Is love for green in our genes? A critical analysis of evolutionary assumptions in restorative environments research

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abstract

Within the field of restorative environments research, it is commonly assumed that restorative responses, triggered by exposure to natural elements and settings, are ultimately adaptive traits originating from our species' long evolutionary history in natural environments. The aim of this article is to critically investigate the viability of this evolutionary view on restoration. In doing so, we specifically focus on Stress Recovery Theory (SRT), as this theoretical framework has most extensively elaborated on the supposed evolutionary origins of restoration. A detailed analysis of SRT's psycho-evolutionary framework shows that neither current empirical evidence nor conceptual arguments provide any strong support for the hypothesis of restorative responses to nature as an ancient evolved adaptive trait. Based on this conclusion we put forward an alternative model for restorative responses to nature based on processing fluency, which prima facie circumvents some of the pitfalls associated with evolutionary accounts for restoration. The Discussion section reflects on the implications of our critical discussion for the theory and practice of urban forestry and urban greening.

Introduction

People's aesthetic preference for natural elements and settings is a well-known phenomenon that is covered by a vast literature and substantiated by well-controlled research (Hartig and Evans, 1993; Tveit et al., 2006; Ode et al., 2009). One important reason why people like natural elements and settings is that they offer excellent opportunities for relaxation and restoration from stress (Purcell et al., 2001; Van den Berg et al., 2003; Hartig and Staats, 2005). Thus far, environmental psychologists have mostly sought to explain people's "love for nature" and concomitant restorative responses in terms of mechanisms that are believed to be rooted in our evolutionary past (Kaplan, 1992; Ulrich, 1993). However, a number of researchers in this area are beginning to recognize that these evolutionary assumptions are in need of revision (e.g., Hartig et al., 2010). The central aim of this paper is to systematically uncover and discuss the main limitations of the evolutionary account of restorative responses to nature and its specific sub-hypotheses. In doing so, we will mainly focus on Stress Recovery Theory (SRT) (Ulrich, 1983; Ulrich et al., 1991) because, within the field of restorative environments research, SRT has most extensively elaborated on its evolutionary assumptions.

This article is structured as follows. First, we discuss what are commonly considered to be the "proximate" and "ultimate" (i.e., evolutionary) causes of restorative responses to nature. In the second and third section, we investigate whether or not there is a sufficient "fit" between the elements that are known to cause restoration (in particular, vegetation) and the characteristics and presumed function(s) of the affective responses underlying restoration. The subsequent section examines whether evolutionary explanations for restorative responses to nature gain support from a conceptual link between biophobia and biophilia, proposed in the restorative environments literature, and from the supposed intercultural agreement in people's preferences for nature. This is followed by a section that sketches the contours of an alternative model for restorative responses to nature based on processing fluency. The discussion of this article reflects on the relevance of our critical analysis for the field of urban forestry and urban greening.

Restoration as an evolved adaptive trait

Proximate explanations for restoration

Why do natural elements and settings have stress-reducing effects on human individuals? In his original articulation of the

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"psycho-evolutionary framework" underlying SRT, Roger Ulrich (1983) mainly explored the possible proximate causes of restoration induced by natural environments. These are the immediate devel- opmental (ontogenetic) and mechanic causes of a certain behaviour or trait. Based on the empirical work of Robert Zajonc (1980), Ulrich (1983) argued that the initial response mode to environments and environmental stimuli is one of generalized affect. Characteris- tic to such affective responses is that they are deemed to occur almost immediately after exposure to the stimulus or environ- ment, to require only little cognitive processing, and to take place without conscious recognition. This initial affective response mode is believed to have prehistoric roots and to have been retained across the human lineage because it contributed to our species' survival.

Ulrich (1983, 1986) specified a number of specific environmental features or "preferenda" that are able to trigger initial positive affective responses. These include "complexity", "gross structural features" (e.g., symmetries), "depth/spatiality cues", "even ground surface texture", "deflected vista", and "absence of threats". What interests us most, however, is that Ulrich (1983) also conjectured that exposure to unthreatening natural environments or to certain types of unthreatening natural content (e.g., vegetation) will offset such immediate positive affective responses. When previous to encounters with such natural settings/elements an individual was in a negative mood or experienced stress, then the posi- tive responses induced by nature could attenuate those negative feelings/states, and restoration might follow. Or, as summarized by Ulrich (1983, p. 116): "For individuals experiencing stress or anxiety, most unthreatening natural views may be more arousal reducing and tend to elicit more positively toned emotional reac- tions than the vast majority of urban scenes, and hence are more restorative in a psychophysiological sense".

According to SRT, restorative responses can thus essentially be considered as by-products of immediate positive affective responses induced by (unthreatening) natural settings. Note that the centrality of affect in SRT marks an important difference with the other major theory on restorative environments, Attention Restoration Theory (ART), which assumes that the proximate cause of restoration lies in the replenishment of depleted cognitive resources (Kaplan and Kaplan, 1989). Of further importance is that SRT assumes that the link between positive affect and restorative responses is specific to natural environments: ". . . modern humans, as a partly genetic remnant of evolution, have a biologically prepared capacity for acquiring and retaining restorative responses to certain natural settings and content . . . but have no such disposition for most built environments and their materials" (Ulrich, 1999, p. 52). But why would it have been beneficial for humans to evolve such a capacity? This question taps into the ultimate or evolutionary causes of restorative responses to nature, which are the focus of this article.

Ultimate explanations of restorative responses to nature

Different ultimate explanations run through Ulrich's psycho-evolutionary framework. For example, Ulrich notes that when a stressor has disappeared the incidence of stress reduction "... would enhance survival chances in part because of its role in promoting recovery from fatigue and other deleterious effects stemming from behaving adaptively in a previous demanding situation" (Ulrich, 1993, p. 98). It is indeed a well-known fact that after a stress- ful episode a failure to return to baseline levels of arousal may have detrimental health consequences and thus may have low- ered survival chances (Selye, 1956). While this account perhaps provides an ultimate explanation for the prevalence of a general stress reduction response, it must be clear that this is not the type of "restorative" response envisioned by SRT.

The central idea underlying SRT is that human individuals more quickly and more deeply recover from stress near unthreatening natural elements and settings than near unthreatening urban environments. As noted earlier, this particular restoration process is supposed to be driven by the differential affective valence of natural versus urban settings. Since the 1980s there seems to be an (implicit) consensus among restorative environments researchers that the occurrence of these affective responses is ".. affected by unlearned factors of evolutionary origin" (Ulrich, 1983, p. 115), and that they need to be considered as remnants of our species' evolution in natural environments. Of further importance is that it is mostly assumed that these (positive) affective reactions are evolved adaptations. Displaying such responses to nature fulfilled a particular function in ancestral environments and ". . . tended to foster [human] survival and well-being during evolution" (Ulrich et al., 1991, p. 209).

It must be clear that the foregoing account still leaves a number of questions unanswered. For example, in what respect did positive affective responses to unthreatening nature exactly foster survival during our species' evolutionary history? Within the restorative environments research field it is generally assumed that some natural content could offer ancestral humans opportunities for safety, could contain food resources, or at least could have been indicative of the presence of food or safety (cfr., Ulrich et al., 1991, p. 226). Having evolved a hardwired tendency or "preparedness" to display positive affective responses to such natural content would have increased ancestral humans' survival chances because it motivated them to pay attention to, or to approach or stay in environments that contained elements or opportunities that were critical to their subsistence (i.e., food and safety).

Another issue relates to the type of nature toward which our species is supposed to have evolved positive affective responses. Although the empirical and theoretical literature associated with SRT is not very often outspoken on this matter, three general categories of "restorative nature" can be identified. First, on numerous occasions it is proposed that exposure to unthreatening natural settings can elicit these immediate positive affective responses. Ulrich (1993, p. 102), for example, notes that "[c]onsistent with the functional-evolutionary perspective . . . viewing unthreatening natural landscapes tends to promote faster and more complete restoration than . . . urban or built environments". A second category of restorative nature is vegetative elements, or settings containing such elements. The reason for including this category derives from the fact that restorative effects are often triggered by vegetated scenes, a finding that is generally regarded to be con- sistent with, and supporting the evolutionary tenets of SRT (cfr., Ulrich et al., 1991). The third and last category of natural content is more specific than the two previous ones, and includes specific types of natural settings or features that are supposed to facilitate stress reduction. Ulrich (2008, p. 90) points out that these can com- prise elements/features like "calm or slowly moving water, verdant vegetation, flowers, savanna-like or parklike properties. . .".

Based on the previous discussion, SRT's ultimate account for restorative responses to nature can be summarized as follows. A biologically prepared readiness to display positive affective responses to different types of unthreatening natural content is an evolved adaptive mechanism (Ulrich, 2008, p. 89), whose function was to guide and support our ancestors in the process of finding food, water and shelter in ancestral environments. When having experienced a stressful episode, exposure to natural content providing food/water/shelter can lead to stress reduction via the (psychologically and physiologically) soothing effects of positive affect (Ulrich, 2008). The fact that, on an evolutionary time-scale, our species has only recently begun to construct and inhabit built environments, but has experienced the ".. rewards associated with natural settings during a few million years of evolution" (Ulrich et al., 1991, p. 209) explains why nature consistently comes out as being more restorative than most urban environments.

Restorative responses to nature and evolutionary psychology

It is important to stress that restorative environments research borrows from evolutionary psychology to explain the ultimate origins and function(s) of restorative responses to nature. According to evolutionary psychology the human mind should be considered as a collection of cognitive modules or programs. These are essentially "problem solving devices", which were positively selected by evolution because they solved a particular, recurring survival-relevant task/problem ancestral environments (Tooby and Cosmides, 1992). For example, as snakes posed a perennial threat to the human species, evolutionary psychologists maintain that specialized modules have evolved for optimally dealing with those threats (Mineka and Öhman, 2002). Likewise, positive affective responses to nature, and especially to vegetated natural elements and settings, have been interpreted as evolved mechanisms which contributed to solving food and safety related problems in ancestral environments. SRT's commitment to evolutionary psychology is clear from the fact that the positive affective responses to natural content have been considered to be functionally equivalent to biologically prepared fearful responses to natural stimuli, such as snakes and spiders (Ulrich, 1993). Making explicit this commitment to evolutionary psychology is important because it constitutes the theoretical back- drop of some of our subsequent criticisms.

In the ensuing sections we will refer to the constellation of positive affective response mechanisms that become activated by restorative natural content as the Phytophilic Response Module (PRM). The term "phytophilic" derives from the Greek "phyto", meaning "plant" or "vegetation", and "philia", meaning "love". We choose to use this term instead of the more widely used "biophilia", meaning "love for life" (Wilson, 1984). This is because of the fact that vegetated elements seem to be the life-like elements that are consistently present in the environments that are able to cause restorative responses. An essential feature of evolved problem- solving devices like the PRM is that there is a fit between the specific characteristics of the device and its actual function. For example, a module that has evolved to deal with snake threats would not perform its function properly if, apart from snakes, it would also become active for all kinds of insects that do not resemble snakes. Although perhaps obvious, this "form-function fit" is worth empha- sizing because this basic principle seems to be regularly violated in evolutionary accounts of restorative responses to nature. In the following paragraphs we will try to pinpoint where exactly these violations are situated.

Input of the PRM versus function of the PRM

It must be clear that a mechanism that has evolved to deal with snake threats will become active for particular types of input, that is, for actual snakes, or snake-like features or forms. Simi- larly, restoration researchers often claim that the PRM is generally activated by "natural-like" stimuli, and not so much by modern artifactual stimuli (specifically buildings). But what might that "natural-like" input of the PRM exactly be? In keeping with our discussion of the ultimate causes of restorative responses to nature (see above), we distinguish among three possible categories of input: (1) "unthreatening nature", (2) "unthreatening vegetated settings", and (3) "particular qualities about unthreatening veg- etated settings". In the ensuing sections we will inquire to what extent each of these proposed input categories are actually able to contribute to, or are consistent with the proclaimed function(s) of the PRM.

Unthreatening nature

In restorative environments research "unthreatening nature" is regularly referred to as an elicitor of restorative responses. Consistent with this notion, it has been empirically demonstrated that natural scenes are less likely to be perceived as restorative when they contain elements of danger (i.e., a stranger lurking in the woods; cfr., Herzog and Rector, 2009). It must be made clear, however, that demonstrating that threatening nature is not restora- tive is not the same as demonstrating that nature is restorative because it is unthreatening. Moreover, to postulate that restorative responses have evolved to such a broad category as "unthreaten- ing nature" sits awkward with the proclaimed function of such responses. Are there not innumerably many instances of nature which are unthreatening, but which do neither provide any food nor protection (e.g., grassy lawns, clouds, and stones)?

Another difficulty for the claim that "unthreatening nature is stress-reducing" is that it seems to be tautological. Consider Ulrich's interpretation of stress as "...the process by which an individual responds psychologically, physiologically, and often with behav- iors, to a situation that challenges or threatens well-being" (Ulrich et al., 1991, p. 202; Ulrich, 1993, p. 100). Based on this inter- pretation, it appears that "unthreatening" already presupposes the relative absence of potential stressors, that is, situations that threaten well-being. It seems fairly evident that individuals having experienced stress will recover faster from stress in unthreatening environments than in threatening environments merely because of the fact that the latter still contain stressors (i.e., threatening elements or situations) whereas the former do not. This, however, leaves it largely unexplained what it is exactly about natural envi- ronments that makes them more stress-reducing beyond the mere fact that they contain less threats than their threatening counter- parts.

Granted, perhaps we are unfair and it just happens to be the case that restorative environment researchers employ the notion "unthreatening nature" as a convenient umbrella term, while they nonetheless have a fairly good idea about the more particular types of nature that lead to restoration. The use of "unthreatening nature" would then be more a case of terminological sloppiness rather than a conceptual flaw. Still, the fact that the use of this notion is both widely and uncritically accepted seems to point out that the restorative environments research community is not much inter- ested in rigorous evolutionary analyses and conceptualizations. But if that interest is indeed lacking, why has there yet been such a tenacious confidence in evolutionary assumptions?

Unthreatening green settings

A slightly more fine-grained proposal is that the PRM's prototypical input are (environments containing) vegetative elements rather than unthreatening nature. This interpretation has not only been expressed as such (e.g., Korpela et al., 2002; Lohr, 2007; Grinde and Patil, 2009), it also speaks from the recurring finding that many different types of vegetation and vegetated settings do indeed cause restorative responses. The fact that some authors view this general finding as being consistent with, or supporting the psycho-evolutionary framework underlying SRT suggests that they assume that responses toward greenery in general contributed to our species' survival and reproduction by their ability to provide food and shelter (Frumkin, 2001; Kuo, 2001; Sullivan, 2003).

Our main concern with the former interpretation is that, much like with the case discussed in the previous section, there is no obvious "fit" between the response behaviour of the PRM (i.e., positive affective responses toward greenery in general) and the proclaimed function of the mechanism (i.e., finding food and shelter). Not every piece of vegetation or any kind of vegetated setting provides equal opportunities for refuge/safety and not all trees, bushes or plants constantly bear fruit or signal that they can supply such resources in the future. It is thus far from even-handed that an evolved positive affective response to greenery in general will have sufficiently contributed to solving the problem of finding food or shelter.

One might counter that evolved problem solving devices or modules can be activated by a much broader range of stimuli than their "prototypical" input. For example, a snake module will not only become active when actual snakes are encountered, but it will also react for objects that look similar to snakes, such as, for exam- ple, branches. Likewise, perhaps it is the case that the prototypical input of the PRM are actually much more specific than the category "greenery in general" (e.g., flowering trees), but that it just happens that the latter still activates the PRM because most of its exem- plars are somewhat similar to this prototypical input. However, a potential drawback for this argument is that the human species has always inhabited more or less vegetated settings. This would imply that the PRM would have been almost constantly active, raising the question why such a mechanism would have been retained by the process of natural selection in the first place.

A further complication is that it is unclear why the imme- diate positive affective responses underlying restoration should have become "situated" at the level of the category "vegetative elements". For an organism seeking refuge, a tree-group signals safety not because of the mere fact that it is a tree-group, but most probably because of its specific organization and/or configuration, which communicates opportunities for hiding and/or protection (e.g., a tree with dense foliage is a good hiding place). It needs to be explained why evolution would have selected for positive responses toward the category "vegetative elements", and not so much for positive responses to "things that offer opportunities for hiding" (of which trees can be particular instances). In agreement with Appleton's prospect-refuge theory (Appleton, 1975), a gen- eral preference for "refuges" instead of trees might have guided our ancestors to safe places equally well, and this mechanism may have worked for any kind of environment – even urban environments lacking vegetation altogether.

Particular cues about unthreatening green settings

A final option is that the prototypical input of the PRM are elements or attributes of vegetative elements that directly signal or correlate with resource availability (e.g., fruit-bearing trees) or safety (e.g., climbable trees). This option has not only been fre- quently suggested by researchers in the field of restoration studies (e.g., Heerwagen and Orians, 1993; Ulrich, 1993), it also seems to avoid the aforementioned "mismatches" between the proclaimed function of the PRM and its preferred or prototypical input. The problem, however, is that there barely exist any experiments into the restorative effects of particular vegetative elements, such as -for example- flowers, (but see: Todorova et al., 2004; Haviland-Jones et al., 2005). Moreover, only few restoration studies (less than 25%) have included subcategories of natural settings (Velarde et al., 2007).

In the restorative environments research literature one particular category of landscapes has nevertheless received considerably more attention, namely savannah-type settings. On numerous occasions is it conjectured that savannahs will score high on actual measures for restoration because it is the type of environment in which our species has presumably evolved. Parsons and colleagues (1998, p. 118–119), for example, predict that "natural environments should be visually preferred and more calming than their artifact-dominated counterparts, and among natural environments, those that more closely approximate supportive African savannas (the environments of our speciation) should be preferred most of all".

Within the environmental psychology literature, the experiment by Balling and Falk (1982) is often quoted as providing support for this "savannah hypothesis" (see also: Falk and Balling, 2010). This experiment shows (among others) that children under the age of 12 prefer savannahs over other and more familiar types of biomes, such as coniferous or deciduous forests. Balling and Falk (1982) hypothesize that this finding illustrates that our species has an innate preference for this type of landscape, which is most strongly expressed during childhood (see also Falk and Balling, 2010). Further evidence adding to the viability of the savannah hypothesis derives from the finding that people prefer trees with "spreading" crowns over trees with rounded or conical canopy shapes (Lohr and Pearson-Mims, 2006). As such crowns are typical to trees that grow on savannahs, this preference response has been interpreted as being a relic of human evolution in savannah-type environments (Lohr and Pearson-Mims, 2006).

It remains to be shown however, whether the previous results are sufficient to conclude to the existence of innate restorative responses to particular types of nature. Research on the savannah hypothesis has mainly investigated cognitively more elaborate aesthetic preferences rather than the immediate affective responses that are supposed to underlie restoration. It is, however, far from certain whether findings from preference research can be directly translated into, or equated with restorative responses to nature. Moreover, even the results regarding preferences for savannah- type environments are far from conclusive. Various studies have not been able to replicate Balling and Falk's (1982) initial find- ings and thus seem incompatible with an evolved preferential bias for savannahs (cfr., Lyons, 1983; Han, 2007; Hartmann and Apaolaza-Ibáñez, 2009; but see: Falk and Balling, 2010). Further- more, alternative, and perhaps more parsimonious explanations for the studies that have obtained a preference for savannah-type land- scapes are available. For example, the effects reported in the Balling and Falk (1982) study might not so much point to a hardwired pref- erence for savannahs, but could equally illustrate a preference for a structural characteristic of savannahs, such as their intermediate complexity or density (cfr., Ulrich, 1983). Also note that the North American subjects in Lohr and Pearson-Mims' (2006) study were probably mostly accustomed to trees with rounded or conical crowns, whereas savannah-type trees were probably fairly unusual and new to them. As (unthreatening) novelty predicts aesthetic preference (Biederman and Vessel, 2006), it cannot be excluded that the differential preference responses for different tree forms is at least partly driven by the relative degree of novelty conveyed by each tree type.

But if the experiments do not support the proposal for a pre-wired restorative response toward particular types of nature, then is there something which they do show unequivocally? They generally demonstrate that restoration (as measured by affective, cognitive or physiological indices) occurs in response to almost any kind of unthreatening nature, from single plants and plain grasslands to idyllic waterfalls and dense forests (see for a review: Velarde et al., 2007). The few studies that have compared differ- ent types of natural settings and/or features have often failed to detect differences in restorative effects between the settings (see: Ulrich et al., 1991; Van den Berg et al., 2003; Lohr and Pearson- Mims, 2006; Van den Berg, 2009). Some studies have also detected differences that are difficult to interpret within SRT's psycho- evolutionary framework, such as the finding that a walk through tended urban forests contributes more to well-being than a walk through wild, and hence more natural urban forests (Martens et al., 2010). It is furthermore conceivable that several other trustworthy non-significant findings exist that have not been published. We agree that there appears to be a tight fit between the suggested function of the PRM and the prediction that restorative effects will be more outspoken for particular conditions/qualities about vegetated settings. That prediction has, however, not received any strong empirical confirmation. This warrants at least some reconsideration of SRT's evolutionary commitments.

Response characteristics of the PRM

The overall conclusion from the previous discussion is that there appears to be a mismatch between the possible input categories of the PRM (e.g., savannah-type landscapes) and the function of the PRM (e.g., facilitating food acquisition). On the one hand, the proposed input of the PRM seems too coarse to fulfil the function of the PRM (see the first two parts of the above section), while on the other hand, hypotheses regarding very specific types of input of the PRM are (still) not, or insufficiently supported by the empirical facts (third part of above section). In the following sections some further mismatches/tensions between the (response) characteristics of the PRM and its functions will be discussed. Note that these tensions predominantly arise when the characteristics of the PRM are confronted with the category "unthreatening vegetative elements/settings" (cfr., second part of above section). This, however, is the category of natural content that consistently comes out as having high(est) restorative potential in restorative environments research.

Why fast?

According to SRT restorative responses will occur very rapidly after exposure to unthreatening natural settings and elements, which is a prediction that has also been empirically confirmed (e.g., Ulrich et al., 1991; Korpela et al., 2002). We are however confused about how this established finding fits within a psycho- evolutionary framework for restoration. Specifically, we do not understand why rapid responses should be a necessary feature of a mechanism that (supposedly) evolved to facilitate the process of food acquisition. The claim for rapidity seems to imply that slower or delayed responses toward nature, and specifically toward veg- etative life would have had significant fitness costs, because they would have made the process of acquiring foodstuff suboptimal or even unsuccessful. Natural elements like vegetation are how- ever often fairly conspicuous and mostly visible from significant distances. Vegetative life does not quickly change location, nor does its overall shape and contents (e.g., fruits) change or appear over an instant. This given – and keeping in mind one of the main functions of the PRM, i.e., food acquisition – it needs to be further elucidated why there should have been a selection pressure to evolve very rapid affective responses toward greenery. It seems to make more sense to claim that such rapid positive responses are required for vegetative elements as "emergency escape routes" or as "refuges" from immediate threats. However, the problem with this proposal is that it again burdens us with the issue already discussed above, namely the question of why restoration needs to be situated at the level of the category vegetative elements.

Why affective?

Another feature assumed to be central to restorative responses to (non-threatening) natural stimuli is their affective immediacy. According to Ulrich (1983) immediate affective responses act to motivate individuals to undertake adaptive actions vis-à-vis a cer- tain natural stimulus or environment. For example, in the face of a threat, such as a snake, an initial negative affective response motivated flight or freeze behaviour, whereas a positive affective reaction to – say – a group of verdant trees might have moti- vated approaching and explorative behaviour, and as such, may have increased survival chances. But as already mentioned ear- lier, one can safely assume that humans have always inhabited more or less vegetated environments, perhaps with the excep- tion of deserts. Because a certain amount of vegetation thus was always present, individuals with an evolved readiness to dis- play positive affect toward greenery had no more easy access to greenery, and thus to its benefits, than those not sharing this predisposition. But why should affect then be so essential to our supposedly "evolved" response mode to this category of natu- ral stimuli? This problem not only poses itself if we assume that positive affect is displayed to greenery in general, but also to par- ticular landscape-types. If the African savannah indeed was the natural décor during most of our species' evolutionary history, which adaptive role could positive affective responses towards such environments then have played? After all, this type of biome was our "natural" habitat, making it unclear why there should have been any further need for affect to motivate to explorative or approaching behaviour. Again it needs to be further clarified why a central characteristic of the PRM, that is, the centrality of affect, is necessary to perform its function (i.e., acquiring food and safety).

Why ancient?

Modern urban environments provide us ample opportunities for obtaining food and possibilities for shelter. But if these rela- tively new environments can easily solve problems for which the PRM is assumed to have been designed, why is it still the case that nature is predominantly more restorative than urban envi- ronments? The answer that can be derived from SRT is that this is because we are equipped with "stone-age" brains, and too lit- tle time has passed for our cognitive architecture to adapt to, and to be moulded by the new urban situation. This assumption, also known as the "adaptive lag" hypothesis (Laland and Brown, 2006), is however controversial and recently it has even been acknowl- edged as such by restorative environments researchers (cfr., Hartig et al., 2010). As the case of – for example – lactose tolerance in cer- tain world populations illustrates, adaptive traits can develop at a fairly fast rate and it should not be a priori excluded that restora- tive responses are fairly recent adaptations. In other words, it seems that the proposed function of the PRM (i.e., food and shelter) does not require it to be an ancient mechanism. Given the fact that explanations in terms of ancient adaptations show clear shortcomings, as demonstrated by our critical review thus far, the idea of restoration as a relatively recent adaptation deserves at least some further consideration.

Arguments in favour of the evolutionary assumptions of SRT

In the previous sections we have attempted to reveal a number of tensions between the adaptive function of the PRM on the one hand (as portrayed by SRT) and the characteristic properties of restorative responses to nature and the stimuli which cause such responses on the other hand. While these tensions suggest that we are still in the dark as to whether or not restorative responses have an adaptive function, that in itself does not preclude an evolutionary explanation for restoration. It is, for example, entirely possible that restorative responses to nature have another adaptive function than the one proposed in SRT's psycho-evolutionary framework, or perhaps such responses are evolved, but non-adaptive traits, much like male nipples are. In the sections that follow we set aside the issue of adaptive function and rather focus on the more gen- eral question whether there is sufficient ground to conclude that restorative responses to nature are a universally shared, evolved human trait. Specifically we will review two arguments which have been put forward in the restorative environments literature to back up the claim for of the evolved nature of restorative responses.

Intercultural agreement points to universality

A first argument starts from the observation that research in different countries reveals substantial intercultural agreement in preferences for natural environments. Based on this observation, it is stated that positive affective responses to nature are universally shared, which renders evolutionary explanations of such responses more plausible than cultural and personal learning perspectives (e.g., Ulrich, 1993, p. 97). One difficulty with this argument for universality is that it relies almost exclusively on research on (fairly elaborate) aesthetic preferences for nature, which, as we have explained before, probably tap into different processes than restorative responses. Another difficulty is that the available cross- cultural research does not seem to cover the full breadth of human diversity. Specifically, (Lewis, 2005, p. 90) notes that populations that are the subject of many preferential studies are often histor- ically and ethnically related (e.g., Americans vs. Australians), and those who are not are mostly still urban or suburban residents, with highly similar nature experiences. A notable exception seems to be the recent Falk and Balling (2010) study, which found that Nigerian subjects who are unacquainted with savannahs prefer this type of biome, over other (more familiar) biomes. According to Falk and Balling this replication of their earlier results (see Balling and Falk, 1982, p. 11) with non-western individuals suggests that our species "... begin[s] life with a preference for savanna-like environments". While the available cross-cultural research unquestionably yields valuable insights, much more research with non-western(ized) samples and more direct measures of restoration are needed before a claim to universality of restorative responses can be justified.

Biophobia supports phytophilia

A second argument, put forward by Ulrich (1993), starts off from the claim that our evolved human nature contains defence mechanisms against certain natural threats, such as snakes or spiders. Based on the assumption that such "biophobic" responses constitute only one half of a "'symmetric' biophobia/biophilia framework" (Ulrich, 1993, p. 88), Ulrich concludes that natural selection must also have endowed humans with mechanisms that make them respond positively to natural entities that were beneficial to their reproductive fitness. In a nutshell, Ulrich believes that proposals for an innate predisposition for (among others) phytophilia "... gain plausibility and consistency if they also postulate a corresponding genetic predisposition for adaptive biophobic responses to certain natural stimuli that presumably have constituted survival-related threats throughout human evolution (Ulrich, 1993, p. 75).

We think that the previous argument is flawed for two reasons. First, it needs to be kept in mind that the extent to which biophobic responses are actually "hardwired" is still debated (e.g., Blanchette, 2006). By extension, one should be careful about considering positive affective responses to greenery as innate or biologically prepared, especially since biophobic responses are explicitly studied to shed light on their possible evolved origins, while this is not, or only marginally the case for the former (cfr., Mineka and Öhman, 2002). A second issue is that there probably is no such thing as a "'symmetric' biophobia/biophilia framework". It rather seems to be the case that organisms are predominantly disposed to be hardwired to attend to and respond to threatening rather than to nonthreatening stimuli/situations. This is because failing to negoti- ate encounters with negative events/elements will have had much higher fitness costs (i.e., death) than failing to negotiate encoun- ters with positive elements/events (Baumeister et al., 2001). This "negativity bias" in evolution thus undermines the claim that the existence of a PRM gains plausibility from the existence of innate biophobic responses.

But suppose, for the sake of the argument, that there indeed is a symmetric biophobia/biophilia framework and that biophobic responses are truly hardwired. Even then, it still needs to be further explained and empirically justified why specifically phytophilic responses – and not some other type of positive response to nature – constitute the symmetric counterpart of biophobic responses. As should have become clear from the previous sections, current empirical research and theoretical arguments struggle to provide such a justification. It appears that the "biophobia means biophilia argument" can barely provide any additional support for the via- bility of the hardwired character of the PRM (see also: Joye and De Block, 2011 for a lengthier exposition of this specific argument).

Restorative responses to nature and perceptual fluency

As discussed in the introductory sections of this paper, SRT's core assumption is that phytophilic elements can quickly offset positive affective responses, which are able to attenuate stress. While in SRT's psycho-evolutionary framework such positive responses are deemed to be adaptive remnants of human evolution in natural environments, we hope to have demonstrated that this evolutionary account has clear shortcomings. It should yet be granted to Ulrich that his psycho-evolutionary account of restoration at least constitutes an attempt to provide a detailed answer to the question of why restorative responses to nature ultimately occur. This contrasts, for example, with Stephen Kaplan's rather crude view on the ultimate origins of restoration: "The way I think of it is that our ancestors evolved in a nature-filled environment.. [and that, as a result, such places] should feel more comfortable, more relaxed, more like home" (cited in: Jaffe, 2010, p. 12). Instead of such general statements, we are in need of a fine-grained causal account that actually addresses the question of how restorative responses come about.

One of the authors of the current article has tried to tackle the question of why unthreatening environments trigger positive affective responses by relating such responses to research on processing fluency (Joye, 2007). Processing fluency is commonly defined as the subjective experience of the ease with which a certain stimulus organization is processed. Research shows that fluent processing is commonly accompanied by positive affect, which is a finding that is ascribed to the fact that fluency points out that "good" and efficient stimulus processing is taking place or that sufficient cog- nitive resources are available to deal with a certain stimulus (Reber et al., 2004). Building on this fluency literature, the Perceptual Flu- ency Account (PFA) of restoration states that unthreatening natural scenes are affectively evaluated more positively than unthreaten- ing urban scenes because our visual system more fluently processes certain aspects of the visual structure of the former than of the lat- ter (see also Redies, 2007). According to PFA, restoration is – much like in SRT – the result of an "undoing process" initiated by positive affect, but in the case of PFA the affective response is due to fluent processing rather than to obscure evolutionary factors. Because PFA posits a processing advantage of natural/green settings over urban scenes, it expects that processing the former will require less cog- nitive resources than the latter, which conforms to the finding that exposure to nature is superior in counteracting attention depletion than urban scenes (Kaplan and Kaplan, 1989).

In a nutshell, PFA views attention restoration and stress reduction (to a considerable extent) as by-products of fluent processing. This theoretical account should, however, not be considered as a "paradigm shift" in restorative environments research. The account rather brings ideas to the foreground, which have been present in this field of research for quite some time, and it relates them to research on processing fluency. For example, the core idea of PFA is already present in ART, where the restorative construct of “fascination” (Kaplan and Kaplan, 1989) is commonly equated with effortless processing. Similarly, Ulrich et al. (1991, p. 205) have briefly alluded to ease of processing when they discuss the view “. . . that natural content may be processed with relative ease and efficiency because the brain and sensory systems evolved in natural environments”. Note that there already is some supporting evidence for PFA. For example, natural scenes are found to be categorized faster than artefactual scenes, which is consistent with the view of a fluency advantage of the former over the latter (e.g., Greene and Oliva, 2009). Fluency and coding efficiency have recently also been inquired by restorative environments researchers and the first results appear to be consistent with PFA (Tinio, 2010).

One of the main challenges for PFA is to pinpoint exactly which (visual) features make natural scenes more fluent than urban scenes. One proposal is based on the finding that natural environments are often experienced as being more coherent than the urban scenes with which they are compared in restorative environments studies (Kaplan and Kaplan, 1989). We conjecture that the higher perceived visual coherence of natural scenes makes that they are experienced as more fluent than their urban counterparts, which contributes to the difference in restorativeness between both scene types. We furthermore believe that this coherence of natural scenes is at least partly related to nature’s so-called “fractal” characteristics (Purcell et al., 2001; Joye, 2007). The notion “fractal” is a mathematical concept that is used to describe the mathematical “language” underlying (the visual aspects of) natural forms and processes. The fractality of natural environments and elements is – among others – clear from the fact that such shapes/scenes consist of increasingly smaller copies of themselves over a large number of scales of magnitude. For example, in a tree, all the branches – from big to small – are scaled-down versions of the entire tree. This property is also known as “self-similarity” and it makes that in nature one part of a scene already gives an idea of what is “going on” in other parts of the scene. In other words, natural environments are often characterized by a deep degree of perceptual predictability/redundancy, whereas urban scenes often tend to consist of perceptually divergent objects/processes, which compete for visual attention and therefore make the scene substantially less easy to grasp and process. The idea that fractality is a determinant of people’s responses to nature has already received some preliminary support. For example, Hagerhall et al. (2004) found that preference responses to natural scenes can be predicted by their fractal characteristics.

Discussion

The assumption that restorative responses to nature are an adaptive remnant of our species’ shared evolutionary history in natural environments has dominated research in environmental psychology since the 1980s. For a long time, this view has remained largely unquestioned. Possibly, this status quo has (partially) been fuelled by the concern that we would lose an argument for nature preservation if it would turn out that positive human affective attitudes to nature are not driven by a deeply engrained connection with nature (Wilson, 1984), but are the result of more malleable cultural dispositions. Despite its critical tone, the current review has been guided by a genuine concern for the future development of the field of restorative environments studies. Rather than thinking that our discussion limits this research field, we hope and anticipate that it will open up new avenues of empirical as well as theoretical research. We want to emphasize that the key theories on restora- tion (i.e., SRT and ART) are still highly relevant, despite the fact that they leave certain questions unanswered. For example, the alterna- tive account for restoration which we briefly touched upon in this paper (PFA), further builds on, and implements constructs that play a key-role in SRT and ART, such as positive affect and effortlessness.

We would like to highlight the relevance of our discussion for the field of urban forestry and urban greening. Specifically, it has been argued that because people have increasingly less opportunities for nature-contact in modern urban settings, they are becoming deprived of the possibility to experience nature’s psychological and health-related benefits (Van den Berg et al., 2007). Based on this, findings from restoration studies may offer landscape planners and architects a much-wanted psychological justification for green interventions in urban and peri-urban areas. But how does our theoretical discussion relate to the practice of urban green- ing? We are concerned that by embracing narrow evolutionary assumptions, the entire research field of restoration studies might all too hastily become refuted or marginalized by critics who do not subscribe to the value of restorative interventions, and that this, in turn, will hamper the process of urban greening. A criti- cal attitude toward prevalent evolutionary ideas, combined with a better informed insight into the specific mechanisms that lead to restoration, might provide a more solid theoretical basis for green interventions, and might take away reluctance to be associated with the field of restorative environments research.

Another reason why we think our discussion is relevant to urban forestry and urban greening is that the evolutionary assumptions which were considered in this article have guided, implicitly as well as explicitly, the restorative environments research agenda. When it is taken for granted that restoration is an ancient adaptive response, researchers might (quite understandably) not be very keen on exploring hypotheses that run against that evolutionary view. Going beyond the prevalent nature-urban dichotomy that is associated with SRT’s evolutionary framework might however reveal that not only pure green interventions, but also a mix of urban and natural environmental features can promote restora- tion. If true, the question of how to successfully merge nature and urban elements deserves further consideration (Joye, 2007). In addition, SRT’s psycho-evolutionary framework seems to sug- gest that the restorative effects of green interventions are largely independent from local and cultural contexts. As we have argued, this could well be an artefact of the fact that restoration research has thus far mainly focused on samples of higher-educated west- ern(ized) urbanites. We are convinced that the research field of urban forestry and urban greening can further chart individual differences in responding to nature and that by transcending the almost traditional urban-nature dichotomy it will play a pioneering role for the field of restorative environments research.

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