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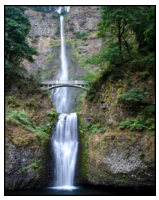

Nature's broken path to restoration. A critical look at Attention Restoration Theory

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ABSTRACT

Over the past three decades, a growing body of environmental psychology research has demonstrated that interacting with natural environments – and especially greenspace – can have beneficial psychological effects on human individuals. One influential and widely-cited theoretical account to explain such effects is Attention Restoration Theory (ART). ART zooms in on the cognitive benefits nature can yield, and assumes that when an individual's ability to concentrate or direct attention has become depleted, then nature is well-equipped to replenish this capacity. Nature's restorative potential is thought to especially derive from its soft fascinating characteristics; these can put an individual in an effortless mode of attention, thereby giving directed attention a relative opportunity to rest and replenish itself. Although ART has been highly influential in the field of restoration studies and continues to inspire health promotion interventions, with the current paper we aim to show that the framework has important empirical and conceptual shortcomings. We specifically aim to show (a) that some of ART's principal theoretical notions are vague (e.g., soft fascination), have remained underdeveloped, and lack a clear operationalization, (b) that the framework has failed to (adequately) test its main theoretical predictions (i.e., that nature effects are recovery effects), and (c) that there is currently little support for the ART-based assumption that restoration is – or derives from – an ancient evolved adaptive response. We conclude our paper with discussing four outstanding questions for ART, and make methodological suggestions that could potentially address some of ART's current shortcomings.

1. Introduction

In their influential 2008 article, Berman, Jonides and Kaplan ask their readers to "(i)magine a therapy that had no known side effects, was readily available, and could improve your cognitive functioning at zero cost" (Berman, Jonides, & Kaplan, 2008, p. 1207). The therapy they have in mind, and for which they hope to gather empirical support, is to go out into nature. While beliefs about nature's healing potential are part and parcel of many current and past cultures, and will, for many, resonate with personal experience, the last three decades a growing body of environmental psychology research has sought to confirm this notion.

But whence this apparently unique capacity of nature to mentally invigorate and sooth us? Is it because (being in) nature invites physical exercise, provides us with opportunities for social contact, or reminds us of relaxing times and activities (e.g., holidays)? Is it because nature, more so than urban and/or indoor environments, offers us fresh air and daylight? While these and other factors have indeed been shown to contribute to nature's salutogenic effects (for a review: Hartig, Mitchell, de Vries, & Frumkin, 2014), environmental psychology research demonstrates that already the direct perceptual (i.e., visual) experience of nature scenes and elements – especially vegetation and water features – can positively impact individuals, by counteracting stress (Ulrich et al., 1991) and facilitating the recovery from mental fatigue (Berman et al., 2008; Kaplan, 1995). Such effects are commonly labelled as "restorative" nature experiences, as they seemingly involve a recovery from depleted cognitive resources and/or undo negative psychophysiological states.

In research on restorative experiences, two important theoretical frameworks have been proposed to explain nature's restorative effects, namely Stress Recovery Theory (SRT; Ulrich, 1983; Ulrich et al., 1991) and Attention Restoration Theory (ART; Kaplan & Kaplan, 1989; Kaplan, 1995; Kaplan & Berman, 2010). SRT especially aims to elucidate how contact with nature can reduce (psychophysiological) stress in individuals. Drawing on evolutionary psychology (e.g., Tooby & Cosmides, 1992), SRT specifically assumes that the human species is

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biologically prepared to rapidly display positive affect towards natural, vegetation-rich environments (Parsons, Tassinary, Ulrich, Hebl, & Grossman-Alexander, 1998; Ulrich, 1983, 1993; Ulrich et al., 1991). The argument goes that such a response was adaptive for ancestral humans, because it facilitated their quest for food, water, and places to shelter (see especially Ulrich, 1993). Based on the evolutionary psychology hypothesis that the modern human brain is wired for the Stone-Age (Tooby & Cosmides, 1997), SRT assumes that in our modern era natural settings and elements still produce positive affect in individuals, which may consequently reduce, or even buffer psychophysiological stress.

Where SRT zooms in on people's immediate affective responses to nature as a driver of restoration, ART focuses on the potential *cognitive* benefits that can derive from interactions with natural environments (Kaplan & Berman, 2010; Kaplan & Kaplan, 1989; Kaplan, 1995). A central notion in ART is "directed attention", which can be defined as the effortful process to focus or concentrate on objects or events, while at the same time blocking out distracting stimulation. While ART considers directed attention to be a limited resource that can be depleted after long and/or intensive use, it also claims that certain environments – especially *natural* environments – are able to facilitate/support the recovery from a state of attentional depletion. According to ART, the reason is that nature is often rife with (soft) fascinating stimuli that capture one's attention in an automatic, bottom-up way. This minimizes the demands on (effortful) directed attention, and consequently allows this capacity to rest and restore itself.

Over the last three decades empirical evidence for nature's restorative benefits has been steadily accumulating. Restoration researchers have – amongst others – attempted to chart the positive cognitive (for a review: Ohly et al., 2016), affective (for a review: McMahan & Estes, 2015) and psychophysiological effects of nature contact (e.g., Chang, Hammitt, Chen, Machnik, & Su, 2008; Hartig, Evans, Jamner, Davis, & Gärling, 2003; Ulrich et al., 1991; Van den Berg & Custers, 2011). Efforts have been made to determine the optimal dose (Barton & Pretty, 2010; Shanahan et al., 2016) and modality (e.g., virtual versus real nature; Pals, Steg, Dontje, Siero, & van Der Zee, 2014) of nature for restoration, while research has also demonstrated how restorative nature effects can depend on group characteristics (e.g., elderly: Ottosson & Grahn, 2005; children: Taylor & Kuo, 2008; Ulset, Vitaro, Brendgen, Bekkhus, & Borge, 2017), on individuals' salient identities (e.g., Morton, van der Bles, & Haslam, 2017) or on the life stage one is in (Scopelliti & Giuliani, 2004).

While nature restoration has occasionally been studied from a qualitative perspective – for example by taking interviews on nature experiences and activities (cfr., Hawkins, Mercer, Thirlaway, & Clayton, 2013) – the majority of restoration studies are quantitative. Such quantitative studies have made use of secondary data to establish a link between restoration and access to natural environments (White, Pahl, Ashbullby, Herbert, & Depledge, 2013), but oftentimes nature's restorative benefits are experimentally researched within lab or field settings, using both subjective (i.e., self-report) and objective measures of emotional and attentional/cognitive functioning (e.g., Joye, Pals, Steg, & Lewis-Evans, 2013). Key findings and reviews on restoration have been published in highly prestigious academic journals (e.g., *Science*: Ulrich, 1984; Hartig & Kahn, 2016; *The Lancet*: Hartig & Marcus, 2006), have become highly cited,[1] and have received ample media coverage – all of which testifies to the importance of this research field, within academia and beyond.

The insight that nature can make people thrive is also increasingly applied to (different parts of) our daily lives. Based on restoration research, healthcare professionals and instances promote contact with natural environments as a means to bolster psychological health and wellbeing, or to reduce pain and stress during clinical interventions (Diette, Lechtzin, Haponik, Devrotes, & Rubin, 2003; Tanja-Dijkstra et al., 2017). Contact with greenery has been found to boost children's cognitive performance in the classroom (Van den Berg, Wesselius, Maas, & Tanja-Dijkstra, 2017), and to enhance workers' mood and productivity in office settings (Korpela, De Bloom, & Kinnunen, 2015; Steidle, Gonzalez-Morales, Hoppe, Michel, & O'shea, 2017). In the commercial sphere, retail environments are greened up to lift the mood of consumers, and to consequently boost their willingness to pay and/or buy (Brengman, Willems, & Joye, 2012; Joye, Willems, Brengman, & Wolf, 2010; Rosenbaum, Otalora, & Ramírez, 2016). Based on the various psychological benefits of nature contact, in some countries (governmental) campaigns have even been initiated to raise awareness of nature's soothing psychological effects (e.g., "green schoolyards" in the Netherlands).

While laudable, the search for further empirical confirmation and for promising applications of nature's salutogenic effects has – in our view – also come with a cost, in that the field of restoration studies has reached a theoretical standstill. Since already three decades SRT and ART have been standing as the main and seemingly undisputable explanatory frameworks for restorative nature experiences, despite some striking limitations and issues. In this paper, we aim to start overturning this theoretical *status quo*.[2] For this, we will review the main theoretical assumptions underlying the field of restoration research, and point to a number of important empirical and conceptual shortcomings. Note that with our critical review we will specifically target ART, rather than SRT, as the former theory has barely received any systematic criticism (for critiques on SRT, see e.g., Kaplan, 1995; Joye & Van den Berg, 2011).

2. General outline

In what follows, we critically examine the main theoretical and empirical assumptions of ART. In a nutshell, ART states that nature's soft fascinating characteristics (i.e., the independent variable) can lead to a recovery of directed attention (i.e., the dependent variable), and this effect is driven by the capacity of fascinating (natural) environments to trigger bottom-up involuntary attention (i.e., the mediator). In the ensuing critical review, we aim to pinpoint difficulties with all three elements of ART's basic model. In our first two criticisms, we address the DV side of the model, and ask whether there is currently sufficient evidence for the assumption that restorative nature effects are recovery effects (Assumption 1), and that a particular cognitive resource (i.e. , directed attention) is replenished during this recovery process (Assumption 2). Next, we focus on the IV side of the model, and argue that the notion of soft fascination is vague and conceptually underdeveloped, and is currently lacking a clear operationalization (Assumption 3 and Assumption 4). We then move on to the proposed mediator for attention restoration, and point out that, besides being untested, it is far from even-handed that the (often mundane) natural settings used in restoration research are able to trigger bottom-up involuntary attention in the first place (Assumption 5). Following this, we zoom out, and question the broader evolutionary background of ART, i.e., the assumption that natural fascinations are restorative because they ultimately fulfilled an adaptive function in ancestral environments (Assumption 6). We close off with some outstanding questions, such as why being in a state of fascination is associated with cognitive effortlessness rather than effortfulness.

[1] For example, Kaplan and Kaplan (1989) receives 5915 citations on Google Scholar, whereas Ulrich (1984) receives 4422 citations (date: 6 June 2018).

[2] This theoretical standstill is probably also exacerbated by the fact that some restoration studies are only loosely based on ART or SRT, and are not particularly interested in rigorously testing ART's/SRT's highly specific assumptions.

3. Questioning ART's central assumptions

Assumption 1. Restorative nature effects are recovery effects

One of ART's central assumptions is that when individuals are attentionally fatigued, contact with natural settings can relax the demands on directed attention, thereby giving this capacity an opportunity to recover and replenish itself (Kaplan & Berman, 2010; Kaplan & Kaplan, 1989; Kaplan, 1995). Because urban environments often contain dramatically distracting stimulation (e.g., car horns, billboards: Berman et al., 2008), in such settings directed attention may need to be further recruited to block out that stimulation, thereby potentially exacerbating directed attention fatigue. Thus, in the most common theoretical characterization of ART, restorative nature experiences are assumed to be *recovery* effects: nature facilitates the replenishment of an initially depleted resource, i.e., directed attention.

Several ART-based studies are aimed at testing whether restorative environments indeed foster a *recovery* from attentional fatigue (e.g., Berman et al., 2008; Berman et al., 2012; Berto, 2005; Bodin & Hartig, 2003; Hartig et al., 2003; Laumann, Gärling, & Stormark, 2003; Shin, Shin, Yeoun, & Kim, 2011). Such studies typically start off by administering participants a task that induces a state of attentional fatigue in them, which is then followed by an environmental treatment (oftentimes exposure to, or immersion in natural versus urban settings), and the target measurement of participants' attentional/cognitive functioning. Employing this experimental paradigm, several studies find that (fatigued) individuals who have subsequently been exposed to, or been immersed in natural/green environments (e.g., forests, parks) score better on the (target) attentional/cognitive task than individuals exposed to urban settings (Joye & Van den Berg, 2012).

While the results of such ART-based studies are often interpreted in terms of a (cognitive/attentional) recovery process, it is worth emphasizing that it is common practice to fatigue *all* participants before environmental exposure in such studies (Beute & de Kort, 2014). Besides notable exceptions (e.g., Hartig, Böök, Garvill, Olsson, & Gärling, 1996; Hartig et al., 2003), the vast majority of restoration studies does not include a control group of low-fatigued individuals to compare the results of the experimental group with (see Ohly et al., 2016 for an overview). With this paradigm, it obviously becomes impossible to determine whether superior (cognitive/attentional) performance after seeing nature (versus urban scenes) in fatigued individuals is diagnostic of a recovery from directed attention depletion, or whether it signals an entirely different process, unrelated to recovery (e.g., vitalizing and energizing potential of natural versus urban settings: Ryan et al., 2010). One of ART's major theoretical claims thus remains to be tested.

The absence of a control group in restoration studies, in and of itself does not disconfirm ART's recovery idea. That could only happen if, in one and the same study, a control group of low-fatigued individuals were shown to benefit as much from the nature intervention as highly fatigued individuals. While systematic and extensive research on this issue is currently lacking, some initial evidence speaks to this idea. Beute and de Kort (2014), for example, found that individuals were better able to self-regulate after exposure to natural versus urban scenes, and showed that this effect occurred for (ego) depleted as well as for non-depleted participants. In line with this finding, prominent restoration researchers propose that "restorative" nature experiences can indeed go beyond mere (attentional resource) replenishment, and point out that "interacting with such environments can restore and even *improve* directed attention abilities" (Kaplan & Berman, 2010, p. 52; italics added; see also: Collado, Staats, Corraliza, & Hartig, 2017).

But how to reconcile ART with the claim that nature can boost attentional functioning? After all, the theory explains the cognitive benefits of interacting with nature solely in terms of facilitating a return to baseline levels of an initially depleted attentional resource (through fascination, and other supporting restorative components). Because ART assumes that nature does not causally intervene in the process of restoration itself, the framework seems by definition unable to explain how nature could boost attentional performance *beyond* that baseline. Combined with the fact that there is currently little empirical evidence for ART's recovery idea, it might be worthwhile – and even more parsimonious – to explore the explanatory potential of non-depletion accounts for beneficial cognitive nature effects.

Assumption 2. Directed attention is restored

While ART identifies directed attention as the main cognitive resource that can be restored through contact with natural environments (Kaplan & Berman, 2010; Kaplan & Kaplan, 1989; Kaplan, 1995), this capacity has not been uniformly operationalized in restoration studies (Ohly et al., 2016). As research stands, restoration researchers have used a fairly heterogeneous and broad set of cognitive tasks to gauge restoration (Ohly et al., 2016), including – but not limited to – proofreading (e.g., Hartig, Mang, & Evans, 1991), the Trail Making Test (e.g., Shin et al., 2011), the Stroop Task (e.g., Faber Taylor & Kuo, 2009), the Sustained Attention to Response Task (e.g., Berto, 2005), or the Digit Span Backward/Forward (e.g., Berman et al., 2008; Berman et al., 2012).

Importantly, the foregoing tasks vary in the type of cognitive functions they primarily capture. This poses a challenge for ART, as such functional variety makes it difficult to ascertain whether nature effects on one or more of these tasks either reflect (restoration of) directed attention functioning or some other cognitive functions or phenomena. Very probably, however, executing any of the aforementioned tasks requires *some* directed attention capacity, merely because one needs a good deal of focus and concentration to complete them. And if the common denominator between the cognitive tasks used in ART studies turns out to be directed attention, is it then not justified to conclude that nature-induced cognitive effects reflect directed attention functioning? Not necessarily, since such cognitive effects are consistent with, and can in principle also be diagnostic of other processes triggered by fascinating natural scenes, such as increased vitality (Ryan et al., 2010) or task motivation (Silvia, 2008). To the best of our knowledge, such plausible alternative explanations have not been systematically explored, nor have they been ruled out within the context of ART.

Note furthermore that a recent meta-analysis reveals that – from the broad arsenal of objective measures used in ART-based research – especially an overall positive significant effect of nature exposure was found for tasks tapping working memory performance (Ohly et al., 2016; see: Hartig & Jahncke, 2017, for a critical review of aspects of this meta-analysis). Are we therefore to conclude that nature is especially beneficial for working memory (e.g., Digit Span Forward), rather than for directed attention? Or, is working memory task performance one of the best ways to capture directed attention capacity? But if so, why then are other tasks than memory tasks being used to gauge directed attention? In its current form, and testifying to its theoretical underdevelopment, the literature on attention restoration does not provide clear-cut answers to these questions. What seems certain, however, is that the current available empirical evidence for nature's cognitive benefits does not unambiguously support the hypothesis, central to ART, that nature especially benefits the execution of directed attention.

Assumption 3. Nature's fascinating qualities restore directed attention

Within ART, the attention restoring capacity of natural environments is (among others) situated in the fact that such environments are more fascinating, or contain more fascinating elements than urban environments. Fascination assumes a central explanatory role in ART: it implies a state of effortless bottom-up attention, through which demands on directed attention can be relaxed, allowing this limited resource to replenish itself. Restoration researchers have mentioned "clouds, sunsets, snow patterns, the motion of the leaves in the breeze" (Kaplan, 1992, p. 139), or waterfalls, caves and fires (Kaplan & Kaplan,

1989) as typical instances of (natural) fascinations.

Importantly, in restoration studies participants are only rarely – if ever – exposed to caves, fires, clouds or sunsets, but they are rather typically shown, or immersed in, vegetation-rich environments, including park-like settings, meadows or forests. While there seems to be general agreement on the idea that the restorativeness of such greenspace is (partly) due to its fascinating qualities, at the same time there is currently very little known about what it is about such restorative green settings – in terms of physical/visual attributes – that makes them fascinating in the first place (see also: Valtchanov & Ellard, 2015; Van den Berg, Joye, & Koole, 2016). Fascination is thus put forward as one of ART's central explanatory principles, but at the same time the notion itself has remained remarkably underexplained. Adding to this conceptual vagueness is the issue that it even remains to be systematically empirically verified that fascination is indeed a crucial driver of restorative nature effects.

Assumption 4. Nature's *soft* fascinating qualities restore directed attention and enable reflection (a.k.a. "full" restoration)

According to ART "full" restoration does not solely amount to a mere recovery of directed attention capacity; part of a restorative experience is that individuals also have an opportunity to reflect on unsolved (life) issues (Herzog, Black, Fountaine, & Knotts, 1997; Kaplan & Kaplan, 1989). Through such reflection, internal noise that could otherwise further burden directed attention capacity can be reduced (Basu, Duvall, & Kaplan, 2018).

Importantly, not all fascinations are equally suited to reach the stage of full restoration. Certain fascinating events or phenomena might perhaps facilitate attention restoration by effortlessly attracting attention (e.g., attending a sports event), but they might at the same time also be so absorbing or dramatic that they leave little place for reflection, thereby making it difficult for individuals to attain full restoration (Herzog et al., 1997). Proponents of ART have specified that full restoration will especially occur upon exposure to natural stimuli or environments that trigger "soft" fascination, a notion referring to a positively valenced but less dramatic type of fascination (Herzog et al., 1997; Kaplan & Kaplan, 1989). Soft fascinating settings attract effortless attention in a moderate and pleasant way, and thereby leave ample place for the mind to wander, for unbidden thoughts to occur, and for serious reflection about important (life) issues.

Despite the importance of soft fascination to reach full restoration, to our knowledge the optimal softness level of fascination that is needed to provoke a full restorative experience has not been clarified in ART, nor has it been explained which attributes make a fascinating stimulus or environment soft rather than hard fascinating (e.g., size, intensity, duration of the stimulus). Adding to this conceptual vagueness is the issue that the commonly used instruments to gauge fascination (e.g., Perceived Restoration Scale: Hartig, Korpela, Evans, & Gärling, 1997; Restorative Components Scale: Laumann, Gärling, & Stormark, 2001) do not differentiate between hard and soft fascination (see also: Basu et al., 2018). The theoretically predicted role of soft fascination thus not only remains untested, the major (validated) instruments to probe fascination are not even designed to test it.

We agree that it may be hard to define a particular point at which soft fascination turns into hard fascination, or vice versa. But without a minimal specification of the bandwidth of optimal softness, any stimulus could potentially be considered as soft fascinating, whereby the notion runs the risk of becoming unfalsifiable. As long as it is not clarified how much softness is required for full restoration to occur, we remain unable to fully understand, and explain why exactly natural, vegetation-rich environments are generally more restorative than urban settings.

Assumption 5. Nature is restorative by virtue of bottom-up effortless attention

So far, we have discussed *what* is needed for restoration to occur: namely that natural environments have softly fascinating characteristics. A next question is *how* (soft) fascination facilitates restoration. As pointed out earlier, in ART fascination is assumed to be akin to (effortless) bottom-up attention (Berman et al., 2008; Kaplan & Berman, 2010), and by recruiting this type of attention the capacity for (effortful) top-down attention is not further burdened, but instead given an opportunity to replenish itself. Nature is restorative by virtue of its fascinating – and hence bottom-up – aspects, whereas urban settings command, and might therefore further deplete, top-down attention.

While being one of ART's central theoretical theses, the assumption that fascinating nature recruits bottom-up attention remains to be empirically verified. What is more is that there seems to be a seeming misfit between this theoretical notion and the particular characteristics of the natural environments used in restoration studies. Specifically, it is well known that bottom-up attention is typically activated by stimuli that stand out and inadvertently attract attention: think for example of a bright red bird in a green tree canopy, the sudden flash of a lightning bolt (Corbetta & Shulman, 2002), or as Stephen Kaplan (1995, p. 170) mentions "… wild animals, danger, caves, blood …". Note, however, that in restoration experiments participants often have to passively watch visuals (e.g., videos, photographs) of, or to walk in fairly unspectacular, mundane natural settings (e.g., an urban park), seemingly devoid of things that truly stand out.[3]

When turning to the urban perspective, it has been noted that "… urban environments are filled with stimulation that captures attention *dramatically*" (Berman et al., 2008, p. 1207), and that directed attention fatigue can ensue, or is exacerbated, when top-down attention is required to block out this dramatic stimulation. Also this theoretical assumption is not evidently reflected in the stimuli that are used: in numerous restoration studies participants have to watch images/videos of fairly ordinary streetscapes, which seemingly lack any of the "dramatic" features that might cause or worsen attentional fatigue. Note that even if the urban scenes would display dramatic stimulation, it is unsure whether – at least in a lab setting – participants would experience a need to overcome that stimulation, given the passive viewing setup characteristic of such restoration studies.

Restoration has been claimed to result from the workings of effortless bottom-up attention (or: fascination) recruited by nature, and effortful top-down attention (or: directed attention) commanded by urban settings (Berman et al., 2008, 2012; Kaplan & Berman, 2010). However, the fact that beneficial nature effects occur using fairly mundane exemplars of both stimulus categories not only suggests that ART does not strictly test what it theoretically predicts, but it also challenges the notion that those nature effects are to an important extent driven by the interplay between bottom-up and top-down attention. If anything, it seems that the stimulation that is thought to underlie the depleting aspects of urban environments (Kaplan & Berman, 2010) – e.g., car horns, billboards, or any other dramatic stimulation – fits the description of typical input of bottom-up attention much better than the natural scenes used in restoration research (Corbetta & Shulman, 2002).

Assumption 6. Fascination with natural settings has an evolved origin

For ART's sixth theoretical assumption, we turn away from the proposed proximate to the ultimate mechanism for attention restoration, and focus on the idea – made by prominent restoration researchers – that restorative nature experiences are ultimately rooted in our shared evolution in natural settings (cfr., Kaplan, 1977; Hartig et al., 1996; Van den Berg, Hartig, & Staats, 2007; Staats, 2012; Collado et al., 2017).

[3] It might be argued that nature recruits bottom-up attention mainly because of the evolutionary significance of natural settings, and not so much because of salient visual characteristics (Awh, Belopolsky, & Theeuwes, 2012). We refer to our discussion of Assumption 6, where we discuss ART's evolutionary assumptions.

This view is for instance expressed by Stephen Kaplan who claims that because "… our ancestors evolved in a nature-filled environment … [nature] *should* feel more comfortable, more relaxed, more like home. It's not a big leap between that and being more competent, less distracted" (Kaplan cited in Jaffe, 2010). Kaplan's acknowledgment of the evolved origins, and possibly adaptive function(s) of our positive (cognitive and emotional) responses to nature, resonates with Edward O. (Wilson, 1984; Kellert & Wilson, 1995), as well as with the tenets of SRT (Ulrich, 1983, 1993; Ulrich et al., 1991), both of which consider mankind's affective bond with nature as an (adaptive) remnant of our evolutionary past in natural settings.

ART's evolutionary theorizing starts off from the idea that "… much of what was important to the evolving human – wild animals, danger, caves, blood, to name a few examples – was (and still is) innately fascinating …" (Kaplan, 1995, p. 170). From this perspective, one of the ultimate functions of fascination – the central driver of attention restoration – was thus to selectively attend to stimuli of evolutionary significance, including possible threat cues (e.g., predators), as well as cues signalling reward value (e.g., food, mates). The view that natural stimuli/characteristics can be innately attention grabbing, receives support from empirical research hinting at an evolved propensity to display selective attention towards animate motion (Pratt, Radulescu, Guo, & Abrams, 2010), as well as to certain biological kinds (Yorzinski, Penkunas, Platt, & Coss, 2014).

If especially green environments/elements grab attention, generate (aesthetic) interest, and have restorative potential, then this of course raises the question what the evolutionary significance was of selective attention to such settings/elements. Proponents of ART have argued that, inasmuch as "(w)ater, trees, and foliage are all indicators of the habitats in which human survival is more likely" (Kaplan, 1987, p. 25), an aesthetic interest/fascination could guide and facilitate the process of finding a safe retreat that contained life-sustaining elements, such as food and water. When individuals are nowadays exposed to nature, and specifically to greenery and foliage, then this still effortlessly draws attention (i.e., fascination), with a number of downstream effects, including restoration from directed attention fatigue (Van den Berg et al., 2007). The upshot is that "… people will restore better in environments that have characteristics that were relevant for survival during early evolution" (Collado et al., 2017, p. 129).

Given the idea that the adaptive function of fascination with green settings was to guide humans to "good habitats", one would expect fascination – and hence restoration – to especially occur for green settings/elements that actually provided food, water and safety for ancestral humans, or at least contained specific cues diagnostic of these. Based on this, researchers studying evolved responses to landscapes have argued (Coss, 2003; Heerwagen & Orians, 1993; Orians & Heerwagen, 1992; Orians, 1980) that individuals should be particularly drawn to trees with broad canopies (offering protection against adverse weather conditions) and short trunks (making them easily climbable), and by verdant, fruit-bearing vegetation (indicating the nearness of water and food).

While there is some (mixed) evidence for an aesthetic preference for savanna-type settings and trees (Balling & Falk, 1982; Falk & Balling, 2010; Lohr & Pearson-Mims, 2006; Sommer & Summit, 1995; Summit & Sommer, 1999), to the best of our knowledge, there is still a dearth of research that systematically tests the fascinating qualities, and superior restorative qualities of green settings that can afford resources and protection. More importantly, and in seeming contrast to the view that selective attention to such settings is an adaptive response, studies show that restoration occurs towards green settings/elements *in general* (Velarde, Fry, & Tveit, 2007), many of which lack obvious indicators of a high-quality habitat (i.e., cues of food, water and refuge). ART has thus posited the existence of an adaptive response, but this response also appears to occur for environments that do not evidently solve the problem for which this adaptation presumably has been designed for by natural selection (Joye & Van den Berg, 2011). In view of this, it remains very unsure whether a general fascination with foliage and greenery could have promoted our ancestors' fitness.

4. Outstanding issues

Our critical review suggests that ART faces substantial conceptual and empirical issues, which call for further theoretical development of the framework, and point to the importance of additional empirical verification of central theoretical assumptions. Below, we list four further outstanding issues/questions, which – we feel – have not been adequately or explicitly addressed and/or clarified within ART.

4.1. How do fleeting episodes of bottom-up attention support restoration?

Attention restoration is commonly interpreted as a process that needs time to unfold (e.g., Hartig et al., 1996), and that is triggered by, and ascribed to (natural) environments in their entirety (cfr., "Natural environments, such as parks, gardens, and lakefronts, are able to capture involuntary attention …", Kaplan & Berman, 2010, p. 48), whereas bottom-up involuntary attention is well-known to be short-lived and triggered by constituent scene elements (Corbetta & Shulman, 2002). Given these outspoken differences in terms of temporal and spatial resolution between the *explanandum* (i.e., restoration via nature contact) and *explanans* (i.e., bottom-up attention), the question arises of how exactly seemingly fleeting and "local" episodes of involuntary attention can mutually combine or connect, so as to support a full-blown restorative experience towards an entire environment or scene.[4]

4.2. Why does hard fascination preclude reflection?

ART suggests that because soft fascinating scenes are only moderately distracting, they leave ample room for reflection about important life issues, and thereby enable individuals to reach full restoration (Kaplan & Berman, 2010; Kaplan & Kaplan, 1989). But why should soft (rather than hard) fascination be a *necessary* requirement for reflection? Research on individuals' responses to awe-inspiring nature (Keltner & Haidt, 2003), for example, suggests that deeply fascinating natural settings and phenomena (e.g., the Grand Canyon) can be mind-filling, but at the same time also make individuals reflective and mindful about themselves, their lives, and their place in the world, *by virtue* of their profoundly attention grabbing qualities (Jefferies & Lepp, 2012; Pearce, Strickland-Munro, & Moore, 2017).[5] By inducing a sense of self-diminishment vis-à-vis the world (Piff, Dietze, Feinberg, Stancato, & Keltner, 2015), and self-transcendence (Stellar et al., 2017), such hard fascinating environments might very well promote the "self-distanced perspective taking", which certain ART researchers assume to be crucial for reflection on life issues (Kaplan & Berman, 2010). The experience of such hard fascinating nature – and the reflective mindset it may

[4] While we are aware that Kaplan and Kaplan (1989) point out that a restorative environment needs to have extent, whereby disparate fascinating elements become connected (to a larger framework), this still leaves us with the question as to how exactly such connectedness is reached.

[5] There can, of course, be differences between reflective episodes stemming from encounters with soft fascinating settings versus reflection originating from hard fascinating, awe-evoking environments. For instance, reflection in hard fascinating (natural) environments probably occurs only *after*, and not during the fascinating experience. In addition, reflection in soft fascinating environments is probably due to mind-wandering, while in the case of awe-evoking settings it might result from the realization of one's own insignificance in the larger scheme of things (Piff et al., 2015). In ART, it has not been specified that the exact moment of reflection, the kind of reflection, or the pathway through which reflection is reached are diagnostic for the reflective episode of a restorative experience. This means that there is no a priori reason to discount reflection resulting from exposure to hard fascinating awe-evoking natural scenes as a "proper" instance of nature-induced reflection.

promote – is far from uncommon, which makes us wonder whether the theoretical distinction between hard and soft fascination is adequate and necessary to explain full restoration.

4.3. Why is soft fascination required for ART?

Soft fascination is triggered by pleasantly distracting visual information that puts individuals in an effortless mode of attention (Kaplan & Berman, 2010; Kaplan & Kaplan, 1989; Kaplan, 1995). However, given the fact that within ART attention restoration is regarded as an autonomous and self-replenishing process, it is unclear why soft fascination should be a *necessary* theoretical component of the framework, as prominent ART researchers suggest (cfr., "Fascination is a necessary, but not sufficient basis for recovering directed attention", Kaplan, 1995, p. 172). Does the recovery of directed attention not merely require a process/stimulus that does not further burden directed attention capacity? And if so, could numerous other non-fascinating stimuli/processes not offer such relief as well (e.g., visually minimalist environments), or does soft fascination provide an exclusive and superior pathway to attention restoration? Perhaps the theoretical necessity of soft fascination derives partly from the fact that it is crucial for reaching full restoration (cfr., Herzog et al., 1997), where the aesthetic pleasure derived from soft fascinating stimuli can offset the pain that can accompany reflection about life issues. But then again, does this not show that especially the pleasurable aspect of soft fascination facilitates full restoration, rather than fascination itself?

4.4. Why are fascinating stimuli relatively effortless rather than effortful?

Although ART has focused on the effortless attention component of fascination as the main driver of attention restoration, it seems that effortless attention is – at least partly – recruited *by virtue* of the fact that fascinating stimuli are often novel, complex or unpredictable (Silvia, 2008). Especially the idea of complexity as determinant of fascination clearly speaks from the often used Perceived Restorativeness Scale (Hartig et al., 1997), where highly fascinating scenes are assumed to be scenes where there is "a lot going on" (consider the items "My attention is drawn to many interesting things" or "There is much to explore and discover here"). The upshot is that while the process of attracting attention (i.e., fascination) might indeed be automatic and relatively low on cognitive resources, processing the actual *stimulus* that attracts attention (i.e., natural setting) seems – given its complexity – also to require considerable cognitive resources (Eng, Chen, & Jiang, 2005). Implicit to ART is the idea that the effortlessness of the process of being attracted by fascinating stimuli, trumps the effortfulness associated with the attracting stimulus, leading to an overall better performance on cognitive tasks after exposure to nature. But why should that be the case? After all, in ART the distractive component of restorative environments is considered to be moderate (cfr., "soft" fascination), and does this not suggest that attending to such environments is not completely effortless?

5. Discussion

While an extensive body of empirical research has sought to confirm the notion that exposure to nature settings can have beneficial psychological effects, with our critical review we hope to have shown that one of the most widely adopted theories on these benefits – i.e., ART (Kaplan & Berman, 2010; Kaplan & Kaplan, 1989; Kaplan, 1995) – has important empirical and conceptual limitations. While numerous researchers in the field share our belief in the importance of criticism and of theoretical expansion of ART (e.g., Hartig & Jahncke, 2017; Ohly et al., 2016), paradoxically, we also observe that in major contemporary theoretical reviews (Collado et al., 2017; Hartig et al., 2014) and in handbooks on environmental psychology (Clayton, 2012; Steg, van den Berg, & De Groot, 2012), ART is often still upheld as one of the main canons for (attention) restoration.

To reiterate, we have three general concerns with ART: (a) some of ART's central theoretical notions are vague, remain conceptually underdeveloped (e.g., soft fascination), and still await a systematic and adequate (experimental) operationalization (e.g., soft fascination), (b) ART's central theoretical assumptions still need to be corroborated, especially the proposed mechanism for attention restoration (i.e., bottom-up attention), and (c) experimental studies often do not accurately or adequately test what ART predicts. Given these concerns, we doubt whether – in its current form – ART can provide an accurate theoretical description of how nature might restore and/or improve cognition and attention in individuals.

Note that, although our discussion especially focused on the notion of fascination, we are aware that additional components have been claimed to be important for the process of attention restoration, such as "being away", "extent", and "compatibility" (Kaplan & Kaplan, 1989; Kaplan, 1995). The rationale for focusing on fascination, however, is that this notion is considered to be the central driver of attention restoration, whereas the other components provide (moderating) conditions under which attention restoration optimally takes place.

Despite the speculative character of the ART, and the fact that there currently is a lack of insight into how exactly nature restoration works, nature is nonetheless integrated in different spheres of human life (e.g., ranging from clinical to school settings) where it seemingly succeeds in bettering the lives of people and bringing out the best of them (Kaplan & Kaplan, 2003). Might we therefore not just be satisfied with the idea that nature interventions work, laying aside critical questions about the possible "ingredients" or mechanism(s) that underlie nature's efficacy? We think that theory development and critique matter, because they can help to develop and optimize applications (cfr., "biophilic" architecture; Joye, 2007), and to identify relevant target groups in a cost-effective way.

How to progress from here? Below we list a number of straightforward methodological steps that could address some of the issues that we have brought up in our critical review.

- In addition to deliberately fatiguing individuals, efforts should be made to include a control group of participants that has not undergone a fatigue manipulation, to verify whether nature actually recovers from mental fatigue. If a deliberate fatigue induction would prove difficult, natural variations in fatigue between individuals could also be exploited. One could, for example, take a baseline measure of fatigue, and test whether restorative nature effects will be most pronounced for participants that display higher (versus lower) levels of baseline fatigue.
- Standardize the method(s) for inducing attentional fatigue in participants prior to environmental exposure, and for measuring directed attention capacity after environmental exposure. Use the same pre- and post-measures, to enable within-subjects comparison.
- Test what the particular physical input conditions of soft fascination are, and, based on this, develop an instrument to measure soft-fascination that is able to differentiate it from hard fascinating stimuli.
- Test whether the bottom-up attentional aspects of natural fascinations mediate the effect of natural versus urban environments on attentional functioning.
- Test whether people in a soft fascinating environment think and resolve more life issues than in hard fascinating settings.
- Because urban and natural environments differ on so many (confounding) dimensions (i.e., visual, symbolic, goal aspects) other than the factors proposed for restoration (e.g., fascination), it might be valuable to create a controlled and validated stimulus-set of urban and natural simulations.
- Create a set of non-urban and non-natural control images to determine where environmental effects are situated, enabling one to pinpoint whether urban scenes worsen, or nature ameliorates directed attention capacity (or both simultaneously). These control

images should be neutral on dimensions that are thought to affect attention restoration, i.e., in terms of attentional aspects and valence (cfr., Lang, Bradley, & Cuthbert, 1995).

- While it might be difficult to test whether fascination with nature is indeed an evolved adaptive response, some ancillary assumptions of this evolutionary hypothesis might still be put to the test. One could for example look at which natural settings are perceived as affording safety and resources (or cues thereof), and subsequently examine whether those settings are also more restorative than natural and urban areas seemingly devoid of these (perceived) affordances.

While we are aware that there might be individual cases of research where the foregoing steps have already been taken, we hope that they will be applied more systematically in restoration research. We mainly see these suggestions as a goal for the broad literature, and realize that individual restoration studies might well disregard some of them, depending on particular research objectives and questions (e.g., when comparing the restorativeness of different nature types, a "neutral" control condition may not be required).

In addition to systematically implementing the aforementioned steps, it might also prove useful to explore alternative, more parsimonious explanations for beneficial nature effects than the one provided by ART. One promising avenue for future research might be to examine whether the motivational component of fascination could play a role in restorative nature effects. Specifically, research into the positive emotion of interest reveals that it is associated with approach motivation, thus spurring exploration, focused attention, and task persistence (Silvia, 2008). Inasmuch as fascination is a form of interest (Kaplan, 1992), superior performance on cognitive tasks after exposure to nature (versus urban) settings might well be the result of increased task motivation/persistence due to nature's fascinating features. Note that such an account would be firmly grounded in current emotion research, and avoids having to posit the existence of a depletable cognitive resource (whose existence is currently hotly debated, e.g., Friese, Loschelder, Gieseler, Frankenbach, & Inzlicht, 2018). At the same time, however, it builds further on a central notion of ART, namely fascination. Of course, this illustrative proposal only zooms in on one very particular aspect and type of restoration (i.e., "cognitive" restoration), and we look forward to research that further maps and tests additional pathways to restoration, possibly involving different adaptive resources (Hartig & Jahncke, 2017).

6. Conclusion

ART has been invaluable in drawing attention to the importance of natural environments in restoring and ameliorating human wellbeing and cognitive functioning, which has paved the way for a rich and societally-relevant empirical research literature. But should we still consider ART itself as viable descriptive and theoretical framework for how nature can yield these cognitive and emotional benefits? We hope that our critical review will have sparked some scepticism in restoration researchers, and that it will stimulate renewed interest in theoretical enrichment and development in the field of restoration research.

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