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ABSTRACT

Research on executive functioning and on self-regulation have each identified a critical resource that is both central to that domain and is susceptible to depletion. In addition, studies have shown that self-regulation tasks and executive functioning tasks interact with each other, suggesting that they may share resources. Other research has focused specifically on restoring what we propose is the shared resource between self-regulation and executive functioning. Utilizing a theory-based natural environment intervention, these studies have found improvements in executive functioning performance and self-regulation effectiveness, suggesting that the natural environment intervention restores this shared resource.

KEYWORDS - Fatigue; Restoration; Attention; Executive Functioning; Self-regulation

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We begin by examining the evidence that executive functioning – a high level cognitive mechanism – and self-regulation (Bronson, 2000; Baumeister and Vohs, 2004) – a mechanism involving the capacity to behave oneself and resist temptation; are both dependent on a common resource. ...

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James hypothesized that nebulous concepts such as will-power and effort are composed of more concrete processes such as attention. This idea of attention underlying will-power and effort is a central theme of this paper, and will help us to more specifically identify the shared resource common to self-regulation and executive function tasks.

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In considering work of this kind, it is important to distinguish the core of the self-regulation concept from the various ways it is expressed. Self-regulation tends to require going against one's inclinations, such as refraining from performing an action that is tempting (e.g., not eating an attractive food that would undermine one's diet) or performing a virtuous but unpleasant action when the alternative is more tempting (e.g., cleaning up a mess vs. walking away from it). Thus inhibiting a response can be seen as a common factor. ...

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ATTENTION RESTORATION THEORY

While the diversity of activities impacted by a depletion of this resource attests to its importance, it also presents a major challenge with respect to identifying the resource involved.

Two Types of Attention: Voluntary and Involuntary

Attention Restoration Theory (ART; Kaplan, 1995, 2001) offers an approach to understanding what is being fatigued or depleted in these studies, as well as suggesting how this element or resource can be restored. ART is based on an extension of James' (1892) approach; James identified two types of attention, distinguished in terms of the effort involved in their use. One type, which he called involuntary attention, refers to attention that requires no effort, such as when something exciting or interesting occurs. James described stimuli that bring forth involuntary attention as having a "direct exciting quality." With characteristic exuberance, he listed examples of such stimuli:

"strange things, moving things, wild animals, bright things, pretty things, metallic things, words, blows, blood, etc. etc. etc" (James, 1892; p. 88). James included in his list of involuntarily interesting stimuli such things as wild animals. One might interpret this as simply an act of "looking to discover what is going on" and hence assume that these interesting stimuli invoke an excitatory form of attention. However an additional adaptive benefit of this rather powerful inclination may well lie in the greater safety of keeping a potential source of danger in sight as opposed to turning one's back to it.

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In contrast, forcing oneself to pay attention to something that is not particularly interesting requires a good deal of effort. James called this kind of attention voluntary attention; clinical neurologists now refer to it as directed attention (Morecraft, Geula and Mesulam, 1993). Directed attention, by contrast, is not tied to particular stimulus patterns in the same way as involuntary attention. One's efforts may involve many specific contents, but the directed attentional component is generic, or content-free. Another potential difference between directed attention and involuntary attention is the dependence on frontal and parietal brain regions that are involved in cognitive control; directed attention is more reliant on these frontal and parietal cognitive control structures while involuntary attention is less so (Fan et al., 2005; Corbetta and Shulman, 2002). It is these neural networks that mediate cognitive control processes which we believe underlie the resource in question.

Another potential approach to distinguishing involuntary and directed attention is on the basis of automaticity; involuntary attention is automatically activated, while directed attention is not. As it turns out, however, there may not be a simple definition for what constitutes an automatic vs. non-automatic process. In Moors and De Houwer's thoughtful review of this topic (2006), they described automaticity as varying on a

number of dimensions such as: intentionality, goal directedness, goal dependence, controllability, bottom-up stimulus dependence (i.e., stimulus driven), consciousness, efficiency and speed. To further complicate matters each individual dimension does not exist in an all or none fashion (Bargh, 2006a, 2006b; Moors and De Houwer, 2006). We would argue that involuntary attention is more automatic than directed attention since it is more autonomous and stimulus-driven, as well as less goal-directed and controlled than directed attention.

Just as it is difficult to define an action as being entirely automatic or not, we would argue that tasks of attention are not either entirely voluntary or entirely directed; rather, tasks of attention vary in the proportion of involuntary and directed attention that is invoked. In addition, tasks that were once highly controlled as evidenced by performance and brain activation patterns can become less controlled and more automatic with practice as evidenced by changes in performance and brain activation (Chein and Schneider, 2005). These data suggest that tasks can change from requiring more directed attention to requiring less, thus becoming more involuntary in nature.

There are also neural data that show that, as we suggested earlier, directed attention and involuntary attention may have some different neural foci. For example, it could be argued that involuntary attention has some similarities to bottom-up attention, while directed attention may have more similarities to top-down attention. We make these comparisons because directed attention is less stimulus-driven than involuntary attention, and thus would be more related to top-down attention, while involuntary attention would be more related to bottom-up processing. Work on non-human primates has shown that bottom-up attention is driven more by parietal lobe neurons, whereas top-down attention is driven more by Pre-frontal Cortex (PFC) neurons (Buschman and Miller, 2007). Dissociations have also been found in human participants where top-down attention is mediated by more dorsal-anterior/frontal and parietal cortical structures, while bottom-up attention is mediated by more ventral frontal and temporal cortex as well as more sub-cortical structures (Fan et al., 2005; Corbetta and Shulman, 2002). It seems then, that the two types of attention have some dissociable neural signatures, suggesting that the psychological processes mediating the two types of attention are likely to be at least somewhat distinct.

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Attention in Context

Involuntary attention must have been at one time a profoundly adaptive force, since it automatically directed the organism's information processing toward things of importance in the environment. In the modern world, however, much of what is involuntarily interesting is not important. For example, images of things that were once important have been hijacked by advertisers and media managers for their own purposes. At the same time, as any grade school student could tell you, much of what is believed to be of great importance in the modern world is not all that interesting. Thus, in a world where the interesting may no longer be important and the important may no longer be

interesting, a strange thing has happened. Involuntary attention, once a highly adaptive mechanism, is now often used against one's own best interests. Thus directed attention becomes essential in pursuing one's purposes, especially as involuntary attention is increasingly irrelevant or even counter to these goals. In this very changed world, directed attention is called upon far more often than it once was, and perhaps at times more often than it is capable of responding to.

The Theory Behind ART

If indeed directed attention is, relatively speaking, "overused" in the modern world *and* of great adaptive importance, depletion of this mechanism is a serious matter, capable of causing considerable hardship and suffering. How can we restore such a vital resource?

ART has proposed a potential approach to facilitating recovery. It is based upon the simple premise that directed attention might be more likely to recover if it is allowed to rest. There would appear to be three primary means of helping such rest occur. One could sleep (although the body only seems to put up with a certain amount of sleep). One could meditate, which does appear to be effective, although it takes both knowledge and skill -- and a bit of patience (Kabat-Zinn, 1990). The third means would be to utilize involuntary attention so as to *not* utilize directed attention. This idea is consistent with Bargh and Chartrand's (1999) conclusion that more automatic mental processes free one's limited voluntary (or conscious) attentional processes (Kahneman, 1973; Miller, 1956; Posner and Snyder, 1975).

That is, the requirement for directed attention in such environments is minimized, and attention is typically captured in a bottom-up fashion by features of the environment itself. Crucially, in ART, such bottom-up attention needs to be sufficiently gentle so as not to interfere with other thoughts and is referred to as "soft fascination." Natural environments, such as parks, gardens, lakefronts, etc. are able to capture involuntary attention without monopolizing attentional channel capacity. At the same time the requirements to direct attention are minimized. It is therefore hypothesized that after an interaction with natural environments, one is able to perform better on tasks that depend on directed attention abilities (Berman, Jonides and Kaplan, 2008; Kaplan, 1995). Natural environments are certainly not the only environments capable of attracting involuntary attention without interfering with other thoughts, but do serve as good candidate environments that have been shown to restore directed attention abilities across a wide array of populations and situations.

Unlike natural environments, urban environments tend to be poor environments for restoring directed attention. Urban environments tend to contain bottom-up stimulation that does preempt capacity for other thoughts and in addition requires directed attention to overcome that stimulation (e.g., avoiding traffic, ignoring advertising, etc.), making urban environments less restorative (Berman, Jonides and Kaplan, 2008). Therefore, what makes an environment restorative is the combination of attracting involuntary attention softly, while at the same time limiting the need for directing attention.

While ART starts from James' voluntary vs. involuntary attention distinction, it also acknowledges a number of complications that call for a subtler theoretical formulation. These complications are of several kinds. First, the presence of automatic, effortless attention-holding stimuli (*fascination*) that softly attracts attention is very likely not the only factor that must be present for restoration to take place. ART posits three additional factors that contribute to restoration.

In addition to being in a fascinating environment, the environment in question must be *compatible*. In other words, the environment must not interfere with whatever purposes brought one to the setting. Thus if one is in a hurry to get home before it rains, an otherwise lovely creek that stands in the way of the route home would fail the compatibility test. It also helps if the environment appears to be large enough to permit one to explore, or at least imagine exploring it. Thus a single potted plant would fail the requirement for *extent*. And finally, a store filled with flowering plants would not meet the requirement for *being away* if it looks just like the workplace one is seeking a break from. Thus, while fascination is an essential aspect of a restorative environment, the other three requirements also play important roles.

It is important to explore the fascination concept in more depth, to understand why soft fascination is so pertinent to recovery. Unlike soft fascination, "hard fascination" is not as restorative since it precludes thinking about anything else. This may explain the limited restorative value of watching athletic events (Canin, 1991). Other examples of hard fascination include watching violence, sex and intense competition. "Soft fascination," is exemplified by looking at a scenic view or an interesting painting, which allows for reflection.

Along these same lines, Zeigarnik (1927) demonstrated that unresolved problems tend to lead to persisting memories and such unresolved problems could produce interference and thus hinder cognitive functioning for other tasks (Wixted, 2005; Berman, Jonides and Lewis, in press, Lewandowsky, Geiger, & Oberauer, 2008; Jonides et al., 2008). Therefore, these unresolved problems could create a kind of internal noise that would lead to excessive demands on directed attention. This might not have occurred if these problems had been worked through and put to rest (i.e., been reflected upon). Informal observation suggests that people often welcome involuntarily interesting stimuli that are so powerful that one is not disturbed by whatever is on one's mind. Such choices are essentially escapist; in other words, they preclude the very reflection that could facilitate the resolution of the disturbing cognitive process. Recent research has corroborated these themes. Pennebaker and colleagues have shown that writing about one's feelings and experiences can have therapeutic value by promoting reflection and limiting brooding (Gortner et al., 2006). In addition, such writing may also reduce the inclination to suppress the thoughts and feelings that lead to stress (Pennebaker, 1997). Kross and Ayduk (2008) have shown that self-distanced perspective taking can lead to better emotion regulation than distraction or self-immersed perspective taking. Distraction was shown to have only short-term benefits, while self-distanced perspective taking (i.e., reflection) had both long and short term benefits. Taken together, these results suggest

that reflecting on problems, in constructive ways, leads to their resolution, while distraction does not.

The short-term pay-off of the distraction provided by highly fascinating stimulation (i.e., “hard fascination”) is obvious. However, the long-term outcome might be that the very problems that might benefit from some reflection do not get resolved. By contrast, the soft fascination offered by natural environments has been found to facilitate such needed reflection³. In the end this needed reflection will expedite problem solving and in the long run free directed attention resources from having to manage these persistent problems.

Attention Restoration Studies

At this point we have explained the theoretical basis of ART, and in particular how natural environments can serve to restore directed attention abilities. In this section we summarize empirical evidence supporting this theory. Table 1 provides a sampling of the diversity of populations, settings, and sources of nature in studies generated by ART. Cumulatively, we believe these studies offer some support for ART; we also include them because one of the primary motivations for writing this article is to make more visible the diversity of opportunities for research and treatment suggested by these findings.

The studies presented in the table are unusual not only in using the natural environment as an independent variable, but also in their applied contexts. Applied research rarely permits random assignment or control over as many extraneous variables as would be possible in the laboratory. Nonetheless applied contexts can reveal practical implications of realistic interventions.

Resource depletion is, of course, a common theme across all studies in this area, although the sources of the depletion vary. The lab studies tend to use demanding information processing tasks to create this deficit. The application-oriented studies, in contrast, identify individuals or groups experiencing the sorts of life problems that typically drain one’s resources. They include being diagnosed with a life-threatening illness, caring for a partner with AIDS, being sufficiently old and functionally compromised to have been placed in a home for the elderly, being incarcerated, living in the uncertain and hazard-filled environment of a large urban public housing project, and (admittedly mild by contrast) coping with a demanding job or academic schedule.

³ Cimprich (1993, Cimprich & Ronis, 2003) has long worked with recovering cancer patients, including attending support group meetings. She reports (personal communication) that it is common at these meetings for recovering patients to talk about how supportive of reflection they find being in nature. This is consistent with work of Herzog et al. (1997), who report that participants rate natural environments as more likely to support reflection than other environments.

Table 1 Summary of Studies Using Nature Interventions

Study	Sample	Nature Contact	Design	Psychological Outcome Measures
Berman et al. (2008) Study 1	College students	2.8 mile walk	Within-subject	DSB
Berman et al. (2008) Study 2	College students	Slides	Within-subject	ANT; DSB
Berto (2005)	College students	Slides	Random assignment	SART
Cackowski & Nasar (2003)	College students	Video	Random assignment	Frustration tolerance
Canin (1991)	AIDS care-givers	Listed activities	Correlational	Questionnaire-based: "Robust Functioning"; "Restorative Evaluation"; "Caregiver Fatigue"
Cimprich (1993)	Cancer patients	20 min. outdoor – primarily walking & gardening; 3 times/wk	Random assignment	Alphabet backwards, DSB, DSF, Letter cancellation, SDMT
Cimprich & Ronis (2003)	Cancer patients	120 min. of outdoor time per week	Random assignment	DSB, NCPC, SDMT, Trail Making a & b
Kaplan (1984)	Wilderness program participants	10-day wilderness program	Pre-post	Questionnaire-based: "Psychological energy"; "Simple life style"; "Positive outlook"; "Hassled"
Kaplan (1993)	Office workers	Window view	Correlational	Questionnaire-based: "Job challenge"; "Task enthusiasm"; "Patient"; "General Health"
Kuo & Sullivan (2001b)	Public housing residents	Presence of trees & grass near residence	Random*	DSB; Conflict Tactics Scale
Moore (1981)	Prison inmates	Prison cell view	Random*	Frequency of visits to health care facility
Ottosson & Grahn (2005)	Residents of home for elderly	1 hour outdoors and 1 hour indoors	Within-subject	DSB, DSF, NCPC, SDMT
West (1986)	Prison inmates	Prison cell view	Random*	Frequency of visits to health care facility

Outcome measures: ANT - Attention Network Task; DSB - Digit span backwards; DSF – Digit Span Forward; Letter cancellation - ; NCPC – Necker Cube Pattern Control ; SART – Sustained Attention to Response Test; SDMT – Symbol Digit Modalities Test;

*Indicates that assignment was random, but the randomization was not experimentally controlled

While the studies differ widely in context, there are many overlaps in the dependent variables. Many of the studies – both applied and lab-based – include performance measures that provide relatively objective assessments of attentional functioning. Other studies use these in combination with self-report measures or rely exclusively on participants' assessment of their functioning.

The table lists the studies in alphabetic order. A more informative grouping, however, may be in terms of their context. Many of the earliest studies (Canin, 1991; Cimprich, 1993) focused on issues of health or health care. Several studies under the direction of Kuo and Sullivan (2001a, 2001b) were carried out in the context of a bleak public housing facility in Chicago. Other studies involved a wide range of topics and contexts related to outdoor settings, including recreational hiking and a two-week wilderness program, as well as more passive contact with nature provided by the view from the window (e.g., in dormitories, prisons, and workplace). More recently, several researchers have focused on studying these issues in the laboratory context, using information processing tasks and restorative interventions involving either nature scenes or walks in a natural environment.

It may be useful to discuss a few of these studies in more detail.

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A Chicago public housing facility provided the context for a research program conducted by Kuo, Sullivan, and their students. While self selection is a likely threat to validity in residential contexts, in this case, as documented by Kuo (2001), the study can assume random assignment given the constraints placed on residents in being placed in the housing project. The research program concerns the impact of access to natural environments (with a particular emphasis on trees) on cognitive abilities. The participants, however, did not consider vegetation in making their choice when offered a housing unit. When the researchers inquired about this issue almost all participants (93%) indicated it made no difference; for the remaining seven per cent vegetation was no differently available than for the rest of the sample.

Kuo and Sullivan (2001b) found that residents who had nature near their apartments were less likely to use aggression and violence in dealing with problems. For our purposes another striking aspect of their findings was that a statistical analysis showed that this effect could be explained by differences in attention and memory capacity as measured by DSB (i.e., those with nature views had greater attention and memory capacity which may have mediated their lower aggression levels).

Ottosson and Grahn (2005) studied the effects of nature on elderly people in a nursing home. Each participant performed the DSF, DSB and the SDMT tasks before and after an hour spent either indoors or outdoors to test participants' directed attention capacities. All participants participated in both conditions in a counterbalanced fashion. The results of the study were that the hour outdoors in nature improved directed attention capacity

significantly more than the indoor intervention. This study was particularly interesting in finding significant results on each of these measures of attention despite a small sample.

Cackowski & Nasar (2003) studied the possibility that the availability of nature views while driving might reduce the incidence of road rage. Participants watched one of 3 videos taken while driving on highways with different amounts of vegetation and different degrees of spatial edges provided by trees. The higher the level of natural scenery, the greater the frustration tolerance the participants demonstrated on a subsequent task.

Berto (2005) provides another current example of the positive effects of nature. The study involved performing the sustained attention response task (SART), which is a modified go-nogo task, before and after viewing pictures. For different groups these pictures consisted of restorative environments (lakes, trees, mountains etc.), non-restorative environments (skyscrapers, buildings, streets etc.), or geometric figures. Participants who viewed the restorative pictures improved their performance on the SART task (as measured by reaction time and sensitivity). Participants who viewed either of the other two categories of pictures showed no improvement in SART performance.

In addition, Berman, Jonides and Kaplan (2008) have shown that simple walks in a park can have restorative effects on working memory as measured by the DSB task, which has a large attentional component as items must be moved in and out of the focus of attention. The participants in these studies were healthy college age students, and suggest that the benefits of restoration can be applied to a wide range of people. In addition, these same findings were replicated when participants viewed pictures of nature. Importantly, when the Attention Network Test (ANT; Fan et al., 2002; 2005) was used as a dependent measure, only the executive portions of the task that required directed attention were improved showing the selectivity of improvement to directing attention as opposed to improving attention of all kinds.

Sleep and meditation may also have similar restorative benefits compared to nature interventions. Chervin et al., (2006) found that children previously diagnosed with ADHD, show reductions in ADHD like symptoms after having tonsillectomies, which improve sleep in these children. In fact, a year after having tonsillectomies, half of the children once diagnosed with ADHD, were no longer diagnosed with ADHD. Here it seems that improvements in sleep were associated with improvements in self-regulation. Kaplan (2001) has also hypothesized that meditation may be able to restore directed attention abilities, and others have found that meditation did alter activity in brain circuits that are active in executive functioning and self-regulation tasks as well as performance on such tasks (Cahn and Polich, 2006; Davidson et al., 2003; Tang et al., 2007). In addition, Tang et al. (2007) found other physiological changes with meditation such as reductions in cortisol concentration.

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In summary, evidence from a variety of sources speaks to the potential usefulness of an intervention based upon attention restoration theory (ART) to improve cognitive executive functioning and self-regulation. While contact with natural environments is not unique in its therapeutic value, it has been tested and found to be a successful restorative intervention across many domains, tasks, and participant populations.

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Summary

Today's world presents numerous challenges to maintaining one's focus. It offers a plentiful supply of interesting, but unimportant stimulation, while many important stimuli lack interest. Thus people must *ignore* much of what surrounds them. This act seems to require frontal and parietal brain mechanisms that mediate cognitive control and are susceptible to fatigue. In order, to replenish these resources, a person should engage in activities high in soft fascination that will activate involuntary attention in non-conflicting ways. We have cited a variety of studies which show how interacting with such environments can restore and even improve directed attention abilities.

| The following excerpt is optional.

Television

As the analysis of the importance of reflection suggests, modern life brings with it innumerable complexities, puzzles and frustrations. While reflection can be helpful in reducing the internal noise, the process is not necessarily pain free. Many a modern individual would welcome a means of shutting down this internal clutter. Not only "would" but also "does," since television offers a quick and effortless way to achieve this.

One might think that, far from being a problem, this handy electronic internal-noise-management-system presents an ideal solution to this endemic problem. As we have seen, however, it does not. Since television takes advantage of involuntary attention, one might think that watching is effortless. However, there are certain contexts in which involuntary attention can lead indirectly to considerable effort. Consider what can occur in the context of conflict. When one's gaze is held by something painful to look at (such as a face disfigured by an accident), effort is often involved in trying to resolve the conflicting inclinations – to look and to look away.

Television is, as Mander (1978) so effectively points out, exquisitely designed to discourage one from leaving the channel one is watching. In other words, television creates attentional capture. One indication that this is an unsatisfactory state of affairs is that a large percent of television watchers wish that they could spend less time watching. (Kubey and Csikszentmihaly, 1990) Thus, the very act of watching would be likely to

create a conflict situation. One indication that this is the case is that the longer people watch television, the more irritable they become. Thus the very activity that many people think of as recreational is in fact increasing mental fatigue rather than reducing it.

While conflicted fascination is for the most part rare, it is not only common in the context of television, but possibly central to understanding its effects. Since guilt and discontent are fairly common reactions to watching television (Kubey & Csikszentmihalyi, 1990), it is reasonable to assume that many people watch television more than they intend to. A growing body of research points to what is called a television addiction. In other words, people are unable to resist spending more time engaging in this activity than they would consider healthy or desirable. Therefore, it is not surprising that people report lower life satisfaction and more anxiety after watching TV (Frey, Benesch and Stutzer, 2007).

Incisive and thoughtful as Mander's perspective is, it would be more reassuring if there were data that spoke directly to these issues. Fortunately such data have been collected. Vividly aware of the problem of post hoc verbal report, Kubey and Csikszentmihalyi (1990) developed the Experience Sampling Method, which they have used extensively.

As we have seen Kubey and Csikszentmihalyi (1990) report that "guilt about watching TV is fairly common" (p. 145). Further, consistent with the non-restorative effect we hypothesized, "viewers tend to feel passive and less alert after viewing" (p. 172.) Other indications that viewing does not produce the positive effects of the typical restorative environment are also evident from Kubey and Csikszentmihalyi's (1990) analysis of their data: ". . . people reported feeling relatively less relaxed, happy, and satisfied after viewing than after the other activities studied"(p.134). And consistent with our hypothesis that television is not a healthy solution to the internal noise problem, "Viewing is often driven by the wish to escape" (p.172). Therefore, we conclude that TV is a counterproductive means of restoring directed attention.