendency to discount it in favour of more present gratification, a behaviour that is strongly associated with a present-hedonistic time perspective (Zimbardo & Boyd, 1999). Interestingly, no significant differences in mood were observed between settings. While the authors recognized limitations in how emotional changes were assessed in this study, they link the differences observed to contextual changes between environments.

Similar results were described by Berry et al. (2014), adding evidence to the suggestion that exposure to natural environments can decrease impulsive behaviours by shifting temporal perspectives. While participants in this study were only visually exposed to different environments, those exposed to natural images were less likely to show impulsive behaviours than participants exposed to urban or geometric (control) images. These studies provide compelling evidence that nature experiences can facilitate a shift in temporal focus, at least momentarily, and align with the idea that the role of such experiences in giving humans perspective should be considered as a cultural ecosystem service (Gould & Lincoln, 2017).

4 | THE IMPORTANCE OF NATURE'S CONTRIBUTION TO SENSE OF TIME FOR HUMAN WELL-BEING

The changes in subjective time perception driven by nature experiences are likely to have a positive influence on human health and well-being. Modern lifestyles are largely driven by 'mechanical time' (i.e. time defined by the schedule and the clock) and regulated by notions of productivity (Marx, 1981; Zerubavel, 1985). This focus on productivity has caused a shift in the symbolic value of time, with major consequences on how societies structure and use time (Keinan

et al., 2019). Indeed, one of the main changes in contemporary social life is the acceleration of the pace of life, which happens despite the expectation that technological change should increase recreational time (Rosa, 2013). This is particularly true in large urban environments with a high population density, as there is long-standing evidence that the pace of life accelerates in such conditions across various cultural contexts (Bornstein & Bornstein, 1976).

One major consequence of the ongoing migration of human populations to large metropolises is the heightened pace of urban life, which contributes to a growing detachment from natural rhythms and to widespread feelings of 'time scarcity' (Giurge et al., 2020; Rudd, 2019). The negative consequences of this perceived time pressure on physical and mental health are increasingly recognized and have led to calls towards identifying remedies to mitigate them (Roxburgh, 2004; Rudd, 2019; Szollos, 2009). Some authors have proposed that the changes in time perception caused by experiencing nature may help to counteract the prevailing time strain in urbanites and its associated health consequences (Davydenko & Peetz, 2017).

The rapid pace that characterizes urban lifestyles can also cause a shift in time perspective (Li & Cao, 2019; Wang & Sun, 2022). A narrow focus on hedonistic or fatalistic views of the past and present is associated with a broad range of risky behaviours (Jochemczyk et al., 2017), including, for example, substance use (Keough et al., 1999), risky driving (Zimbardo et al., 1997) and even suicide (Laghi et al., 2009). Experiencing periods of time in nature can induce a more positive outlook of the present (i.e. a eudaimonic view of the present as proposed by Vowinckel et al., 2017) and facilitate the flow between past, present and future temporal frames, which is considered a key characteristic of a balanced time perspective (Stolarski et al., 2015; Zimbardo & Boyd, 1999). Such experiences can therefore have a defining and positive role on human health and well-being by promoting a more positive and balanced time perspective (Bonniwell & Zimbardo, 2004; Zimbardo & Boyd, 1999).

5 | CONCLUSIONS AND FUTURE DIRECTIONS

In the context of increasing time poverty in modern urban societies (Giurge et al., 2020), with dire consequences for human health and well-being, I argue that nature experiences can shape our sense of time and help restore a healthier and more balanced relationship with time. To realize this potential, there is a need to develop a better understanding of the complex ways through which nature experiences shape subjective time processing, and I propose this can be achieved through an ecosystem services approach (Bratman et al., 2019). While the perspective outlined here opens up several questions and potential avenues for future inquiry, I suggest a few ideas that can help guide future research efforts.

First, it is likely that the characteristics of natural landscapes will influence the effects of nature experiences on time perception. Most of the research so far has focused on comparing time perception

in urban and natural environments, and much less attention has been paid to the actual characteristics of the tested environments. However, there is ample evidence suggesting that the features of natural environments shape their psychological and physiological restorative potential (e.g. Chiang et al., 2017; Deng et al., 2020; Nordh et al., 2009), and it is therefore likely that time perception is similarly affected.

It is also plausible that the type and amount of nature exposure and individual characteristics of the experiencer influence nature regulation of human sense of time. The influence of nature on cognitive function and well-being can change depending on whether nature is experienced directly or indirectly, the duration of the experience and the type of activity involved (e.g. Bratman et al., 2012; Nakagawa et al., 2020). Others have also found individual differences shape the outcomes of nature experiences, for example the degree of individual connection to nature (e.g. Bailey & Kang, 2022; McMahan et al., 2018). Both nature experiences and nature connections warrant further exploration in the context of nature's influence on time processing, including the potential existence of synergistic interactions between these factors (Martin et al., 2020).

Finally, if nature does influence human time perception as proposed here, then there is also a need to better understand how the effects of this influence translate to human behaviours. For example, both future thinking (e.g. Lee et al., 2020; Pahl & Bauer, 2013) and perceptions of time availability (e.g. Melo et al., 2018; Wu et al., 2019) can influence how people engage in sustainable behaviours. It can therefore be hypothesized that the beneficial effects of nature experiences on time perception could act as a leverage towards more sustainable behaviours, but these links should be tested empirically.

Ultimately, developing a better understanding of how immersion in nature affects our subjective experience of time can expand our comprehension of the therapeutic benefits of nature and provide actionable insights for urban design, transportation planning and other areas that influence modern daily lives. Such insights may prove instrumental to enhance human health and well-being, now and into the future, by helping to mending our broken relationship with time and nature.

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CONFLICT OF INTEREST STATEMENT

Ricardo A. Correia is an associate editor of People and Nature but took no part in the peer review and decision-making processes for this paper.

DATA AVAILABILITY STATEMENT

This paper does not include any data.

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