

Attention Restoration Theory: Exploring the Role of Soft Fascination and Mental Bandwidth

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Abstract

Soft fascination is a key but underexamined element of Attention Restoration Theory (ART). According to ART, attending to softly fascinating stimuli not only requires little effort but also leaves mental space for reflection. We propose that soft fascination can be characterized as the interaction of both attentional effort and mental bandwidth and hypothesize that the restorative potential of everyday activities can be categorized based on this interaction. In an online survey, 398 adults rated four activities on Mental Bandwidth (MB), Perceived Restorativeness (PR), and preference. Supporting the hypothesis, the results showed that walking in nature was perceived as softly fascinating, whereas watching television was a source of hard fascination. Furthermore, PR, but not MB, was highly correlated with preference. Findings are discussed in the context of developing a measure to help people better anticipate activities that may or may not be restorative.

Keywords

perceived restoration, reflection, attentional effort, mind wandering, preference, default network

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According to Attention Restoration Theory (ART; Kaplan, 1995), natural environments are ideal places to restore diminished attentional capacity. Nature's ability to moderately hold one's attention while leaving sufficient headspace for reflection permits the "essential mental housekeeping" (Kaplan, 1993, p. 48) necessary to address lingering, unresolved thoughts that could otherwise be a drain on attentional resources. ART describes this modest attentional hold as "soft" fascination. By contrast, "hard" fascination occupies the mind fully, leaving little space for contemplation.

The distinction between these two types of fascination is relevant to the choice of environments people seek for restoration. Although natural environments are conducive to restoration, not everyone turns to them when fatigued. Rather, many retreat to movies and television when seeking relaxation. Such decisions may be driven by what people *perceive* to be restorative. By measuring properties of restorative environments proposed by ART (i.e., Being Away, Fascination, Extent, and Compatibility), a substantial amount of research has focused on perceived restoration. Across many of these studies, results have shown natural settings to be perceived as restorative, and such settings are also frequently shown to be preferred (Han, 2010; Ivarsson & Hagerhall, 2008; Purcell, Peron, & Berto, 2001; Staats, Jahncke, Herzog, & Hartig, 2016; van den Berg, Hartig, & Staats, 2007; Wilkie & Stavridou, 2013). The numerous studies using Perceived Restorativeness Scales (PRSSs; e.g., Han, 2003; Hartig, Evans, Jammer, Davis, & Garling, 2003; Hartig, Korpela, Evans, & Gärling, 1997; Laumann, Gärling, & Stormark, 2001) consider fascination broadly without adequately distinguishing between hard and soft fascination. This omission is problematic. Although ART predicts that soft fascination has superior restorative potential to hard fascination, situations affording hard fascination may be more entertaining and thus more appealing (Herzog, Chen, & Primeau, 2002). For example, television, social media, and other popular modes of escape and "chilling out" are emblematic of hard fascination. Utilizing measures that fail to differentiate soft and hard fascination may erroneously lump nature walks and television in the same restorative category. This article attempts to tease apart these two varieties of fascination by examining the role attentional effort and mental bandwidth play in the restorative experience.

To convey in more detail how fascination impacts restoration, we begin with a brief discussion of the attentional mechanisms that underpin ART. The central premise of ART is that there are two distinct modes of attention. The first, Directed Attention, involves the volitional and effortful control of attention. Over time, exerting this form of attentional control drains the limited resource of Directed Attention, eventually leading to mental fatigue and symptoms such as distractibility, impulsivity, and irritability. The restoration

of Directed Attention requires “an alternative mode of attending that would render directed attention temporarily unnecessary” (Kaplan, 1995, p. 172). Kaplan originally called this alternative mode “involuntary,” following William James’s (1962/1892) discussion of attention, and later referred to it as “fascination” because it draws on our attraction to fascinating stimuli without requiring sustained effort or conscious control. To minimize confusion, we have chosen to refer to this second mode of attention as “effortless.” These two attentional modes—Directed Attention and Effortless Attention—can be thought of as complementary but separate systems that can, and often do, operate in parallel. The attention restoration mechanism proposed by ART depends on engaging the Effortless Attention mode, so that demands on Directed Attention are reduced enough to allow this limited and finite attentional mode to rest and restore itself. Thus, although restoration depends on easing the demands on Directed Attention, it does not necessarily require eliminating this attentional activity entirely.

Soft and Hard Fascination

Although attending to fascinating stimuli is effortless and presumably allows Directed Attention a respite, Kaplan (1995) noted that not all kinds of fascination are equally restorative. Stimuli categorized as “hard” fascination forcefully grab one’s attention and are difficult to resist. As a result, they tend to fill the mind, leaving little room for more peripheral mental activity or reflection. The sight of a snake is a classic example of hard fascination, but movies and television provide more common encounters. By contrast, stimuli classified as “soft” fascination, while still capturing attention effortlessly, do not entirely occupy the space in one’s head. Simple elements in nature, such as wind blowing through leaves or ripples of water traveling across a pond, are classic examples of soft fascination. These types of stimuli capture attention more loosely, permitting unrelated thoughts to emerge. Such elements offer “a special advantage in terms of providing an opportunity for reflection, which can further enhance the benefits of recovering from directed attention” (Kaplan, 1995, p. 172).

Thus, reflection plays a second-order role in the restorative process. Whereas a diminished load on Directed Attention directly permits its restoration, reflection can reduce the internal noise that would otherwise burden Directed Attention. Such a burden can be cognitively expensive because, as Zeigarnik (1927) showed long ago, unfinished thoughts tend to linger in the mind. This lingering can be a continuing drain on attentional resources. Therefore, a robust restorative experience not only needs to allow Directed Attention a rest but also would afford opportunities to reflect on and address

internal noise (Kaplan, 1993). Settings and activities that draw on soft fascination aid attention restoration by leaving enough free mental space to reflect on thoughts that are often running around in one's head. One may find such opportunities for reflection during a walk in the woods or a brief respite looking out the window. Such softly fascinating stimuli may make it easier for one to recognize and process such thoughts. The consistent finding that natural environments provide attentional benefits (e.g., Bowler, Buyung-Ali, Knight, & Pullin, 2010; Bratman, Hamilton, & Daily, 2012; Kaplan & Berman, 2010) implicitly supports the beneficial role of soft fascination.

Although hard and soft fascination are often characterized by environmental properties, as von Lindern, Lyneus, and Hartig (2016) point out, "restorative environments research does not focus on particular environments, defined only in some objective sense, but on transactions that join a person and an environment" (p. 188). The various kinds of fascination reside neither in the environment nor in the person but "rather refer to the transaction between them" (Collado, Staats, Corraliza, & Hartig, 2017, p. 130). The role of fascination in restoration is thus a transaction between qualities of the environment and the person's past experiences as well as current state. Our study incorporates the person side of the transaction, focusing on the mental states environments afford their inhabitants.

Mental Bandwidth

Fascination is characterized by a state that requires little mental effort to pay attention. However, mental effort alone is not sufficient to distinguish between soft and hard fascination. This distinction also depends on how much mental space is available. This notion has similarities to what computer scientists sometimes call bandwidth, referring to a system's available capacity to process data. We adapt this terminology, defining *mental bandwidth* as the amount of space available in one's head for processing. Fascination can then be characterized as an interaction of attentional effort and mental bandwidth. Specifically, soft fascination requires being effortlessly engaged while simultaneously having some free mental bandwidth for reflection. By contrast, hard fascination is characterized by effortless attention and little available mental bandwidth.

Mental bandwidth may also be used to differing degrees under the Directed Attention mode; some contexts may require high levels of Directed Attention and leave little room for other thought, whereas other contexts may require only moderate levels and leave some room for reflection. In parallel with the terminology of hard and soft fascination, we might call these hard and soft *focus*, respectively. Everyday activities readily fit into these categories.

Reading a book can be a mind-filling activity that requires attentional effort (hard focus), whereas watching the movie version requires far less effort but can be equally mind-filling (hard fascination). Walking in nature can engage the mind without filling it (soft fascination), whereas running errands might require some attention but leave enough mental space for reflection (soft focus). Whether these activities lead to attention fatigue or restoration depends on not only the attention mode being utilized (i.e., Directed Attention or Effortless Attention) but also the mental bandwidth occupied.

Attempts to assess mental bandwidth may provide insight into the settings and activities that individuals typically consider restorative. As mentioned previously, many people seem to associate settings and activities that they find enjoyable with low attentional effort and greater restorative potential. Although many settings and activities that we prefer are in fact less demanding of attentional effort, they may not be equally restorative due to variable demands placed on mental bandwidth. This problem, of confounding preference with restorative potential, has been a concern in numerous studies on perceived restorativeness (Berto, 2014) and raises questions about whether measures of attentional effort alone are good indicators of restoration. Asking individuals to consider the mental bandwidth an activity or setting affords may be less influenced by how much that particular activity or setting is preferred.

Links to Neuroscience

Although soft fascination has not been explicitly studied with brain imaging, the neuroscience literature provides some support for our characterization of soft fascination as a function of attentional effort and mental bandwidth. One line of evidence supports the notion of varying levels of attentional effort. Different brain regions are responsible for different aspects of attentional effort. For example, the dorsal attention network is recruited when we focus on stimuli in the external world, akin to Directed Attention (Corbetta, Patel, & Shulman, 2008). The ventral attention network automatically shifts our attention to salient stimuli, akin to Effortless Attention of the hard fascination variety (Corbetta et al., 2008). The volitional control of attention has been linked to a set of regions in the brain known as the executive network (Petersen & Posner, 2012). When attentional demands are reduced, another set of brain regions (prefrontal cortex, posterior cingulate cortex/precuneus region, and the temporoparietal junction) known as the default network is recruited (Christoff, Irving, Fox, Spreng, & Andrews-Hanna, 2016; Raichle, 2015). This network shows activity during attentional processes that are driven from the bottom-up, allowing a response to both cues in the

environment and internal thoughts (Andrews-Hanna, Smallwood, & Spreng, 2014; Leech & Sharp, 2014).

Studies on working memory capacity support the notion of mental bandwidth and its role in reflection. These indicate that working memory capacity is limited (Cowan, 2010), implying that bandwidth can be used up completely as in the cases of hard fascination or hard focus. According to Smallwood and Schooler (2006), situations that place fewer demands on working memory capacity permit “a state of decoupled information processing,” (p. 956) where attention can shift from monitoring the external environment to internal thoughts. This suggests that having available bandwidth affords more opportunities for reflection. Furthermore, Soto and Silvano (2014) discuss emerging research showing that placing greater demands on working memory can interfere with our ability to employ subconscious modes of processing and recognize residual thoughts lingering below conscious awareness. Thus, lower available bandwidth may prevent the resolution of internal noise. Periods of low processing demand (i.e., high available bandwidth) have also been linked to mind wandering (Christoff et al., 2016; Immordino-Yang, Christodoulou, & Singh, 2012; Mason et al., 2007; Schooler et al., 2011), a family of spontaneous thought processes that include reflection, daydreaming, self-awareness, planning, and other forms of internally generated thought (McMillan, Kaufman, & Singer, 2013). Under such conditions, mental bandwidth is available and little attentional effort is required, suggesting a state similar to soft fascination.

Simultaneous activity has been observed in both default and executive networks during mind wandering (Christoff, Gordon, Smallwood, Smith, & Schooler, 2009), suggesting that Directed Attention and Effortless Attention need not operate in a mutually exclusive fashion and that attending to one's internal thoughts is possible during a restorative experience. This parallel operation supports the resolution of internal noise through incubation (Baird et al., 2012; Posner, 1973) that includes both conscious reflection and subconscious processing. Based on these studies, we would expect soft fascination, which is characterized by a diminished burden on both Directed Attention and mental bandwidth, to be associated with greater opportunities for reflection and attention restoration.

Activities Varying in Attentional Effort and Mental Bandwidth

Figure 1 shows how hard/soft fascination and hard/soft focus could be characterized by differing levels of attentional effort and mental bandwidth. High mental bandwidth denotes when there is space for mind wandering and

	High Attentional Effort (Directed Attention)	Low Attentional Effort (Effortless Attention)
High Mental Bandwidth (Available space for reflection)	Soft Focus; Uses Directed Attention, but allows resolution of internal noise <i>Activity:</i> Hanging out at home	Soft Fascination; Permits resolution of internal noise <i>Activity:</i> Walking in nature
Low Mental Bandwidth (No space for reflection)	Hard Focus; Uses Directed Attention and impedes resolution of internal noise <i>Activity:</i> Using a smartphone	Hard Fascination; Impedes resolution of internal noise <i>Activity:</i> Watching television

Figure 1. Activities varying in a 2×2 space of attentional effort and mental bandwidth.

reflection, whereas low mental bandwidth leaves little space for such internal processing. Effortless Attention is engaged by fascinating circumstances, whereas less fascinating ones may require some amount of Directed (or effortful) Attention to carry out one's purposes. Under Effortless Attention, low and high bandwidth equate to the ART notions of hard and soft fascination, respectively. Similarly, under Directed Attention, low and high bandwidth equate to hard and soft focus, respectively.

Figure 1 also lists four everyday activities characterizing the interaction of attentional effort and mental bandwidth. "Walking in nature" and "watching television" both draw on Effortless Attention but differ with respect to mental bandwidth. The soft fascination afforded by nature walks leaves room for processing internal noise and permits the recovery of Direct Attention. This idea is supported by the large research literature examining the restorative impacts of natural settings and, in particular, the finding that nature settings are seen as being particularly supportive of reflection (Herzog, Black, Fountaine, & Knotts, 1997). By contrast, the hard fascination associated with watching television requires little attentional effort as the content is often engaging but consumes a great deal of bandwidth leaving little mental headspace to address other thoughts. Although many people turn to television as a way to relax, the low available bandwidth raises

doubts about the restorative benefits of this activity. Kaplan and Berman (2010) have endorsed a similar view, arguing that the restorative potential of television is questionable and that watching television might actually interfere with reflection. These ideas are bolstered by research suggesting that television can impose a significant cognitive load on viewers (Lang, Kurita, Gao, & Rubenking, 2013) and reduce feelings of self-awareness (Moskalenko & Heine, 2003).

The two remaining activities depicted in Figure 1, “hanging out at home” and “using a smartphone,” represent ordinary activities that are more likely to demand Directed Attention but differ in how much space they allow for reflection. Hanging out at home is a source of soft focus, where some attentional effort is required but mental bandwidth is still available because of the stable and predictable setting. This perspective is consistent with emerging theoretical and empirical evidence indicating that time spent at home can support emotion regulation and attention restoration (Graham, Gosling, & Travis, 2015; Hartig, Johansson, & Kylin, 2003; Meagher, 2016). However, using a smartphone is a source of hard focus given that activities such as browsing, searching, and messaging demand attentional focus and leave little mental bandwidth for reflection or contemplation. Although there is limited research on the cognitive demands associated with smartphones, there is evidence suggesting that smartphone use can lead to acute declines in attentional functioning (Ward, Duke, Gneezy, & Bos, 2017; Wilmer, Sherman, & Chein, 2017).

Hypotheses

Thus far, we have characterized soft fascination as a function of attentional effort and mental bandwidth. The remainder of the article presents an empirical test of this claim. Based on ART and theories of reflection and mind wandering discussed earlier, we develop a scale to measure the amount of mental bandwidth an activity is perceived to occupy, and we assess its psychometric properties. The mental bandwidth scale, along with the four activities described in Figure 1, is then used to test the following hypotheses:

Hypothesis 1: Mental bandwidth and attentional effort are independent dimensions of attention restoration.

Hypothesis 2: Mental bandwidth is less susceptible to preference judgments than measures of attentional effort.

Hypothesis 3: Measuring both attentional effort and mental bandwidth distinguishes soft and hard fascination.

Method

Research Design

This exploratory study utilized a 2×2 , nonexperimental, within-subjects design. Data were gathered using an online survey. The independent variables were attentional effort and mental bandwidth, each split into two levels (Figure 1). Four activities (walking in nature, watching television, hanging out at home, and using a smartphone) were chosen to represent the four conditions in the 2×2 factorial design (soft fascination, hard fascination, soft focus, and hard focus). The dependent variables were participants' self-assessments of mental bandwidth, perceived restorativeness, and preference. Each participant rated all four activities on the three dependent variables.

Constructs and Measures

Sampling everyday activities. The four activities operationalizing the attentional effort $\times$ mental bandwidth conditions (Figure 1) were selected based on the criteria that they are highly familiar, easily envisioned, have a range of preferences, and evoke different levels of restorative potential. Each activity was described as a 30 minute activity (the exact wording is provided in parentheses). As described earlier, *walking in nature* ("taking a walk in a nearby park or natural area") was chosen to represent an activity that requires little attentional effort and allows for high mental bandwidth. As a result, walking in nature may offer opportunities to both disengage Directed Attention and address internal noise. *Watching television* ("watching a television program that you enjoy") was selected as it was presumed to not only require little attentional effort but also demand more mental bandwidth. *Hanging out at home* ("hanging out around the house by yourself without watching television or using a computer, smartphone, or tablet device") was nominated to represent an activity that may demand Directed Attention while still leaving high mental bandwidth. Finally, *using a smartphone* ("using your smartphone") was chosen to exemplify a typically high effort activity that also consumes a good deal of mental bandwidth.

Mental Bandwidth. The Mental Bandwidth (MB) scale is a 7-item self-report measure designed to assess mental activities associated with reflection, mental housekeeping, mind wandering, and heightened self-awareness—in other words, mental states that would be more easily permitted under high bandwidth conditions. The items (Table 1) were inspired by existing measures of mindfulness (Jacob, Jovic, & Brinkerhoff, 2009; Tanay & Bernstein, 2013) and the types of mental processes associated with default network activity,

Table 1. Mental Bandwidth Factors With Group Means for Each Activity.

	Activity				Alpha/ loading
	Nature	Home	Phone	TV	
	M (SD)	M (SD)	M (SD)	M (SD)	
Self-awareness	3.73 (1.00)	3.58 (0.97)	2.63 (1.09)	2.62 (1.04)	.72
Aware of things going on around you	3.96 (0.89)	3.69 (0.94)	2.73 (1.13)	2.80 (1.04)	.90
Able to take note of thoughts or feelings	3.51 (1.06)	3.47 (0.99)	2.53 (1.05)	2.44 (1.00)	.67
Daydreaming	3.58 (1.08)	3.42 (1.03)	2.53 (1.11)	2.39 (1.07)	.81
Lost in thought	3.45 (1.10)	3.28 (1.07)	2.43 (1.10)	2.24 (1.06)	.87
Letting your mind wander	3.71 (1.04)	3.56 (0.97)	2.62 (1.11)	2.53 (1.06)	.82
Planning	3.20 (1.12)	3.40 (1.07)	2.37 (1.13)	2.09 (1.05)	.83
Thinking about things you need to do	3.20 (1.13)	3.73 (0.96)	2.67 (1.12)	2.43 (1.11)	.84
Making plans for the future	3.16 (1.08)	3.30 (1.06)	2.39 (1.16)	1.92 (0.98)	.79
Reflecting on things that happened in the past	3.24 (1.15)	3.18 (1.10)	2.05 (1.01)	1.91 (0.96)	.62

Note. Question stem: "During this activity, to what degree are you ..." Scale: 1 = *not at all*, 2 = *a little*, 3 = *somewhat*, 4 = *a lot*, 5 = *extremely*.

such as reflection, daydreaming, and planning (Buckner, Andrews-Hanna, & Schacter, 2008; Greicius, Krasnow, Reiss, & Menon, 2003).

Principal component analysis reduced the seven scale items into three factors (Table 1). *Self-awareness* was about being aware of one's surroundings and one's internal thoughts. *Daydreaming* reflected being lost in thought and mind wandering. Finally, *Planning* included items related to thinking about tasks, making plans for the future, and reflecting on the past. Cronbach's alphas ranged from .72 to .83, indicating a high level of internal consistency for each of the factors. Correlations among the three factors were moderate, ranging from .56 to .66.

Perceived Restorativeness. The PRS has been widely used to assess the restorative potential of environments. As the purpose of this study was to assess activities, we utilized a modified Perceived Restorativeness for Activities Scale (PRAS). Norling, Sibthorp, and Ruddell (2008) developed this measure using items from the PRS to construct a parsimonious scale focused specifically on evaluating the perceived restorativeness of activities. The PRAS has demonstrated acceptable construct validity; confirmatory factor analysis has identified four distinct subscales (i.e., Being Away, Fascination,

Table 2. Perceived Restorativeness Factors With Group Means for Each Activity.

	Activity				Alpha
	Nature	Home	Phone	TV	
	M (SD)	M (SD)	M (SD)	M (SD)	
Being Away	3.97 (1.06)	2.88 (1.29)	2.84 (1.27)	3.54 (1.09)	.93
This activity helps me get away from it all	4.05 (1.02)	2.86 (1.33)	2.74 (1.28)	3.52 (1.08)	
This activity is an escape for me	3.93 (1.08)	2.82 (1.29)	2.96 (1.27)	3.60 (1.09)	
This activity helps me get relief from unwanted demands on my attention	3.92 (1.06)	2.95 (1.26)	2.82 (1.24)	3.49 (1.10)	
Extent	3.71 (1.09)	2.69 (1.26)	3.30 (1.21)	3.57 (1.07)	.92
This activity sustains my interest	3.74 (1.10)	2.65 (1.23)	3.25 (1.15)	3.57 (1.01)	
This activity has qualities that draw me further in	3.72 (1.10)	2.71 (1.25)	3.26 (1.21)	3.49 (1.10)	
Once I start this activity, I can easily get pulled in	3.66 (1.09)	2.72 (1.30)	3.38 (1.27)	3.65 (1.08)	
Fascination	3.76 (1.06)	2.55 (1.23)	3.05 (1.20)	3.19 (1.10)	.90
During this activity, my attention is drawn to many interesting things	3.83 (1.04)	2.78 (1.18)	3.16 (1.15)	3.07 (1.11)	
This activity has many fascinating qualities	3.73 (1.05)	2.49 (1.25)	3.09 (1.22)	3.22 (1.05)	
Participating in this activity is a captivating experience	3.72 (1.08)	2.39 (1.23)	2.90 (1.21)	3.28 (1.12)	

Note. Question stem: "Please indicate how much you agree with the following statements about this activity ...". Scale: 1 = *not at all*, 2 = *a little*, 3 = *somewhat*, 4 = *a lot*, 5 = *extremely*.

Extent, and Compatibility) that strongly resemble the subscales that comprise the PRS and parallel the theoretical constructs suggested by ART. The 9-item Perceived Restorativeness (PR) measure in the current study included slightly modified versions of the Being Away, Fascination, and Extent subscales from PRAS (Table 2). Items from the PRAS Compatibility subscale could not be used because our study stipulated goals and purposes for the activities.

Numerous items included in the PR scale, and the PRS/PRAS on which it is based, center on the effortless nature of the activity. The Fascination component of the PR scale (see Table 2) addresses this directly by measuring how little attentional effort is required (e.g., "This activity has many fascinating qualities"). Similarly, the Extent subscale taps the level of effortless engagement with an activity (e.g., "This activity has qualities that draw me further in"). And the Being Away subscale measures to what extent one feels removed from the draining demands of everyday life (e.g., "This activity helps me get relief from unwanted demands on my attention"). In this way, each of the

components of the PR scale taps different aspects of the attentional effort required by an activity.

Cronbach's alphas for the PR factors ranged from .90 to .93 (Table 2), showing that the established components of Being Away, Extent, and Fascination held up well. However, the correlations between the factors were also high, ranging from .77 to .86, suggesting there is substantial overlap in what is being measured by the different factors.

Preference. A single-item ("I like doing this activity") was used to assess preference for each of the activities, following approaches used in other perceived restoration studies (e.g., Ivarsson & Hagerhall, 2008) as well as many studies of environmental preference (Herzog, Maguire, & Nebel, 2003; Nordh, Hartig, Hagerhall, & Fry, 2009; Staats, Van Gernerden, & Hartig, 2010).

Participants

In total, 539 Mechanical Turk workers responded to a request to participate in a 10 minute online survey in exchange for modest monetary compensation. Of those, 141 were screened out by quotas or attention checks. The remaining 398 were from 47 U.S. states and the District of Columbia. The sample was split almost equally between men (198) and women (199), with one respondent marking "other" for gender. The age distribution was skewed toward the younger side as would be expected from Mechanical Turk workers (Paolacci, Chandler, & Ipeirotis, 2010). However, quotas effectively limited those under 30 years to one third of the sample with the remaining respondents in their 30s (28%), 40s (17%), 50s (15%), 60s (7%), and 70s or above (1%). One third of the sample had a bachelor's degree and 19% had graduate education. Out of the total respondents, 40% had children who are less than 18 years old in their household.

Procedure

The online survey was created in Qualtrics and posted as a Human Intelligence Task on Amazon's Mechanical Turk via TurkPrime.com (Litman, Robinson, & Abberbock, 2017). Participants were asked to consider questions related to mental bandwidth, perceived restorativeness, and preference in the context of spending 30 minutes doing each of the four activities. The order of the activities was randomized as were items within each of the MB and PR scales. However, the question regarding preference for a particular activity was always placed at the end of the PR items so as not to bias answers relevant to

that activity. The survey also contained two attention checks to ensure that participants were reading the questions. Participants who failed to answer these questions correctly were screened out of the study. The participants meeting the criteria were each paid US\$0.90 for completing the study. The study procedures and survey questions were submitted to a university-affiliated institutional review board (IRB) and deemed exempt from IRB oversight. In addition to the MB, PR, and Preference scales for each of the four activities, the survey included a variety of demographics questions. The survey also contained several other questions that are beyond the scope of this article.

Analysis

Analysis was carried out in R (R Core Team 2015) using the packages psych (Revelle, 2016), lme4 (Bates, Mäechler, Bolker, & Walker, 2015), lsmeans (Lenth & Hervé, 2015), and ggplot2 (Wickham, 2009). Common themes across the MB scale were identified using principal component analysis with Varimax rotation on scale items across all four activities simultaneously. This was done with a long form data set created by stacking the four within-subject activity ratings for each participant. Items with loadings greater than 0.55 were included, and items loading on more than one factor were excluded. Cronbach's alpha and composite scores were calculated for each of the factors. For the PR scale, we calculated the Cronbach's alpha to confirm the internal consistency of Being Away, Fascination, and Extent subscales and generated the composite scores for each subscale. Pearson correlation coefficients were calculated between the factors of each scale to further address internal consistency.

To address Hypothesis 1, Pearson correlation coefficients were calculated between MB and PR subscales. Similarly, Hypothesis 2 was tested with correlations between Preference and the two scales. Hypothesis 3 was addressed by testing for significant differences between activities for the MB and PR subscales as well as Preference. The data were modeled using a linear mixed effects model which parameterizes both the fixed effect, accounting for the group differences in ratings between the four activities and the random effects, accounting for the correlation of each participant's ratings across the four activities. Model p values were obtained using likelihood ratio tests, using a *chi-square* metric, of the full model with the effects in question against the model without said effects. For pairwise comparisons across the set of four activities, p values were obtained using Tukey post hoc comparisons. In short, the mixed effect model accounts for within-subject correlations that result from repeated measures across the four activities and permits a test of whether those activities are significantly different from one another on the MB, PR, and Preference scales.

Table 3. Correlations Between Mental Bandwidth, Perceived Restorativeness, and Preference.

		Mental Bandwidth			Perceived Restorativeness		
		SA	D	P	BA	E	F
Mental Bandwidth	Self-Awareness						
	Daydreaming	.56					
	Planning	.65	.66				
Perceived Restorativeness	Being Away	.19	.23	.04			
	Extent	.08	.09	-.07	.78		
	Fascination	.19	.19	.03	.77	.86	
Preference	(Single item)	.15	.12	-.05	.77	.81	.77

Note. SA = Self-Awareness; D = Daydreaming; P = Planning; BA = Being Away; E = Extent; F = Fascination.

Results

Hypothesis 1: Independence of Mental Bandwidth and Attentional Effort

The correlations between MB and PR factors ranged from $-.07$ to $.23$ (Table 3), indicating low overlap between the two scales. Figure 2 shows the mean values for each of the four activities across each of the MB and PR subscales as well as preference. Nature walks received the highest ratings on all but one of the subscales, supporting their capacity for requiring little attentional effort while still leaving ample mental bandwidth for reflection. By contrast, the other three activities show distinct and varied patterns. Means for using a smartphone and watching TV were lower than the scale midpoint on MB but mostly higher for PR. This suggests that although Phone and TV may be engaging, they leave little room for reflection. Conversely, spending time at home rated low on PR and high on MB, suggesting that activities that require some attentional effort may still provide the mental bandwidth necessary for restoration. The different group mean patterns between PR and MB scales, corroborated by the low inter-scale correlations (Table 3), reinforce the hypothesis that PR and MB are independent of each other and measure different dimensions of restoration.

Hypothesis 2: Mental Bandwidth Is Less Susceptible to Preference Judgments Than Measures of Attentional Effort

Correlations between preference and the three PR subscales were very high, ranging from $.77$ to $.81$ (Table 3). By contrast, the correlations between

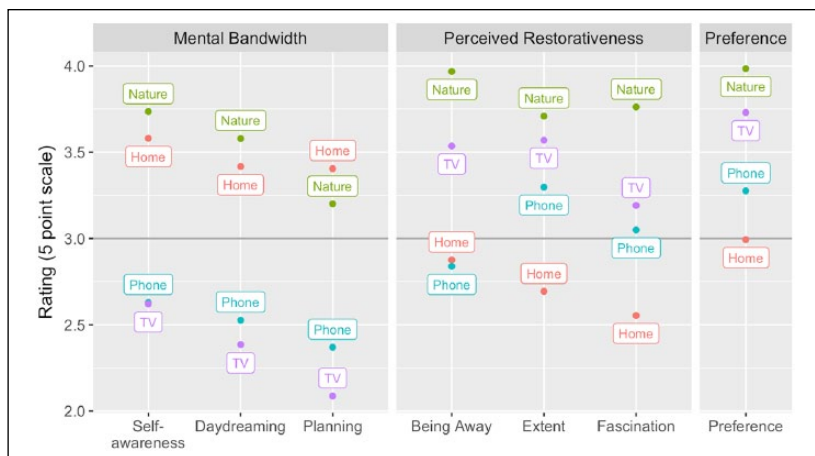


Figure 2. Mean ratings of Mental Bandwidth, Perceived Restorativeness, and Preference for four everyday activities.

Note. Scale: 1 = not at all, 2 = a little, 3 = somewhat, 4 = a lot, 5 = extremely.

preference and the three MB subscales were quite low, ranging from $-.05$ to $.15$. As shown in Figure 2, preference ratings followed the same ordering for the PR Fascination and Extent subscales and nearly the same for the Being Away subscale. However, that ordering was markedly different from the MB subscale orderings that had lower ratings for TV and smartphone than their preference ratings. These findings not only support the hypothesis that assessments of mental bandwidth are less susceptible to preference judgments than assessments of attentional effort but also raise questions about whether existing measures of perceived restorativeness are confounded by how much enjoyment an individual anticipates receiving from an experience or activity.

Hypothesis 3: Measuring Both Attentional Effort and Mental Bandwidth Distinguishes Soft and Hard Fascination

On average, participants rated the activities differently in each of the MB and PR subscales (Table 4). Post hoc comparisons showed a significant difference between each of the activities, with two exceptions. For the Being Away subscale of PR, being at home and phone use had similar ratings, both well below ratings for watching television and nature walks. For the Self-Awareness subscale of MB, ratings for using a smartphone and watching TV were indistinguishable, reflecting a decreased awareness during screen-time activities.

Table 4. Activity Differences Across Mental Bandwidth and Perceived Restorativeness Factors.

	Mental Bandwidth			Perceived Restorativeness			Preference
	SA	D	P	BA	E	F	(Single item)
$\chi^2(3)$	928.25	1,390.6	912.81	883.95	635.38	803.68	187.12
Nature	3.73 (1.00)	3.58 (1.08)	3.20 (1.12)	3.97 (1.06)	3.71 (1.09)	3.74 (1.06)	3.98 (1.03)
Home	3.58 (0.97)	3.42 (1.03)	3.40 (1.07)	2.88** (1.29)	2.69 (1.26)	2.62 (1.23)	2.99 (1.27)
Phone	2.63* (1.09)	2.53 (1.11)	2.37 (1.13)	2.84** (1.27)	3.30 (1.21)	3.17 (1.20)	3.28 (1.18)
TV	2.62 ^a (1.04)	2.39 (1.07)	2.09 (1.05)	3.54 (1.09)	3.57 (1.07)	3.38 (1.10)	3.73 (0.99)

Note. Each factor model was modeled separately and each was significant at $p < .0001$. Group means are shown for each activity followed by the standard deviation in parentheses. Group differences were tested between activities within each factor and, unless denoted by a superscript, all were significant at $p < .01$. SA = Self-Awareness, D = Daydreaming, P = Planning, BA = Being Away, E = Extent, F = Fascination. * $p = .9990$. ** $p = .8141$.

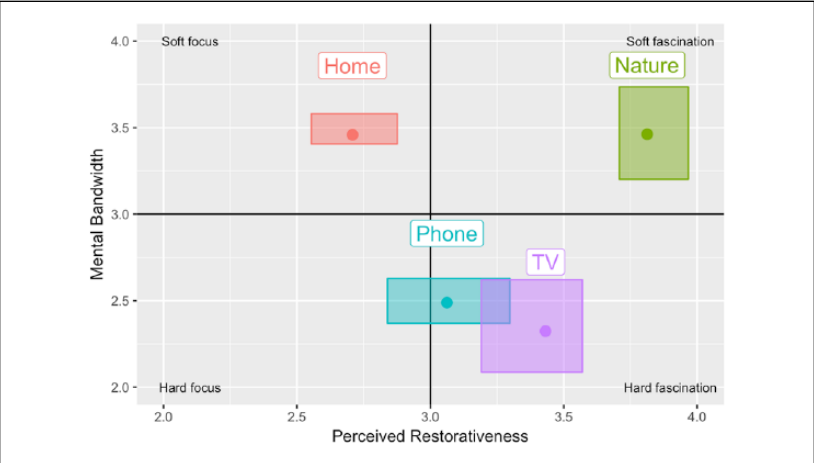


Figure 3. Differentiating everyday activities according to hypothesized dimensions of hard/soft fascination and hard/soft focus.
Note. The rectangles represent the spread of the means over the three Mental Bandwidth and three Perceived Restorativeness factors for each activity. The xy-coordinates of the point inside the rectangle represent the mean of each scale over its corresponding factors. Scale: 1 = not at all, 2 = a little, 3 = somewhat, 4 = a lot, 5 = extremely.

Figure 3 shows a two-dimensional space with PR on the horizontal axis and MB on the vertical axis. Each of the four activities is represented by a rectangle. The horizontal and vertical edges of the rectangle depict the range of means for the PR and MB subscales, respectively. The point inside each rectangle represents the overall mean across the PR and MB subscales.

The midpoint of each 5-point scale, at a value of “3” and corresponding to the label “somewhat,” divides the figure into four quadrants corresponding to the cells of Figure 1. The upper right quadrant represents soft fascination and contains nature walks that consume little mental bandwidth and rate high on PR subscales, indicating a lower requirement of attentional effort. The lower right quadrant representing hard fascination contains watching television, which is perceived to require less attentional effort but does not seem to facilitate planning or mind wandering, as indicated by low mental bandwidth ratings. Smartphone use overlaps both lower quadrants indicating that it allows less bandwidth but with varying levels of attentional effort. The upper left quadrant contains hanging out at home, which is perceived to require some attentional effort but also allows more mental bandwidth. The span of activities across all four quadrants supports our hypothesis that measuring both attentional effort and mental bandwidth can distinguish between the theoretically proposed categories of hard and soft fascination.

Discussion

ART posits that soft fascination permits reflection and the resolution of internal noise. This, in turn, reduces future attentional demands and enhances recovery from mental fatigue. Because soft fascination is characterized by low attentional effort and high available bandwidth, this study incorporated measures of both PR and MB. PR measures the degree to which an activity is perceived to be fascinating, offers extent, and provides an escape, directly assessing components of ART. As with other measures of perceived restorativeness, PR focuses on the perceived qualities of an activity (e.g., “This activity has many fascinating qualities” and “This activity is an escape for me”) providing a sense of how much attentional effort activities are perceived to require. The MB measure, first used in this study, incorporating items such as “Lost in thought” and “Reflecting on things that happened in the past,” asks participants about the mental state produced by specific activities. The three empirically derived MB subscales—Self-Awareness, Daydreaming, and Planning—thus focus on the anticipated mental state rather than the perceived qualities of the activity. To test the hypothesis that attentional effort and mental bandwidth are independent dimensions, we asked participants to rate each of four everyday activities using both PR and MB measures. The resulting low correlation between the two scales supports that, at least for the activities addressed in this study, MB and PR are distinct concepts. For example, people may find watching television “fascinating,” “captivating,” or an “escape” (PR) but may not feel it allows them to notice lingering thoughts or reflect on the past (MB).

The choice of the four activities reflected our expectation that each required different levels of attentional effort and allowed for different levels of mental bandwidth (Figure 1). One of the activities, walking in nature, represented soft fascination, whereas the other three represented hard fascination (watching TV), hard focus (using a smartphone), and soft focus (hanging out at home). The pattern of participant responses across the MB and PR scales largely supported our hypotheses and raises questions about whether PRS-based scales alone predict what would be restorative. Three out of four categories were represented by the activity we expected (Figure 3). The exception was for hard focus, which was not represented by smartphone use or any of our chosen activities. Rather, participants rated using a smartphone as leaving little bandwidth but ratings varied widely in terms of how much attentional effort it required. This may reflect the various ways in which people use their phones as well as individual differences in handling technology. Hard focus may have been better represented by more clearly effortful activities, such as studying for an exam. Watching television was seen as equally bandwidth-consuming as smartphone use but required less attentional effort, well characterizing hard fascination. For soft focus, participants perceived hanging out around the house as not particularly interesting and somewhat effortful, as indicated by low PR scores, but also anticipated that it would not use up mental bandwidth. Familiar places such as the home may seem routine and mundane, but they may also reduce the need for constant vigilance allowing some bandwidth for reflection. Nature walks, as expected, reflected soft fascination requiring less effort, allowing for high bandwidth. In total, participant evaluations of the various activities suggest it is possible to distinguish different types of fascination and focus by measuring both effort and bandwidth.

Although differing substantially with respect to bandwidth, both watching TV and walking in nature rated highly on PR, suggesting that PRS-based scales may not adequately discriminate between hard and soft fascination, a distinction that is central to ART. Such scales might improperly identify activities that appear fascinating and effortless as restorative. Also, seemingly mundane activities might allow for reflection but be miscategorized as fatiguing. For example, hanging out at home rated low on PR but still offered opportunities for reflection.

Also noteworthy are the correlations between preference and the PR and MB subscales. The low correlation between preference and the MB subscales suggests that participants could separate how much they liked an activity from their assessments of planning, daydreaming, and self-awareness. That MB seems unrelated to preference judgments may be because its items are emotionally neutral, asking participants to reflect rather dryly on their mental state. This introspective approach may help participants anticipate the mental

states that are conducive to attention restoration without conflating it with preference. By contrast, the high correlation between each of the PR subscales and preference possibly reflects the positive sounding language of the PR items. It suggests that, in answering how fascinating or interest-sustaining they find an activity, participants may be influenced by how much they like it thus profoundly undermining the construct validity of this measure. This mirrors other findings of high correlations between PRS items and preference (Herzog et al., 2003). Given the host of published studies that rely on PRS-based measures (e.g., Ivarsson & Hagerhall, 2008; Laumann et al., 2001; Purcell et al., 2001; Staats et al., 2016; Wilkie & Stavridou, 2013), the biasing effect of preference in assessing perceived restoration is cause for concern. In principle, attention restoration and preference need not be correlated. Although it is hardly surprising that preferred places and activities would also be restorative, there is nothing about the underlying constructs that assumes such a relationship. Whether or not they are perceived as such, even lackluster activities may permit restoration of depleted attentional resources. In other words, although people are generally sensitive to what they like, they may be far less cognizant of their attentional capacity (Lin, Tsai, Sullivan, Chang, & Chang, 2014).

Limitations

This study is an initial foray into considering how mental bandwidth plays a role in perceived attention restoration. As such, it bears the limitations of the perceived restorativeness measures it draws on as well as limitations of the newly developed MB measures. We developed the MB measures to tap states of reflection that are thought to be associated with soft fascination, which is predicted by ART as necessary for restoration. The measure has not received formal validation and needs further development in its sampling of concepts. The use of an introspective measure may also be problematic as we may not have intuitive access to and foresight of our mental bandwidth, though self-report measures have been shown to be reliable (Antrobus, Coleman, & Singer, 1967).

In addition, two issues may raise construct validity concerns. Although incorporating a multi-item measure of preference would reduce the potential for mono-operation bias, our study follows the pattern of many studies that have assessed preference with a single-item (Herzog et al., 2003; Nordh et al., 2009; Staats et al., 2010). Assessing one exemplar activity for each quadrant of the attentional effort and mental bandwidth matrix also poses issues in terms of a mono-operation bias. Sampling a larger set of activities should be a goal of future research.

The use of scenarios is also a potential limitation to the internal validity of the study. However, scenarios have been widely used in research, including research related to ART. For example, Staats, Kieviet, and Hartig (2003) used scenarios to get participants to envision attention fatigue and included manipulation checks that confirmed that participants were able to use the procedure. More recently, Staats et al. (2016) investigated the restorative potential of urban settings by asking participants to think about doing activities alone or with others in a city park, cafe, shopping mall, and along a busy street. Again, manipulation checks indicated that participants were capable of imagining themselves doing these activities in each of the settings described. The measures of von Lindern's (2017) online survey were also based on perceived experiences, including the "need for restoration after they have experienced a situation that they described as a typical source of stress in their daily life" (p. 11). Similarly, Laumann et al. (2001) asked participants to rate the restorative features of two imagined settings—a nearby, familiar natural environment and an urban environment. As daily functioning and conversation often draw on envisioning places and activities, it is not surprising that such tasks have not been problematic in research settings.

Contributing to the external validity of the study, the task in our study draws on highly familiar and frequently enacted activities. However, as with scenarios used in other studies, such a task cannot precisely control for what participants might think about doing during those activities or what aspect of the activity they are considering. Each of the activities permits a wide variety of circumstances and experiences: a nature walk can be threatened by a downpour or accompanied by chirping birds, the television program may be a horror movie or a nature film, the smartphone may be the source of unwanted news or a time to connect with friends, and hanging out at home may be a time for relaxing on the sofa or doing household chores. Although we did not ask participants to elaborate, the brief scenarios (e.g., "taking a walk in a nearby park or natural area") included some guidance with respect to potential confounders, such as spending time at home without screen-time.

Despite this potential source of variation across participants, the significant differences between average ratings of the activities across the scales (Figure 3) suggest that participants made relatively clear distinctions between the scenarios. One possible explanation may be that participants' responses are based on their internal summary of experiences with the activities, representing a kind of prototypical encounter rather than an idiosyncratic one. Although tighter control of the activities may be desirable, it is worth noting that because participants are given the opportunity to envision the activities in ways that are normal for them, their responses may be more realistic, thus improving the generalizability of the findings. What is more, how we

envision different activities has real-world consequences. When we consider whether to take a walk or watch a television program, for instance, our expectations about these experiences play a role in directing our behavior.

Conclusion

Mental bandwidth as a psychologically important construct is not new. For example, it has been used to explain how poverty creates internal noise—in the form of concerns about making rent, keeping one's family safe, and searching for employment—that reduces the brain's capacity for problem-solving and decision-making (Mullainathan & Shafir, 2013). More generally, situations and activities consuming mental bandwidth have been linked to a diminished ability to exert executive control and actively control attention (Schilbach, Schofield, & Mullainathan, 2016). Although mental bandwidth has not previously been used in the attention restoration literature, many studies examining mental fatigue have focused on populations who might also have diminished mental bandwidth due to increased internal noise from being poor (Kuo, 2001; Kuo & Sullivan, 2001), being incarcerated (Moore, 1981), suffering from illness (Cimprich, 1992, 1993; Merriman et al., 2011), or caring for the ill (Canin, 1991). In these situations, people may be particularly vulnerable to opting for activities that may, in fact, undermine their need for reflection. Using the mental bandwidth concept to distinguish hard and soft fascination may be valuable for considering ways to assess and alleviate the attentional demands imposed by such challenging contexts.

The differences between the four activities revealed by the combined use of the PR and MB scales suggest the need to better understand the role these different dimensions play in attention restoration. Although PRSs are widely used, the roles of soft fascination and reflection in the restoration process have largely been ignored. Walking in nature is a common focus of attention restoration studies but the other three activities, although they represent typical ways to cope with mental fatigue, have not been studied in the context of ART. Considering the time people spend in front of screens versus walking in nature, it is imperative to understand how such common activities might differ in supporting restoration. Incorporating mental bandwidth into measures of perceived restoration may illuminate these differences.

Although this study did not address actual restoration, a future study might consider how well different perceived restoration measures can predict actual restoration. This would help validate and further extend ART, which is now over 20 years old. Such an effort might help develop a measure, perhaps like the MB scale presented here, that helps people anticipate what might be restorative. This would certainly benefit those of us who are not particularly perceptive about what is and is not restorative.

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