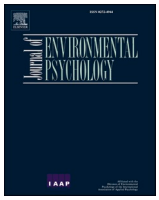
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A goal-discrepancy account of restorative nature experiences

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ABSTRACT

The role of nature in promoting both affective and cognitive benefits has been extensively studied in the field of environmental psychology. Two well-established theories, Stress Recovery Theory (SRT) and Attention Restoration Theory (ART), are commonly used to explain these restorative benefits. However, despite their popularity, both theories face important challenges. To address these challenges, in the current paper, we propose an alternative goal-discrepancy account of restorative nature experiences. In our account, we consider individuals as goal-directed agents and argue that the to-be-restored states that are central to SRT and ART – stress and negative affect (in SRT) and declines in cognitive performance (in ART) – can be interpreted as discrepancies between an individual's goals and their current situation, instead of drained affective and/or cognitive resources. We propose that affective (see SRT) and cognitive nature benefits (see ART) both arise from a process of discrepancy reduction, where nature helps individuals to reduce discrepancies between their current situation and their goals. Nature can facilitate this discrepancy reduction process through three pathways: (a) by modifying goals (i.e., accommodation), (b) by modifying interpretations of the situation (i.e., immunization), or (c) by affording actions that can fulfill thwarted goals (i.e., assimilation). We compare our account to SRT and ART, highlighting similarities and differences between our proposal and the two theories, and illustrate how it can guide empirical studies and real-life interventions.

1. Introduction

In 2000, former United Nations Secretary-General Kofi Annan emphasized the importance of assessing "… the *consequences* of ecosystem change for *human well-being* and the scientific basis for action needed to enhance the conservation and sustainable use of those systems and their contribution to human well-being" (cited in Haines-Young & Potschin, 2010, p. 110). Since Annan's declaration, there has been a significant increase in research on human-environment interactions in the field of environmental psychology, with researchers showing particular interest in the ways in which *natural* environments (e.g., forests, wilderness, biodiverse nature) can provide both affective and cognitive benefits (Hartig, Mitchell, De Vries, & Frumkin, 2014). Studies have especially revealed that spending time in natural (vs. urban) environments, or even just watching nature scenes, can reduce stress (Jiang, Chang, & Sullivan, 2014), counteract rumination (Bratman, Hamilton, Hahn, Daily, & Gross, 2015), and improve concentration (Gamble, Howard, & Howard, 2014; Nisbet, Zelenski, & Grandpierre, 2019). These affective and cognitive nature benefits have become recognized as a valuable ecosystem service (Burkhard & Maes, 2017), and are commonly referred to as "restorative" nature experiences.

Environmental psychology research on nature's restorative potential has laid the groundwork for nature-based interventions aimed at improving cognitive functioning and mental wellbeing. This research has, for example, inspired urban planners to incorporate greenery into formerly "gray" inner-city areas (Wolch, Byrne, & Newell, 2014), led to projects for greening up schoolyards (Van Dijk-Wesselius, Van den Berg, Maas, & Hovinga, 2020), and encouraged general practitioners to prescribe nature as a way to address mental health problems, such as burnout and depression (Robinson, Jorgensen, Cameron, & Brindley, 2020; Van den Berg, 2017). The COVID19 crisis has further sparked popular interest in (research on) the beneficial effects of nature (Soga, Evans, Tsuchiya, & Fukano, 2021). Newspapers and health blogs continue to publish pieces highlighting the positive effects of nature

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contact during lockdowns (e.g., Douglas, 2021), and several nature organizations rose to the occasion and have emphasized the psychological blessings of nature and biodiversity in addition to the other ecosystem services they provide (Beatty et al., 2022).

For many years, theorizing about the mechanism(s) driving restorative nature experiences has been dominated by two theories: Stress Recovery Theory (SRT; Ulrich, 1983; Ulrich et al., 1991; Ulrich, 1993) and Attention Restoration Theory (ART; Kaplan & Kaplan, 1989; Kaplan, 1995; Kaplan & Berman, 2010). While these theories have been, and still are, very influential and widely cited, recent research has raised important concerns about their viability and usefulness for understanding psychological nature benefits (Egner, Sütterlin, & Calogiuri, 2020; Joye & De Block, 2011; Joye & Dewitte, 2018; Joye, Lange, & Fischer, 2022; Joye & Van den Berg, 2011; Neilson, Craig, Travis, & Klein, 2019). In response to these concerns, we here develop an alternative integrative framework for affective and cognitive nature benefits. In this framework, we view individuals as goal-directed agents and propose that affective and cognitive nature benefits arise through a process of discrepancy reduction, where nature helps individuals to minimize discrepancies between their current situation and their goals.

This paper has three parts. In the first part, we aim to demonstrate the need for theory revision, by discussing and critically evaluating the two main restoration theories, SRT and ART. In the second part, we outline our alternative account for restorative nature experiences. We argue that the to-be-restored states that are central to these theories – stress and negative affect (in SRT) and declines in cognitive performance (in ART) – reflect discrepancies between an individual's goals and their current situation, rather than drained affective and/or cognitive resources. We propose that nature can help solve these discrepancies, either by (a) modifying an individual's goals (i.e., accommodation), (b) modifying an individual's interpretation of their current situation (i.e., immunization), or (c) affording actions that allow the individual to align the situation with their goals, thereby fulfilling them (i.e., assimilation). In the third and final part, we compare and contrast our alternative account with the two established restoration theories and illustrate how our account can be used as a framework for guiding empirical studies and real-life interventions.

2. The "two theories" of restorative nature effects

The two restoration theories, SRT and ART, assume that some of our everyday activities, experiences, and obligations (e.g., work, family, and relationship demands) can drain emotional and cognitive resources, and that contact with nature can help restore these resources. Both theories each focus on a specific restorative effect – affective or cognitive restoration – and propose distinct mechanisms through which these restorative effects occur. There is currently a wealth of experimental studies on nature's beneficial affective and cognitive effects, with these studies varying in the methods they use to manipulate nature exposure (e.g., picture slideshows: Berman, Jonides, & Kaplan, 2008; actual nature: Berman et al., 2008, 2012; virtual reality: Ünal, Pals, Steg, Siero, & van der Zee, 2022), the methods they use to measure affect and cognitive functioning (for a review, see Stevenson, Schilhab, & Bentsen, 2018), and the samples they study (e.g., elderly: Ottosson & Grahn, 2005; children: Taylor & Kuo, 2009; Ulset, Vitaro, Brendgen, Bekkhus, & Borge, 2017).

In the following sections, we outline the basic tenets of each of the two restoration theories, we zoom in on the empirical paradigms used to demonstrate restoration for both theories and highlight their relevance for practical applications. After that, we describe the challenges that both theories face, and point to recent alternative proposals for SRT and ART. To avoid overcomplicating our argument, throughout the paper we will mostly use the generic term "nature" (or closely related concepts) to refer to a variety of unthreatening natural elements, settings, and features. In our use of this terminology, we specifically follow Frumkin et al. (2017, p. 1), who characterize nature as referring to "areas containing elements of living systems that include plants and nonhuman animals across a range of scales and degrees of human management, from a small urban park through to relatively 'pristine wilderness' … together with abiotic elements such as sunset or mountain views".

2.1. Stress Recovery Theory (SRT)

In SRT, nature's restorative potential is situated in its ability to reduce psychophysiological stress and to undo associated negative affect in individuals. While advocates of SRT acknowledge that cultural and social learning can contribute to affective restoration (Ulrich, 1983, 1993; Ulrich et al., 1991), the prevailing view is that nature-induced stress-reduction is an adaptive relic of our species' evolutionary history (see Koivisto & Grassini, 2022; Schiebel, Gallinat, & Kühn, 2022). More specifically, the argument is that during ancestral times, natural environments containing vegetation and water features could provide early humans (cues to) life-supporting resources, such as food and drinkable water (Ulrich, 1983, 1993). In addition, natural landscapes with structural properties such as moderate complexity, mystery, and an even ground surface, enhanced scene understanding, motivated exploration (Ulrich, 1983, 1993), and allowed humans to see without being seen (Appleton, 1975). Proponents of SRT argue that because such (resource-rich and safe) natural environments were conducive to human survival, natural selection has equipped our species with an adaptive readiness for psychophysical stress reduction in such settings, accompanied by a decrease in negative affect and a shift towards positively toned moods (Ulrich, 1983, 1993; Ulrich et al., 1991). This ancestral restorative response is assumed to have been retained in the human lineage, which is why we still enjoy and appreciate nature's stress-reducing potential today. In contrast, evolutionarily more recent urban environments are argued to often be a source of stress and negative affect because they mismatch with our evolved psychology.

2.2. Attention Restoration Theory (ART)

While SRT situates nature's restorative effects in *affective* processes, ART focuses on *cognitive* processes, in particular on nature's presumed ability to promote the recovery from attentional fatigue (Kaplan, 1995; Kaplan & Berman, 2010; Kaplan & Kaplan, 1989). ART is specifically built around the notion of "directed attention", the cognitive capacity we use when we need to concentrate on a specific stimulus (e.g., reviewing a research paper), while at the same time blocking out competing and distracting stimulation (e.g., noise from a construction site down the road). In ART, directed attention is assumed to be a limited resource that can become depleted through intensive and/or prolonged use, resulting in a compensatory need to replenish this capacity (Kaplan & Berman, 2010). Experiencing nature can be restorative because it can support the replenishment of directed attention.

Advocates of ART argue that nature can restore cognitive resources specifically through its "soft fascinating" features and elements, such as "… clouds, sunsets, snow patterns, the motion of the leaves in the breeze …" (Kaplan, 1995, p. 174). These features are often aesthetically pleasing, and *effortlessly* capture attention, allowing (effortful) directed attention to rest and replenish. The theory furthermore assumes that attention restoration is enhanced when the natural environment has sufficient extent (i.e., the environment is physically or conceptually vast), allows one to be away from the source(s) of directed attention fatigue (Kaplan, 1995), and is compatible with an individual's goals (e.g., a tranquil lakeside supporting the goal of reflection; Kaplan, 1995).

Research on ART often highlights that urban environments are generally less restorative than nature settings, particularly when they are filled with "dramatic" or "hard fascinating" stimulation (e.g., busy traffic, loud noises) which is thought to further drain rather than replenish directed attention (Berman et al., 2008; Kaplan & Berman, 2010). However, unlike in SRT, the nature-urban distinction does not seem to be intrinsic to ART, and despite the predominant focus on

natural environments, research indicates that urban settings might also possess restorative potential (e.g., awe-evoking buildings, Collado & Manrique, 2020; cemeteries, Nordh, Evensen, & Skår, 2017; monasteries, Ouellette, Kaplan, & Kaplan, 2005), especially when they are soft fascinating, have extent, provide a sense of being away, and are compatible with an individual's goals.

2.3. The three-phase paradigm in SRT and ART research

SRT and ART often infer that nature can *restore* affective and cognitive resources based on results produced using an experimental paradigm consisting of three phases. In Phase 1 of SRT research, participants are commonly placed in a stressful situation (e.g., watching footage of working accidents; Ulrich et al., 1991) or they enter the study already in a somewhat stressed state (e.g., driving to the lab; Hartig, Evans, Jamner, Davis, & Gärling, 2003). In ART research, Phase 1 involves participants to take a cognitively challenging/depleting task, such as the sustained-attention-to-response task (Berto, 2005), the backwards digit span task (Berman et al., 2008; Stenfors et al., 2019), and puzzle-solving tasks (Taylor & Kuo, 2009). In Phase 2 in both SRT and ART research, participants are either exposed to a natural or a control environment - the latter commonly being an urban environment. In Phase 3, participants' stress and affect (in SRT research) or their performance on a second cognitive task (in ART research) is measured. This three-phase experimental setup is designed to create an affective or cognitive "deficit" in Phase 1, so that the subsequent nature intervention administered in Phase 2 can provide affective or cognitive recovery, which is assessed in Phase 3 through measurements of affect or cognitive performance.

Despite the widespread use of this three-phase paradigm in restoration studies, it is worth mentioning that a handful of studies have shown that exposure to nature can also yield affective and cognitive benefits when there was no prior depletion manipulation (i.e., without a Phase 1; e.g., Beute & De Kort, 2014; Gidlow et al., 2016). Thus, nature not only seems able to *replenish* depleted resources, but also to *build* resources that were not depleted, a process sometimes referred to as "instoration" (Hartig, 2007).

The existence of such instorative effects presents both opportunities and challenges. On the one hand, they underscore the value of nature interventions for individuals who are neither affectively nor cognitively depleted, highlighting that nature contact does not solely have curative but also enhancing and preventive potential. On the other hand, a challenge is that instorative experiences are difficult to explain by the two restoration theories, and especially by ART, as the theory centers entirely on the notion of *restoring* depleted cognitive resources. This challenge has spurred restoration researchers to combine SRT and ART with other perspectives (Roe & Sachs, 2022), such as Fredrickson's (2004) broaden-and-build theory, according to which the positive emotions triggered by nature can also contribute to building resources.

2.4. The impact of the two theories on research and applications

Since their development during the 1980s and 90s, SRT and ART have inspired both theoretical and applied work on the psychological benefits of nature. This is among others evident in the fact that virtually any publication on restorative nature experiences discusses the two theories, and that the landmark works by Ulrich et al. (1991) and the Kaplans (Kaplan & Kaplan, 1989) have been widely cited over the past three decades, respectively 6262 and 11,269 citations in August 2023 (source: Google Scholar). While anecdotal, these citation counts illustrate the prevalent role of SRT and ART in past and current thinking about the underlying mechanisms of affective and cognitive nature benefits.

SRT and ART have also spurred the development of a wide range of nature-based interventions aimed at improving psychological well-being and cognitive functioning. The findings have, for example, inspired health insurance companies to promote outdoor activities as a way to improve citizens' mental health (Yu, 2019), and have motivated doctors to prescribe time in nature as a treatment for conditions such as burnout and depression (Robinson et al., 2020). Supported by findings from SRT-based research, some healthcare institutions (e.g., hospitals) nowadays provide patients, staff, and visitors with access to greenspace as an intervention to reduce stress and negative moods and to promote overall well-being (e.g., Mihandoust, Pati, Lee, & Roney, 2021; Ulrich et al., 2020). Building on findings from ART research, schools have introduced greenery in classrooms and schoolyards to improve children's concentration and general cognitive performance (e.g., Van Dijk-Wesselius, Maas, Hovinga, Van Vugt, & Van den Berg, 2018). Findings from restorative environments research thus provide a fertile ground for applications aimed at enhancing different stakeholders' quality of life.

2.5. Challenges for the restoration theories

In order to achieve successful, optimized, and cost-effective nature interventions in relevant areas of human life, it is of course crucial that these applications are based on strong theories that strive for a precise understanding of the potential mechanism(s) underlying the target effects. However, despite their popularity and significant impact on both fundamental and applied work, we believe that both SRT and ART face several important challenges. In the following sections, we elaborate on these challenges: We argue that the two theories are theoretically underdeveloped, that key assumptions of the theories have not been rigorously tested, and that the field of restoration research lacks theoretical integration.

2.5.1. SRT and ART are theoretically underdeveloped

A first challenge for the two restoration theories is that, despite being formulated over almost four decades ago, they have remained remarkably underdeveloped. For example, while the notion of "soft fascination" is central to ART, it is still unclear which features make natural settings and elements soft-fascinating or which degree of softness is required for optimal restorativeness (Joye & Dewitte, 2018). Similarly, although SRT, and to some extent also ART, make sweeping claims about the evolutionary origin and adaptive value of restorative nature responses, to the best of our knowledge, there has been no attempt in conducting a thorough functional analysis of this presumed adaptation. Such a nature-specific adaptive system would likely include perceptual mechanisms for recognizing and categorizing nature, inferential and reasoning mechanisms that drive specific behavioral outcomes and interact with memory, and emotion and attention systems (see Barrett, 2005). Without more thoroughly developing and testing SRT's and ART's evolutionary account, it runs the risk of being dismissed as a "just so" story (Gould, 1997).

2.5.2. Key assumptions of SRT and ART remain untested

In addition to theoretical underdevelopment, a second challenge for SRT and ART is that the empirical studies inspired by these theories only rarely test the theories' key assumptions. There is specifically a lack of research that examines predictions/assumptions about (a) the types of natural environments that should be most restorative according to the two theories (i.e., savannas for SRT, soft-fascinating nature for ART) and (b) the particular states that should be affected by nature contact (i.e., stress, cognitive functioning).

2.5.2.1. Typical restorative environments. Several fine-grained predictions can be made about the types of nature that should have the high (est) restorative potential in the two restoration theories. For instance, it follows from SRT that savanna-type landscapes should be particularly effective at reducing stress (Ulrich, 1983, 1993), not only because they are considered to be the cradle of human evolution (Bennett, 2019;

Orians, 1980; Orians & Heerwagen, 1992) but also because they contain natural contents (e.g., greenery, water features) and are characterized by structural landscape features (e.g., intermediate complexity, a fairly even ground surface) that supported behavior conducive to human survival (e.g., exploration, finding shelter; Ulrich, 1983, 1993). ART, on the other hand, predicts that attention restoration is most likely to occur in aesthetically pleasing nature settings that moderately draw attention (Kaplan, 1995). Such soft-fascinating nature can include, but is not limited to, environments such as beaches, meadows, lakesides, and forest settings.

A challenge for the two restoration theories is that there has been little interest in rigorously testing the restorative potential of these "ideal" types of restorative nature environments. Instead, research has primarily focused on the restorative potential of green and blue spaces (Li et al., 2022) and highly biodiverse nature (Marselle et al., 2021). Although some tests of SRT's savanna hypothesis have been conducted (Balling & Falk, 1982; Falk & Balling, 2010), they have yielded mixed results (Hartmann & Apaolaza-Ibanez, 2010; Mangone, Dopko, & Zelenski, 2021) and positive affect and stress reduction have also been observed for nature that seemingly lacks life-sustaining elements and/or safety (e.g., deserts; Yin, Bratman, Browning, Spengler, & Olvera-Alvarez, 2022). In addition, cognitive benefits also seem to occur for natural environments that would typically be classified as "hard" rather than "soft" fascinating, such as awe-evoking nature (Collado & Manrique, 2020). In sum, restoration research does only rarely follow through with predictions about typical restorative environments, and in some cases, empirical findings sit difficult with the theories' central assumptions.

2.5.2.2. Outcome states affected by nature. The two theories also make predictions about the specific outcome states that should be affected by exposure to nature, namely stress/affect in SRT and directed attention in ART. From SRT, it follows that nature should especially reduce stress deriving from situations where the pursuit of physical safety and/or material resources (e.g., food) was thwarted, as restorative responses are assumed to have evolved to alleviate this type of stress. However, this prediction is only rarely tested in SRT research, and is furthermore not unequivocally supported by the current empirical data. In fact, studies have shown that natural settings can also be restorative for stressors other than those related to natural threats, such as acute social stress (Greenwood & Gatersleben, 2016; Jiang et al., 2014), performance stress on a mathematical task (Van den Berg & Custers, 2011), and stress deriving from getting electric shocks (Hedblom et al., 2019).

ART, from its side, claims that experiencing nature facilitates the replenishment of depleted cognitive resources. However, we observe that the particular experimental setup of the majority of ART studies does not allow verifying this hypothesis because it is common for *all* participants undergo a cognitive depletion manipulation prior to nature exposure in these studies, and there is rarely a control condition of non-depleted participants to compare cognitive performance with (Joye & Dewitte, 2018; Joye, Lange, & Fischer, 2022). Moreover, the exclusive use of performance on cognitive tasks as the sole outcome measure in ART studies makes it difficult to assess whether the observed performance benefits are specific to cognitive resources or whether they reflect a more general motivational effect that would also benefit performance on non-cognitive tasks (see Joye, Lange, & Fischer, 2022).

2.5.3. Lack of theoretical integration of affective and cognitive restoration

Finally, a third and longstanding challenge for restoration researchers is to elucidate how both affective and cognitive nature benefits can be integrated into one comprehensive framework. This challenge garnered early attention in the field, with Ulrich et al. (1991) suggesting that improved attention following nature contact is a result of affective restoration, while Kaplan (1995, p. 178) argued that stress reduction is a result of attention restoration, stating that "… insufficient attentional resources are an antecedent of stress". Despite these early debates about the primacy and integration of restoration theories and their associated constructs (i.e., stress, directed attention), contemporary restoration researchers tend to sidestep the issue of integration and treat SRT and ART as independent but complementary frameworks, each focusing on a particular restorative effect (Hartig, 2021; Hartig et al., 2003). Yet integration of both fields might be possible since affective and cognitive benefits can arise from experiencing *one and the same* natural environment (e.g., Bratman, Daily, Levy, & Gross, 2015) and because affect and cognition are closely intertwined (Moors & Fischer, 2019). Integrating both theories, and preferably connecting them to a more general theory of human behavior, is also desirable, as it can contribute to building a more cumulative psychological science (Muthukrishna & Henrich, 2019).

In sum, while it is widely accepted that the experience of nature can have positive effects on affect and cognition, in our reading of the literature, there is currently only limited evidence that affective restoration is an adaptive response that evolved to deal with safety- and resource-related challenges (as in SRT) or that cognitive benefits indicate the replenishment of depleted cognitive resources (as in ART). Given the challenges of theoretical underdevelopment and lack of rigorous testing, we cannot escape the sobering conclusion that adherence to either theory seems currently more an article of faith than that it is supported by a robust evidence base. This, we believe, highlights the need to revise the two theories and replace them by new proposals that also address the challenge of integrating affective and cognitive nature benefits into one comprehensive framework.

2.6. Alternatives for SRT and ART

In recent years, several alternative accounts of affective and cognitive restoration have been put forward in response to the challenges facing SRT and ART. For example, based on the notion that positive affect (from SRT) and low(er) cognitive load (from ART) are hallmarks of perceptual fluency, the Perceptual Fluency Account (PFA; Joye & Van den Berg, 2011; 2012) suggests that affective and cognitive restoration are due to fluent perceptual processing of nature's fractal characteristics. Another recent alternative account, the Conditioned Restoration Theory (CRT; Egner et al., 2020), proposes that restoration effects are conditioned responses that arise from the association of natural environments with positive affect and relaxation, due to experiencing enjoyable leisure activities in such environments. While PFA and CRT keep away from sweeping evolutionary claims (as in SRT) and avoid issues of resource specificity and depletion (as in ART), their main tenets have yet to be extensively tested. It is furthermore unclear whether the subtlety of fluency effects (assumed in PFA) can account for more pronounced restoration effects, and why natural environments have become sites of pleasure and relaxation in the first place (as presupposed in CRT).

3. A goal-discrepancy account of restorative nature effects

Guided by the need for theoretical revision, we aim to outline an alternative and integrative goal-discrepancy account for the affective and cognitive benefits of nature experiences. In their essence, we consider individuals as goal-directed agents and argue that nature experiences can yield affective and cognitive benefits by reducing discrepancies between individuals' current situation and their goals. In the following sections, we first outline the goal-directed account of behavior and affect by Moors, Boddez, and De Houwer (2017; Moors, 2022), which serves as the foundation for our alternative account. We will then argue that the states targeted by SRT and ART – stress, negative affect, and declines in cognitive performance – can be understood as discrepancies with certain goals. Finally, we discuss the ways in which nature experiences can help reduce these discrepancies, leading to affective and cognitive benefits. By integrating findings from SRT and ART into a

single integrative framework, we aim to provide a clearer understanding of how nature experiences can enhance well-being. After presenting our alternative account, we spell out the similarities and differences with SRT and ART, and we discuss implications of our account for future research and practical interventions.

3.1. A goal-directed account of human behavior and affect

Moors et al. (2017; Moors, 2022) propose that behavior and affect arise from a goal-directed cycle of events that starts with individuals comparing their situation (the current state) with their goal(s) (the desired state). The situation can encompass the individual's social or physical environment, or even particular personal characteristics (e.g., one's body image; Edwards, 2000). At any given moment, the situation can be perceived as either aligning or being discrepant with personal goals. For example, a meeting with friends in a pub is likely to align with the goal of social connection, while being in a lockdown is probably discrepant with this goal. Similarly, being in a quiet environment is likely to align with the goal of relaxation, while noise from a nearby construction site may conflict with this goal. As long as the situation aligns with a person's goal(s), the person remains in its current state. Detecting a discrepancy between the situation and one or several goals prompts the individual to reduce this discrepancy and leads to (initial) negative affect (Moors, 2022).

Moors (2022; Moors et al., 2017) identifies three general pathways for reducing situation-goal discrepancies: An individual can (a) modify the goal to eliminate the discrepancy with the current situation (i.e., "accommodation"), (b) reinterpret the situation so that it no longer appears to be discrepant with the goal (i.e., "immunization"), or (c) engage in actions to fulfil the thwarted goal (i.e., "assimilation"). In the last case, the person compares the available action options in their action repertoire and chooses the one with the highest subjective likelihood of reducing the discrepancy. The action options in the action repertoire are determined by the individual's learning history and may be constrained by the current situation (i.e., affordances of the environment; Köster et al., 2021). The reduction of a discrepancy (or the anticipation of such a reduction) leads to the experience of positive affect (Moors, 2022; Moors, Van de Cruys, & Pourtois, 2021).

To illustrate these three pathways, consider the case of a first-year PhD student who received negative feedback on a manuscript from their supervisor (see Fig. 1). If the student considers the negative feedback to be at odds with their goal of being successful at work, they would experience negative affect and strive to reduce this discrepancy. Following Pathway 1 (i.e., accommodation), the student could try to reduce the discrepancy by modifying the goal of being successful at work. For instance, the student could downplay the importance of professional success and consider other goals, such as friendship, kindness, and being successful in other domains, as ultimately more important. Following Pathway 2 (i.e., immunization), the student could try to reduce the discrepancy by reinterpreting the negative feedback on the manuscript, for instance, by viewing the feedback as an "opportunity for growth and learning". Finally, in keeping with Pathway 3 (i.e., assimilation), the student could try to reduce the discrepancy by engaging in actions to fulfill the goal for success, for example, by reworking the manuscript so that it meets the supervisor's expectations or by convincing the supervisor that some of their negative comments are unwarranted.[1] In each of the three pathways, something is either changed about the goal or about the (interpretation of the) situation to reduce existing discrepancies between them.

We propose that nature experiences can help reduce discrepancies between a situation and goals through one or more of the three pathways described above, and suggest that affective and cognitive nature benefits result from such discrepancy reductions. If this is true, then the first step in developing our theory is to argue that states targeted by SRT and ART – stress and negative affect (in SRT) and declines in cognitive task performance (in ART) – should be interpreted as situation-goal discrepancies rather than as drained affective and cognitive resources. A second step is to argue that contact with nature can facilitate the three pathways to discrepancy reduction and, in so doing, reduce stress and reduce/prevent declines in cognitive performance.

3.2. Step 1: reinterpreting stress and reduced cognitive performance as situation-goal discrepancies

In this section, we argue that stress and negative affect (central to SRT) indicate discrepancies between a range of different situations and goals, whereas declines in cognitive task performance (central to ART) primarily reflect a discrepancy between a work situation and a goal for hedonic stimulation. To be able to explain how these situation-goal discrepancies are created in restoration research, it is crucial to return to the typical three-phase setup of experimental studies of affective and cognitive restoration (Joye, Lange, & Fischer, 2022; Stevenson et al., 2018; see Section 2.3). In this setup, participants are affectively/cognitively depleted in Phase 1, after which the restorative effect of nature exposure during Phase 2 is registered in Phase 3 through measurements of affect/stress or cognitive performance.

3.2.1. Stress and negative affect reflect situation-goal discrepancies

We propose that the experience of stress and negative affect in Phase 1 of SRT-based studies does not reflect a deficit or depletion of some kind of psychological resource. Rather, building on goal-directed views of stress (Carver & Connor-Smith, 2010; Edwards, 2000; Moors, 2022), we see stress and negative affect as states that arise when individuals are in a situation that prevents them from achieving specific goals. Or, as Carver and Connor-Smith (2010, pp. 683–684) put it: "… stress is nothing more (and nothing less) than the experience of encountering or anticipating adversity in one's goal-related efforts".

The stress and negative affect experienced in Phase 1 of SRT-based studies seem to reflect discrepancies with various types of goals (not all of which belong to the type of goals that are theoretically central to SRT, i.e., avoiding physical threats or finding food; see Section 2.5.2). In many cases, stress may arise simply because individuals are put in a situation that conflicts with their desire to experience something pleasant (i.e., to fulfill a hedonic goal). For example, stressors such as movies of macabre working accidents (Meuwese, Dijkstra, Maas, & Koole, 2021; Ulrich et al., 1991), mild electric shocks (Hedblom et al., 2019), and auditory noise (Huang, Yang, Jane, Li, & Bauer, 2020; Valtchanov, Barton, & Ellard, 2010) are likely to be discrepant with participants' goal of engaging in more pleasurable activities. In other studies, goals other than pleasure-seeking seem to be thwarted. For instance, having to give an impromptu speech for others (e.g., Greenwood & Gatersleben, 2016; Jiang et al., 2014), doing a challenging math task (Jiang et al., 2014; Valtchanov et al., 2010), or disclosing one's poor task performance to others (Van den Berg & Custers, 2011) are all situations that may conflict with participants' goal of being (seen as) competent. Another example is experiencing an episode of social exclusion (Yang et al., 2021), which may conflict with the goal of social belonging. Overall, the goals that are (and can be) potentially frustrated in SRT research seem to vary greatly.

3.2.2. Reduced cognitive performance reflects a discrepancy between work and a hedonic goal

To identify the specific types of discrepancy present in ART research, we took inspiration from Inzlicht et al.'s (2014) process model of

[1] Which of these pathways/actions gets selected depends on the expected utilities of the pathways/actions that are being compared, that is, the expectancies that these pathways/actions help fulfill the goal (Moors, 2022). These, in turn, depend on a person's learning history as well as on the affordances of the environment. If the supervisor is known for being hard to convince, the student may be more likely to rework the article.

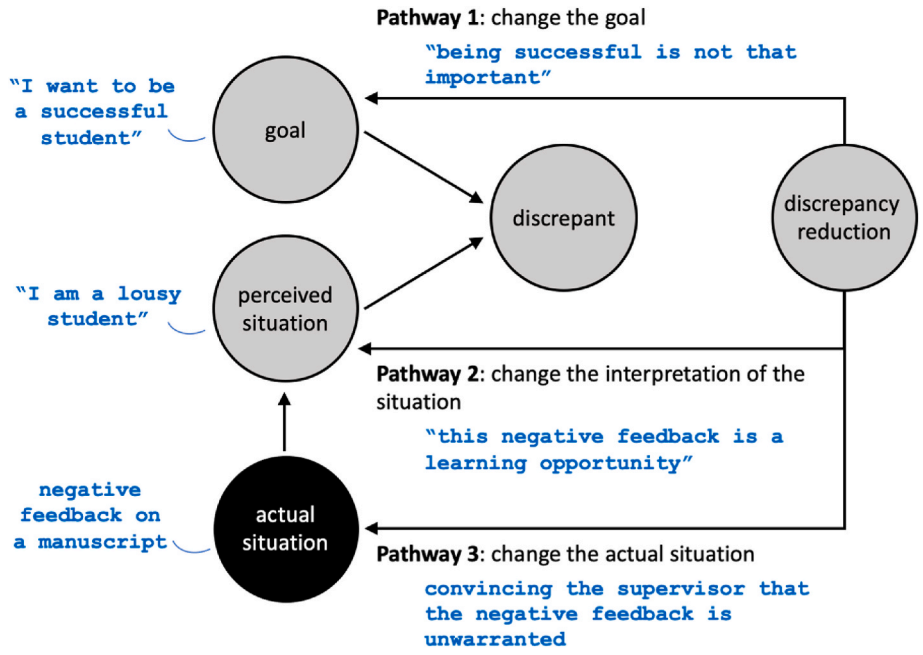


Fig. 1. Schematic presentation of the elements of the goal-discrepancy account, including illustrations of the three pathways to discrepancy reduction.

self-control. This model provides an alternative to resource-based views of self-control in which exerting self-control relies on a finite and depletable resource (Baumeister, Bratslavsky, Muraven, & Tice, 1998). Instead, the process model considers self-control as a form of "labor" and suggests that self-control failures occur when individuals adaptively disengage from labor to fulfill other goals, particularly "leisure" goals, also called "want-to" goals (Inzlicht, Schmeichel, & Macrae, 2014). Given the close similarities between the resource-based view of self-control and ART's characterization of directed attention (see Berman et al., 2008), we also reinterpreted attention restoration in terms of the push and pull between labor or work, on the one hand, and leisure or hedonic goals, on the other hand.

We specifically propose that the cognitive tasks used in ART research (in Phases 1 and 3) create a discrepancy between a work situation and a hedonic goal. As outlined in Joye, Lange, and Fischer (2022), a common characteristic of these tasks is not just that they are *cognitive* in nature but also that they require participants to *work*, putting them in a *work* situation. It is likely that for many participants, working on a fairly uninteresting task (e.g., Stroop task, sustained-attention-to-response task, or digit span backwards task) is neither intrinsically motivating nor rewarding (Filipas, Mottola, Tagliabue, & La Torre, 2018; Pattyn, Neyt, Henderickx, & Soetens, 2008). It is therefore likely that at some point, working starts to conflict with the goal for hedonic stimulation (i.e., wanting to experience/do something pleasurable; Inzlicht et al., 2014; Joye, Lange, & Fischer, 2022).

As the discrepancy between the work situation and a hedonic goal increases during the cognitive task, individuals will want to resolve the discrepancy. Assuming that participants are relatively indifferent about their performance on the cognitive tasks used in ART research, they could try to reduce the discrepancy by reducing effort while completing the task or by pursuing activities that (partially) fulfill the hedonic goal that was initially thwarted by the work situation. They could, for example, find some distraction by checking social media on their phone or by daydreaming. However, by reducing effort or by giving in to a hedonic goal, task performance will inevitably decline. This is not only the case in Phase 1, but also when participants have to do cognitive work again during Phase 3. Thus, declines in performance within and across those phases may not so much reflect attentional resource depletion, but rather indicate reduced task engagement resulting from a discrepancy between a work situation and a hedonic goal (Inzlicht et al., 2014; Joye, Lange, & Fischer, 2022).[2]

To summarize, in the first phase of the typical three-phase experimental setup of SRT and ART studies, discrepancies are created, which can lead to stress and/or negative affect (in SRT research) and performance declines on (non-rewarding) tasks in Phase 3 (in ART research). In ART research, but oftentimes also in SRT research, the discrepancy caused in Phase 1 arises from a situation that conflicts with the goal to do something pleasant (i.e., a hedonic goal). In the following sections, we will explain that by exposing individuals to natural (vs. urban) environments, situation-goal discrepancies can be reduced, eventually (a) mitigating stress and (b) improving cognitive performance.

3.3. *Step 2a: nature reduces stress and creates positive affect by facilitating the pathways to discrepancy reduction*

SRT suggests that stress can be reduced through a *single* psychological mechanism, ultimately rooted in our shared evolutionary history (Ulrich, 1983, 1993). As we aim to outline below, our alternative account for affective restoration takes a more *pluralistic* stance. In essence, we consider an initial episode of stress (in Phase 1) to reflect a discrepancy between a situation and a goal. Exposure to nature can reduce such a situation-goal discrepancy (in Phase 2) through multiple distinct pathways (i.e., Pathways 1, 2, and 3, respectively accommodation, immunization, and assimilation), which ultimately results in stress reduction and a shift to positively toned moods (in Phase 3; see Fig. 2 for a visual representation of these pathways and associated examples). This process not only plays in restoration studies but also applies to real-life settings.

[2] We do not rule out that other goals might also be thwarted during a work episode. For instance, in both lab-based and real-life work situations, individuals may be requested to follow instructions from others, which may compromise their goal for autonomy. This can lead to disengagement from work as a means to reclaim autonomy, subsequently having a negative impact on work performance. Inasmuch as engaging with nature can foster a sense of autonomy (see Box 1) discrepancies between work and these goals could also be reduced via this route.

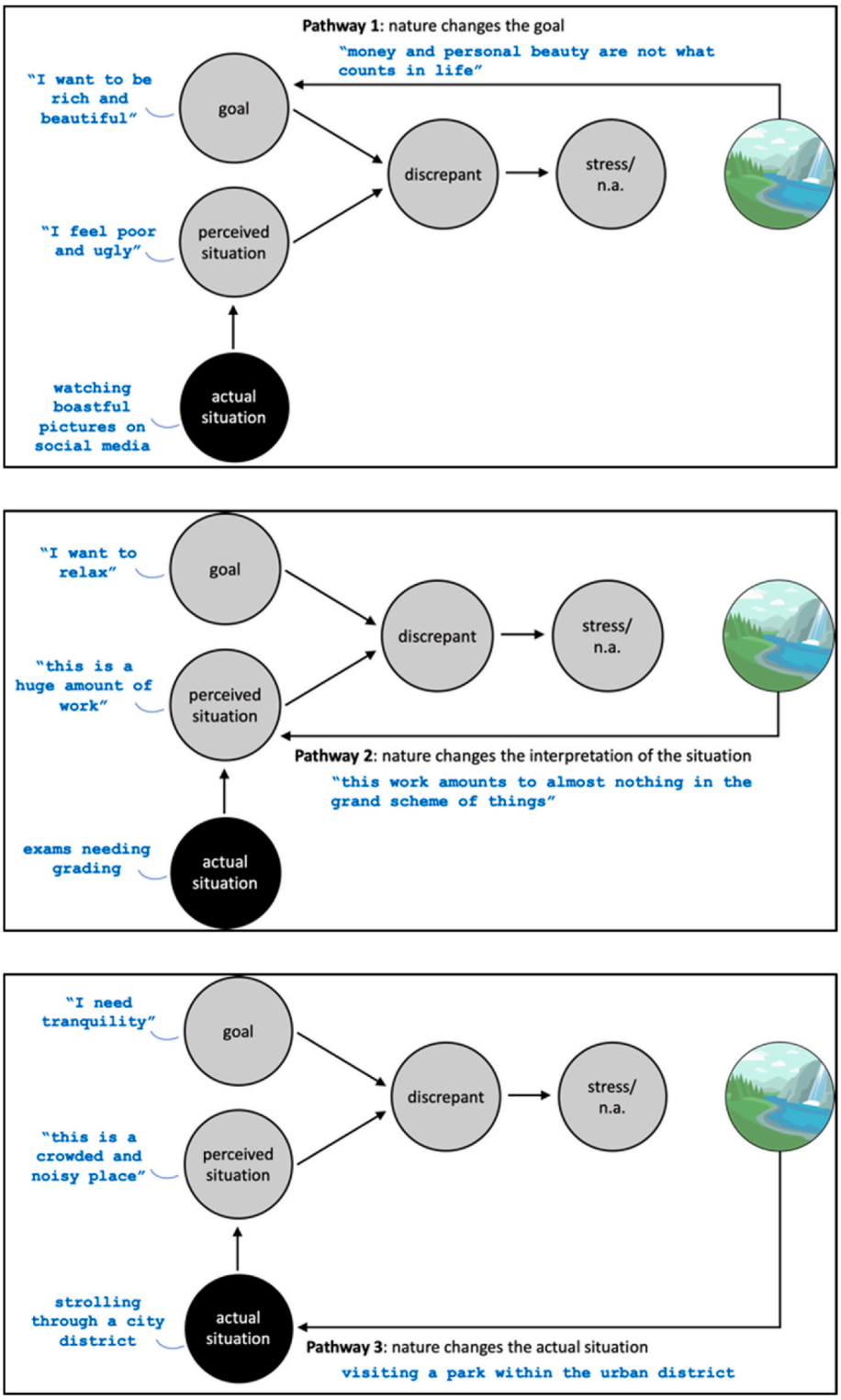


Fig. 2. Schematic presentation and examples of how nature can lead to affective restoration (SRT) by facilitating the three pathways to discrepancy reduction. *Note:* "n.a." refers to negative affect.

3.3.1. Affective restoration through modifying (self-enhancement) goals (Pathway 1: accommodation)

A first way in which natural environments can help reduce stress and negative affect arising from situation-goal discrepancies consists in *modifying* the discrepant *goals* (Pathway 1: accommodation). This pathway to affective restoration dovetails with a burgeoning line of research that indicates that exposure to nature can decrease the value people place on self-enhancement goals, while simultaneously increasing the importance of self-transcendence goals (for a review, see Goldy & Piff, 2020). Individuals pursue self-enhancement goals when they, for example, strive for high-paying jobs, acquire positional goods for conspicuous display, or engage in political activities to gain power and control over others (rather than doing politics for altruistic reasons). When pursuing self-transcendent goals, on the other hand, individuals

strive to increase the well-being of others and/or the environment (Schwartz, 1992, 2012).

Different studies have shown that contact with nature can lead to a shift in goals, moving individuals away from self-enhancement goals towards self-transcendence goals, especially when the nature is beautiful (e.g., Zhang, Piff, Iyer, Koleva, & Keltner, 2014) and/or awe-evoking (e.g., Piff, Dietze, Feinberg, Stancato, & Keltner, 2015). Compared to urban or control settings, such nature settings have been found to lead individuals to become less self-focused (Goldy, Jones, & Piff, 2022; Goldy & Piff, 2020; Shiota, Keltner, & Mossman, 2007) and less interested in materialistic values and consumption (Joye, Bolderdijk, Köster, & Piff, 2020). Instead, when exposed to such nature, they tend to place greater importance on self-transcendence goals (Schwartz, 1992, 2012), as they become more prosocial and oriented to others (Goldy & Piff, 2020; Joye et al., 2020; Zhang et al., 2014) and pursue intrinsic rather than extrinsic aspirations (Weinstein, Przybylski, & Ryan, 2009).

Various explanations have been put forward for the devaluation of self-enhancement goals to the benefit of self-transcendence goals through nature contact. First, cues related to self-enhancement goals may simply be less prevalent in natural than in (modern) urban environments. Advertisements promoting the importance of wealth and status, for example, are most commonly found in urban contexts (Joye et al., 2020; Kasser, 2016). Second, witnessing nature's beauty can be a captivating experience, and can divert attention away from the self and self-oriented goals, such as pursuing material wealth (e.g., Zhang et al., 2014). Third, experiencing nature can provide a break from the demands and pressures of daily life, allowing people to reflect on their values and priorities (Kaplan & Kaplan, 1989). This may lead to a reevaluation of what is truly important. Finally, in the face of nature's immense physical scale (e.g., vast mountain ranges), or upon learning about the huge timescale over which natural structures have evolved/-formed (e.g., continental drift), individuals may come to realize the relative insignificance and pettiness of pursuing achievement and power goals (e.g., Keltner & Haidt, 2003; Shiota et al., 2007).

Affective restoration through goal modification or accommodation seems particularly relevant when individuals experience stress and negative affect that arises from their (perceived) inability to live up to self-enhancement standards/ideals, which are pervasive in modern society (e.g., Bessenoff, 2006). Such discrepancies may, among others, stem from individuals feeling unable to achieve the level of material wealth or status of their peers or from not being able to meet the beauty standards promoted on social media. The experience of nature can reduce such discrepancies, and their associated stress, by decreasing the importance of such self-enhancement goals.

3.3.2. *Affective restoration through reinterpreting the situation (Pathway 2: immunization)*

In addition to modifying goals, a second way in which nature experiences can reduce situation-goal discrepancies causing stress, is by facilitating the *reinterpretation* of goal-discrepant *situations*, so that they appear less discrepant with certain goals (Moors et al., 2017; Pathway 2: immunization). This pathway may especially apply to goal-discrepant situations with a (perceived) temporal or physical dimension. In cases like this, the physical vastness that characterizes many natural settings and features (Goldy & Piff, 2020; Piff et al., 2015; Shiota et al., 2007) can modify the perception of the size and duration of goal-discrepant situations (see Le et al., 2019), making them appear smaller and more manageable than before. Thus, while the prospect/situation of a 60-h working week can conflict with the goal of spending time with family, experiencing nature's grandeur ahead of work can help individuals reinterpret that long working week as an insignificant event in the grand scheme of things (Goldy & Piff, 2020; Piff et al., 2015; Shiota et al., 2007). By helping individuals to downsize the perceived size of a goal-discrepant situation, exposure to nature diminishes the discrepancy between work and the goal for family time, thus reducing stress and negative affect.

There may be further ways in which nature can promote the reinterpretation of goal-discrepant situations, beyond downsizing situations through vastness. For instance, it has been shown that attributes commonly associated with natural environments, such as calmness (Imburgio & MacNamara, 2019) and their distance from stressors (Powers & LaBar, 2019), can facilitate reinterpretation of stressors. Thus, when a controlling boss causes employee stress by frustrating the goal of autonomy, retreating to a calm and far-away natural setting might allow employees to view the situation in a more positive light, or help them reinterpret the boss's behavior as an effort to bring out the best in them. While calmness and distance are known to facilitate reinterpretation, the reasons for why they do so are not exactly understood yet.

3.3.3. *Affective restoration through actions that can fulfill thwarted goals (Pathway 3: assimilation)*

A third way to reduce situation-goal discrepancies involves taking actions that *modify* the goal-discrepant *situation* with the aim of aligning it with one's goals, thereby reducing associated stress and negative affect (Pathway 3: assimilation). We see two ways in which natural environments can facilitate this pathway.

3.3.3.1. Nature activities can fulfill thwarted goals. A first option is that people actively engage in particular nature-based activities. For example, when a long and tedious working week thwarts the goal for pleasure, then doing pleasant nature-based activities after work, such as forest hiking or watching wildlife, can fulfill that thwarted goal. Similarly, while a public speaking exercise gone awry is likely to be discrepant with the goal of being competent (Greenwood & Gatersleben, 2016; Jiang et al., 2014), performing nature-based activities, such as trail running or taking beautiful nature photos, might allow individuals to regain a sense of competence. Thus, by actively engaging in certain activities *within* natural environments, individuals can try to align a goal-discrepant situation with personal goals, and thus reduce stress and negative affect ensuing from such discrepancies.

3.3.3.2. Switching environments can fulfill thwarted goals. A second option is when the action consists of people choosing to switch from a non-natural (e.g., urban) to a natural setting. The mere change to nature (without doing anything in particular in it) may already align the situation with goals that were initially thwarted, simply because natural environments can better satisfy certain goals than non-natural environments can. Suppose that in urban contexts, professional and social obligations constitute a discrepancy with one's goal for autonomy. Then the mere changing to nature can reduce the discrepancy with this goal because nature imposes relatively few demands on individuals and very often allows them to simply be and behave as they desire (see Box 1).

Importantly, we propose that this pathway of goal fulfillment can explain affective restorative effects observed in the SRT research. In the landmark study by Ulrich et al. (1991, Section 3.2.1; see also Meuwese, Dijkstra, Maas, & Koole, 2021), for instance, having to watch a film of macabre working accidents in Phase 1 probably brought individuals into a situation that frustrated the goal of experiencing something pleasurable (or of avoiding unpleasant things). When, after these movies, participants were either shown a nature or an urban video in Phase 2, in the nature condition, this entailed a change to a situation that could actually fulfill the thwarted hedonic goal. This is because natural environments, more than urban environments, are a known source of aesthetic enjoyment (see Box 1). The difference in hedonic goal fulfillment in Phase 2 between the nature and urban conditions might have caused the difference in affective restoration observed between the two conditions in Phase 3 of the study. A similar explanation can be suggested for the results of other affective restoration studies in which different stressors frustrated the goal to engage in something pleasurable (e.g., receiving mild electric shocks: Hedblom et al., 2019; being exposed to auditory

Box 1
Acknowledged services (in bold) through which nature can fulfill thwarted goals (applying to Pathway 3: assimilation).

- **Hedonic Value**. Spending time in nature might fulfill a hedonic goal through nature's hedonic value. From studies on landscape (e.g., Kaplan, Kaplan, & Wendt, 1972; Kaplan & Kaplan, 1989; Ulrich, 1983) and artwork preferences (e.g., Ercegovac, Dobrota, & Kuščević, 2015), to people's consumer choices (e.g., Crompton, 2001; Jim & Chen, 2009), various lines of research consistently suggest that natural environments are a shared source of (aesthetic) pleasure and enjoyment in adult individuals (Meidenbauer et al., 2019; Vessel, Maurer, Denker, & Starr, 2018), even if the nature is fairly unspectacular.
- **Tranquility**. Many people value tranquility, and visiting natural environments, such as forests, urban parks and wilderness areas, can provide sensorial and social tranquility. These environments are often relatively quiet places (Gidlöf-Gunnarsson & Öhrström, 2007; Payne & Bruce, 2019) where scene elements tend to harmonize well together (e.g., Van den Berg, Joye, & Koole, 2016). At the same time, nature allows individuals an opportunity to escape from the crowds, thus also providing social tranquility.
- **Autonomy**. Spending time in nature or engaging in particular nature-based activities can foster a sense of autonomy (Capaldi, Passmore, Nisbet, Zelenski, & Dopko, 2015; Weinstein et al., 2009; Yang et al., 2022), enabling individuals to act in self-determined ways and to be their authentic selves (Meuwese, van der Voort, Dijkstra, Krabbendam, & Maas, 2021). When in nature, people report that they are "able to be me" (Meuwese, van der Voort, Dijkstra, Krabbendam, & Maas, 2021) or that they "don't have to have … a mask on" (Birch, Rishbeth, & Payne, 2020).
- **Connectedness**. Natural elements and settings can provide individuals with opportunities for connection and bonding (Mayer & Frantz, 2004). A sense of connection arises not only from the fact that natural environments are often sites of social interactions (De Bell, Graham, Jarvis, & White, 2017; De Vries, Van Dillen, Groenewegen, & Spreeuwenberg, 2013), but also because the (life-like) elements of nature are perceived as social agents (i.e., anthropomorphized) with which individuals can establish (para-)social relationships (Kellert & Wilson, 1993; Wilson, 1986). Additionally, the awe-evoking grandeur of certain natural environments is known to evoke feelings of connection and a sense of **belonging** to something greater than the self (Shiota et al., 2007). Connectedness seems also intimately linked to further services of nature, such as its being a source of **spirituality** and its capacity to foster **a sense of place** (Ives et al., 2018).
- **Competence.** Natural environments can support the goal for competence (Yang et al., 2022) by offering opportunities for learning or exploration, for example. Engaging in outdoor activities, such as hiking, camping, or adventure sports, challenges individuals to acquire new skills and problem-solving abilities, fostering a sense of accomplishment and self-efficacy. Learning about natural processes and history (e.g., plate tectonics), or observing patterns in nature (e.g., the fractal geometry characteristic to many natural structures) can cultivate a deeper understanding of the natural world, empowering individuals with a sense of mastery over their environment.

noise: Huang et al., 2020; Valtchanov et al., 2010).

Autonomy and hedonic stimulation are of course only two examples of the many "services" that nature can provide. Other examples of well-documented natural services featuring prominently in restoration research are connectedness and tranquility (see Box 1). When individuals find themselves in an environment or situation that thwarts these goals (e.g., an episode of social exclusion/rejection, experiencing social crowding) then replacing those environments/situations with natural settings can fulfill them again (e.g., by providing a source of parasocial connection, by offering tranquility). This, we propose, is one pathway to reduce situation-goal discrepancies and associated stress and negative affect. In Box 1, we take a closer look at several well-known services through which nature can fulfill thwarted goals, whether through engaging in specific activities in nature or through transitioning from an urban to a natural setting. It is noteworthy that some of the services afforded by natural environments are well-aligned with the fundamental needs from self-determination theory (Deci & Ryan, 2000), i.e., autonomy, competence, and relatedness.

3.4. *Step 2b: nature improves cognitive performance by facilitating the three pathways to discrepancy reduction*

Central to our goal-discrepancy account for cognitive restoration is the idea that cognitive performance benefits observed in ART research result from the reduction of a discrepancy between a work situation and the goal for hedonic stimulation, rather than the replenishment of

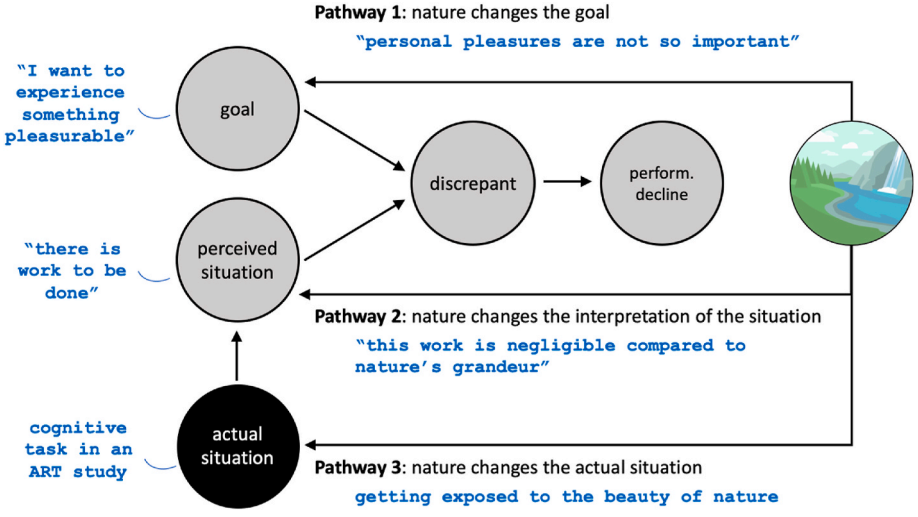


Fig. 3. Schematic presentation and examples of how nature can lead to cognitive restoration (ART) by facilitating the three pathways to discrepancy reduction.
Note: "perform.decline" refers to the (cognitive) performance declines observed in ART studies.

cognitive resources. Similar to our reinterpretation of affective restoration, we propose that by exposing participants to natural (vs. urban) environments in Phase 2 of a cognitive restoration study, the initial situation-goal discrepancy from Phase 1 can be reduced, and/or the occurrence of a similar discrepancy in Phase 3 can be prevented (see Fig. 3). Such discrepancy reduction can occur through nature exposure (a) leading to a devaluation of the self-enhancement goal for hedonic stimulation (Pathway 1; accommodation), (b) leading to a reinterpretation of the size/duration of the work episode (Pathway 2; immunization), or (c) entailing a shift away from the work situation in Phase 1 toward a situation that can actually fulfill the initially thwarted hedonic goal (Pathway 3; assimilation). It is worth noting that there is already preliminary support for this last pathway. Specifically, Joye, Lange and Fischer (2022) found that the pleasurable experience of viewing beautiful nature images before a work episode increased work motivation and persistence, and this effect was unrelated to (the recovery of) directed attention.

Throughout the preceding sections, we have outlined the diverse pathways in which nature can reduce situation-goal discrepancies. It is crucial, however, to recognize that different types of nature and natural elements can be conducive to distinct pathways. For instance, even seemingly mundane yet beautiful natural environments (e.g., a forest) have proven to be effective in Pathway 1 of modifying goals (Joye et al., 2020), while the physical vastness of landscapes or specific features within them (e.g., the vast depths of the Grand Canyon) can facilitate Pathway 2 of reinterpreting situations (Pearce, Strickland-Munro, & Moore, 2017). Regarding Pathway 3, which involves taking actions to fulfill thwarted goals, research indicates that experiencing nature during autumn and spring can better foster implicit connections to nature compared to experiencing it during winter (Duffy & Verges, 2010). Additionally, the qualities of pastoral/rural landscapes (Kim, Kil, Holland, & Middleton, 2017), the presence of water (Pheasant, Fisher, Watts, Whitaker, & Horoshenkov, 2010; Wartmann, Tieskens, van Zanten, & Verburg, 2019), and the diversity of flora and geological features (Pheasant et al., 2010) can evoke feelings of tranquility, while a sense of autonomy seems especially supported in remote and wild nature settings (Freeman, Akhurst, Bannigan, & James, 2017; Ridder, 2005). In other words, the various types of nature and diverse ways and timeframes of interacting with nature can play unique and significant roles in (providing services that can facilitate) the process of discrepancy reduction.

3.5. Similarities and differences between the goal-discrepancy account and the two restoration theories

The goal-discrepancy account differs in important respects from the established theories of restoration, but also shares significant similarities. For example, similar to our account, goal fulfillment (i.e., Pathway 3: assimilation) is also an important aspect of SRT, as the theory assumes that venturing into resource-rich natural settings was stress-reducing for ancestral humans when these allowed them to fulfill the goals for safety and food (Ulrich, 1983, 1993; Ulrich et al., 1991). A crucial difference with SRT's theorizing, however, is that our account considers other goals beyond those for physical safety/resources that were relevant to our ancestors, such as connectedness, autonomy, and tranquility. Additionally, we also propose that nature can reduce stress by modifying discrepant goals (i.e., Pathway 1: accommodation) or by changing the interpretation of the goal-discrepant situation (i.e., Pathway 2: immunization), two pathways not considered in SRT (or ART).

Turning to ART (Kaplan, 1995; Kaplan & Berman, 2010; Kaplan & Kaplan, 1989), one notable feature is that this theory (unlike SRT) is not inherently bound to the classic nature-urban distinction, and recognizes that also other environments/stimuli than natural ones can be restorative (see Section 2.2). This aligns with the goal-discrepancy account, where non-natural activities, such as watching beautiful architecture or having drinks with friends, can also reduce discrepancies. Another noteworthy feature involves ART's emphasis on the importance of "compatibility" between a person's goals and the environment for attention restoration (Kaplan, 1995; see Section 2.2). This aligns with a fundamental aspect of the goal-discrepancy account (Moors et al., 2017) which attributes cognitive nature benefits to the restored compatibility between situations and goals. Finally, both ART and our account highlight nature's aesthetic and (soft) fascinating features as drivers of cognitive performance benefits. However, our account departs from ART in that we propose that those features primarily reduce discrepancies (especially between a work situation and a goal for hedonic stimulation), rather than supporting resource replenishment, as suggested by ART.

A further important difference with both restoration theories lies in the ability of the goal-discrepancy account to accommodate the fact that interacting with nature can also have instorative effects or the (seeming) capacity to build resources before they get depleted (see Section 2.3). In the context of the goal-discrepancy account, instoration occurs when nature prevents situation-goal discrepancies from arising, avoiding subsequent stress and negative affect, and (cognitive) performance declines. Such discrepancy prevention can be achieved because, for example, regular contact with nature encourages individuals to chronically place less importance on the pursuit of self-enhancement goals (Joye, Brosnahan, & Piff, 2022), reducing the likelihood of discrepancies with this type of goal. Similarly, experiencing the beauty of nature before work can already fulfill a person's hedonic goal and thereby avert that a work-impairing discrepancy with this goal will occur during work. In other words, nature is not only able to reduce existing discrepancies but can also prevent situation-goal discrepancies from occurring in the first place.

Finally, differences between the two restoration theories and our goal-discrepancy account also become apparent at the level of the predictions these theories yield. To illustrate this point, we refer to Box 2, where we discuss several predictions stemming from SRT and ART and demonstrate how these differ from predictions deriving from the goal-discrepancy account.

3.6. Integrating further research on human-nature interactions

In addition to integrating SRT and ART findings, our proposal incorporates other well-established research findings on the psychological benefits/effects of human-nature interactions. This includes insights from studies on the aesthetic preference for nature over urban settings (e.g., Kaplan et al., 1972; Kaplan & Kaplan, 1989; Ulrich, 1983), the impact of nature exposure on human goals (Yang et al., 2022), research on nature connectedness (Mayer & Frantz, 2004; see "connectedness" in Box 1), and studies on the awe-evoking qualities of vast natural environments (Goldy & Piff, 2020; Piff et al., 2015; Shiota et al., 2007). By integrating these findings into our goal-discrepancy account, we can elucidate the proximal processes through which nature contact can lead to changes in either goals (e.g., nature increasing the importance of self-transcendence goals) or situations (e.g., going to nature to change to a situation that affords connection), thereby potentially reducing situation-goal discrepancies.

While presenting a novel proximal mechanism for restoration, we recognize that our account does not elucidate the distal or remote processes by which nature acquires its restoring qualities. To illustrate, even though we assume that nature's hedonic value plays a central role in reducing discrepancies featuring in both SRT and ART research, our account remains silent about the processes through which nature has acquired that value in the first place. While it is often assumed that nature's hedonic value is an adaptive remnant of our evolutionary history in natural environments (see Ulrich, 1983, 1993), recent socio-behavioral accounts (Tomasso & Chen, 2022) draw attention to the learned component of such positive nature experiences, pointing out that they can be driven by individuals' formative experiences in nature (e.g., going mountain trekking with friends) and can be influenced by

Box 2
Predictions Derived from the Goal-Discrepancy Account

- ART expects that nature will be particularly restorative for directed attention tasks. According to the goal-discrepancy account, nature will enhance performance in *both* cognitive (e.g., digit span backwards) and non-cognitive tasks (e.g., clicking radio buttons; Joye, Lange, & Fischer, 2022), provided that they are perceived as equally dull and unrewarding work. However, when such tasks are perceived as intrinsically rewarding (e.g., by experiencing them as a game), then exposure to nature will not improve task performance.
- In the context of SRT, resource-rich natural environments are expected to be more restorative than resource-deprived environments. The goal-discrepancy account suggests that when stress is caused by situations that hinder the pursuit of pleasurable stimulation (e.g., having to do a dull task), exposure to beautiful yet resource-deprived environments (e.g., beautiful images of the Atacama desert) will be more restorative than less attractive resource-rich natural scenes (e.g., images of a grove of fruit-bearing trees).
- SRT suggests that natural environments are inherently more restorative than evolutionarily more recent urban environments. However, the goal-discrepancy account proposes that after a period of stress, urban environments can be equally/more stress-reducing than natural settings, provided they can diminish the underlying situation-goal discrepancy. For example, if stress results from a discrepancy with the self-enhancement goal for material wealth, then grand, self-diminishing urban structures (e.g., a cathedral, a vast town square) may be more restorative than nature lacking such grandeur.
- At present, SRT and ART fail to (or are unable to) consider individual differences. In the proposed account, individual differences are expected to moderate the impact of nature both on measures of affect and on (cognitive) task performance. For instance, individuals with a high (vs. low) appreciation for natural beauty (Diessner, Parsons, Solom, Frost, & Davidson, 2008) or a high (vs. low) connection to nature (Mayer & Frantz, 2004) are likely to experience more pronounced affective and cognitive restoration, given their heightened orientation to (the beauty of) nature. Additionally, providing a nature intervention to boost work performance will probably not be effective for high (vs. low) conscientious individuals, who require less external motivation to maintain task engagement.

one's wider social context (e.g., one's cultural society supporting nature contact) and by the policy/regulatory environment (e.g., ease of nature access). Distal accounts like these are not incompatible with the goal-discrepancy account, but can actually complement it by acting on or feeding into the proximal processes we have outlined.

3.7. Implications of the goal discrepancy account for research and practical interventions

Our approach offers not only integrative potential, but also has significant practical value, providing guidance for empirical research and practical interventions. If affective and cognitive restoration indeed function by reducing discrepancies, then successful experiments and/or interventions hinge on (a) identifying the particular discrepancy that causes stress or poor cognitive performance (e.g., the case of stress reflecting a discrepancy between one's body image and social media's beauty standards); (b) ensuring that the proposed nature intervention can, in principle, reduce the target discrepancy through one or more of the three pathways to discrepancy reduction (e.g., taking an "awe walk", Sturm et al., 2022, whereby individuals realize that outward appearance is not important in the grand scheme of things, Joye et al., 2020); and (c) verifying whether individuals indeed experience the nature intervention in the intended way (e.g., checking if the awe walk indeed leads to goal devaluation, rather than that it causes fear, Nakayama, Nozaki, Taylor, Keltner, & Uchida, 2020, or reminds the individual of boastful social media posts).

Importantly, individual-level specificities that are due to individuals' unique learning history with nature can be easily incorporated within the goal-discrepancy account. This is simply because the account does not mandate a specific level of generality or specificity concerning goals, situations, or responses to nature. The central units of analysis are situations and goals, as well as the potential discrepancies between them, and (solutions to) situation-goal discrepancies can vary widely, from being very general and universally shared (as seen in evolutionary accounts of human-nature relationships, see SRT) to being highly idiosyncratic (see Tomasso & Chen, 2022). Should a nature intervention fail to reduce a particular discrepancy for an individual, then this just goes to show that this intervention is not the best solution for this individual.

Several measures could be taken to factor in individual-level specificity in restorative environments research. One effective approach could be to incorporate a qualitative component into the research. This could involve asking participants to identify the specific goals that have become thwarted in a particular situation, exploring participants' reflections on a particular nature intervention (e.g., "Is it hedonically rewarding?"), and finding out which services individuals associate with a certain nature intervention (see Box 1). Another approach is to measure individual differences, especially gauging participants' relationship *vis-à-vis* (qualities of) nature (e.g., nature connectedness, Mayer & Frantz, 2004; engagement with natural beauty, Diessner et al., 2008; reward sensitivity, Carver & White, 1994) or assessing their sensitivity to situations that are expected to cause discrepancies (e.g., measuring rejection sensitivity when stress is induced via social rejection, Downey & Feldman, 1996). These individual difference measures can then be used as moderator variables in subsequent analyses, which allow for investigating if the strength of nature's restorative potential is a function of those individual differences.

Finally, despite the issue of individual-level specificity, we are still confident that participants with a shared (cultural) background will tend to respond similarly to certain types of nature, and that this allows broadly applicable intervention approaches. This can be gleaned, for example, from the shared aesthetic preference for natural rather than architectural scenes in Western populations, as evidenced by the study by Vessel et al. (2018). Similarly, while situation-goal discrepancies can be idiosyncratic (e.g., some people may see a pigeon as thwarting a safety goal), many discrepancies will be shared across people. For many people, for instance, being ostracized will frustrate the goal for social connection, and losing one's job will be discrepant with the goal of (financial) security.

4. Conclusion

A substantial body of environmental psychology research indicates that exposure to natural environments can provide both affective and cognitive benefits (for a review, see Hartig et al., 2014). Researchers traditionally draw upon two prominent theories to explain these findings. According to SRT, affective restoration through nature is an adaptive response that evolved to deal with safety- and food-related challenges in ancestral environments. ART, on the other hand, postulates that cognitive restoration occurs through a process of cognitive resource replenishment, facilitated by nature's soft-fascinating features.

SRT and ART have been around for almost 40 years and are widely considered as established explanations for restorative nature

experiences (Joye & Van den Berg, 2012). However, as we have pointed out, some of their concepts remain vague and underdeveloped (e.g., the notion of soft fascination), their key assumptions have hardly been tested systematically and therefore remain speculative, and there is lack of integration between the two theories. Also, it is doubtful whether alternative accounts, such as PFA and CRT, have sufficient scope to explain the full range of psychological benefits that nature can yield. We therefore think the time has come to consider a more comprehensive alternative account for affective and cognitive nature benefits.

We propose that stress recovery and attention restoration are essentially two sides of the same coin; they are two particular outcomes of the reduction and/or prevention of situation-goal discrepancies. While the discrepancies that cause stress can be diverse and situation-specific, we argue that reduced cognitive task performance observed in ART studies stems from a discrepancy between a work situation and the desire for hedonic stimulation. By giving center stage to goals and discrepancies, our account follows theoretical developments in other fields of psychology and cognitive science (e.g., decision making models, computational neuroscience) where resource models are being abandoned (e.g., ego-depletion; Kurzban, Duckworth, Kable, & Myers, 2013).

We have discussed what we consider to be the logical and most probable ways in which nature can decrease situation-goal discrepancies. These pathways include: (a) modifying goals (i.e., accommodation, such as reducing the value of self-enhancement goals), (b) reinterpreting the situation (i.e., immunization, such as grand nature scenes making goal-discrepant situations seem smaller), and (c) taking actions to fulfill thwarted goals (i.e., assimilation, such as switching from an urban to a natural environment to experience tranquility or to regain a sense of autonomy). Although previous research has shown that nature can facilitate these pathways (e.g., nature can devalue self-enhancement goals; Goldy et al., 2022; Goldy & Piff, 2020; Shiota et al., 2007), further research is needed to demonstrate that affective and cognitive nature benefits are indeed achieved via the reduction of situation-goal discrepancies through these pathways (e.g., demonstrating that stress can be reduced by devaluing self-enhancement goals). We are confident that our account, and the research it may inspire, will contribute to the development of a more robust and comprehensive psychological science of nature's affective and cognitive benefits.

Conflicts of interest

We have no conflicts of interests to disclose.

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