

1 **Title:** Exposure to Awe-evoking Natural and Built Scenes has Positive Effects on  
2 Cognitive Performance and Affect

3  
4 **Authors:**

5 Silvia Collado<sup>1\*</sup> & Héctor Marín Manrique<sup>1</sup>

6  
7 <sup>1\*</sup>Department of Psychology and Sociology, Universidad de Zaragoza, Spain. Email:  
8 [scollado@unizar.es](mailto:scollado@unizar.es); [manrique@unizar.es](mailto:manrique@unizar.es)

9  
10 \*Direct all correspondence to Silvia Collado, Department of Psychology and Sociology,  
11 Universidad de Zaragoza, Ciudad Escolar, 44003, Teruel, Spain; email  
12 [scollado@unizar.es](mailto:scollado@unizar.es)

#### 14 **Acknowledgments**

15 We thank Y. Joye for kindly sharing the stimuli used in a previous study of the effects  
16 of exposure to extraordinary scenes. This study was supported, in part, by the Spanish  
17 Ministry of Science, Innovation and Universities (PGC2018-095502-B-I00) and FUAG  
18 (2018/B008). We also thank the two anonymous reviewers for their work and insightful  
19 comments.

20

21

1 **Abstract**

2 We investigated the possible restorative effects of exposure to awe-evoking scenes  
3 (natural/built) compared to mundane scenes (natural/built). A careful selection of visual  
4 stimuli was carried out, followed by an experiment with 250 participants. We included a  
5 mentally fatigued condition and a not mentally fatigued condition (i.e., control group).  
6 Participants' performance on an attentional task and positive affect were recorded  
7 before (T0) and after (T1) exposure to one of four slideshows (i.e., natural/built, awe-  
8 evoking; natural/built, mundane). In addition, participants reported how restored they  
9 felt after the slideshow presentation, and how awe-evoking and familiar the slideshow  
10 was for them. Our depletion task did not affect participants' performance on the  
11 attentional task at T0, so we cannot claim that psychological restoration took place.  
12 Nevertheless, we found positive effects of exposure to awe-evoking scenes, and we  
13 provide alternative explanations for these effects.

14 *Keywords:* awe; experiment; instoration; restoration; affect; well-being

15

1           It has been empirically demonstrated that exposure to nature provides people  
2 with various benefits. Overall, experiences in nature enhance attentional capabilities and  
3 positive affect (Hartig, Evans, Jamner, Davis, & Gärling, 2003; Hartig, Mitchell, De  
4 Vries, & Frumkin, 2014; Kaplan & Kaplan, 1989; Ulrich et al., 1991), lower blood  
5 pressure (Hartig et al., 2003; Kelz, Evans, & Röderer, 2015) and heart rate (Laumann,  
6 Gärling, & Stormark, 2003), encourage prosociality (Guéguen & Stefan, 2014;  
7 Weinstein, Przybylski, & Ryan, 2009), and have vitalizing effects (Ryan et al., 2010).  
8 Most studies on the benefits of nature exposure have been conducted as part of the  
9 research on restoration. By restoration, we refer to the recovery of adaptive resources  
10 that have been depleted in meeting the demands of everyday life (Hartig, 2004; Staats,  
11 2012). Based on attention restoration theory (ART; Kaplan & Kaplan, 1989),  
12 researchers have demonstrated that direct visual contact with nature leads to the process  
13 of restoration (Collado, Staats, Corraliza, & Hartig, 2016; Hartig, 2004; Hartig et al.,  
14 2014; Staats, 2012).

15           The majority of studies on restoration has investigated whether exposure to  
16 everyday natural settings, as opposed to built settings or scenes, has restorative benefits.  
17 For instance, researchers have examined the restorative benefits of the presence of  
18 nature within the neighborhood (Kuo & Sullivan, 2001) or school grounds (Kelz et al.,  
19 2015), and of a natural view from home (Kaplan, 2001) or one's office (Chang & Chen,  
20 2005). Restoration is not exclusively linked to natural settings. Time spent in settings  
21 without prominent natural features, such as monasteries (Ouellette, Kaplan, & Kaplan,  
22 2005), houses of worship (Herzog, Ouellette, Rolens, & Koenigs, 2010), contemporary  
23 urban neighborhoods (Karmanov & Hamel, 2008), and urban plazas (Abdulkarim &  
24 Nasar, 2014), can also be restorative.

1           The use of everyday settings in the above-mentioned studies makes sense for  
2 practical reasons (i.e., they are the most frequently encountered), but people are also  
3 attracted to extraordinary scenes and phenomena outside their everyday environment,  
4 and they actively seek experiences in which they can encounter such scenes (Suedfeld,  
5 2012; Van Cappellen & Saroglou, 2012). By extraordinary scenes, we refer to sights  
6 that are highly memorable and special, the experience of which is characterized by  
7 emotional intensity (Jefferies & Lepp, 2012). These experiences are evoked by exposure  
8 to both natural and built scenes, such as a mountain view (Shiota, Keltner, & Mossman,  
9 2007) or an exceptionally high building (Joye & Dewitte, 2016). Examples include  
10 views of the Grand Canyon and the Egyptian pyramids. Exposure to everyday natural  
11 scenes, as well as to extraordinary ones, has positive effects such as improved well-  
12 being (Rudd, Vohs, & Aaker, 2012), reduced aggressive behavior (Yang, Yang, Bao,  
13 Liu, & Passmore, 2016), and increased pro-social orientation (Joye & Bolderdijk,  
14 2015).

15           The restorative potential of exposure to extraordinary scenes has been suggested  
16 (Joye & Bolderdijk, 2015; Williams & Harvey, 2001), but to the best of our knowledge,  
17 it has not been systematically investigated. In the current study, we intend to fill this gap  
18 in the literature by empirically examining the possible restorative effects of exposure to  
19 either natural or built extraordinary scenes, compared to exposure to everyday scenes.  
20 We focus on the emotion of awe, evoked by contemplating extraordinary scenes, and its  
21 possible relation to restoration. In the psychological study of awe, the terms awe-  
22 evoking and extraordinary have been considered synonymous (e.g., Joye & Bolderdijk,  
23 2015). Although there may be subtle differences between the two (e.g., not all  
24 extraordinary scenes are necessarily awe-evoking, but awe-evoking scenes are usually  
25 extraordinary), given the present study's scope, and in the interest of clarity, we refer to

1 extraordinary scenes as awe-evoking scenes. In the following sections, we briefly  
2 review the literature on the emotion of awe and the elicitors and effects of awe-evoking  
3 experiences; and we comment on the possible link between restoration and awe that is  
4 the basis for the current study.

## 5 **The Emotion of Awe**

6 Religion, philosophy, sociology, and psychology, among other disciplines, have  
7 all taken an interest in the emotion of awe, so a systematic review of the literature on  
8 awe would be excessive for the purposes of the present study. We focus instead on two  
9 systematic evaluations of awe that offer a comprehensive framework for this emotion  
10 and describe specific features of awe experiences. Keltner and Haidt (2003) define awe  
11 as a complex emotional response to perceptually vast stimuli that require mental  
12 accommodation. Those authors link awe to different experiences, including religious  
13 episodes of clairvoyance, encountering charismatic leaders (e.g., Jesus, Ghandi), facing  
14 powerful forces unleashed by nature, and even contemplating exceptionally beautiful  
15 works of art (e.g., Mona Lisa). According to Keltner and Haidt (2003), vastness does  
16 not necessarily refer to physical size, because it can apply to anything that is  
17 experienced as being much bigger than oneself. Accommodation, in turn, refers to the  
18 mental process that takes place during unfamiliar experiences that cannot be directly  
19 incorporated into our mental schemas. Keltner and Haidt (2003) propose that emotional  
20 experiences that do not have one or both of the core features of awe (i.e., vastness and  
21 accommodation) should not be categorized as awe experiences. For instance, if a  
22 stimulus is not vast but it prompts accommodation, it would produce surprise, a basic  
23 emotion whose facial expression is almost identical to the one triggered by awe (Haidt  
24 & Keltner, 1999).

1           The framework Halstead and Halstead (2004) propose to study awe is quite  
2 similar to Keltner and Haidt's (2003) in that it draws parallels between awe and wonder.  
3 These authors consider them twin terms, and yet awe is both narrower and broader than  
4 wonder. It is narrower because awe is a certain kind of wonder, and it is broader  
5 because awe can spur feelings that far exceed the magnitude of those evoked by  
6 wonder. Halstead and Halstead (2004) view awe as an emotion experienced when  
7 facing something vast and more powerful than the self. An important aspect that  
8 distinguishes Halstead and Halstead (2004) from Keltner and Haidt (2003) is their  
9 emphasis on experiencing awe as a solemn, reverential feeling. Halstead and Halstead  
10 (2004) see awe experiences as having a sort of sacred or transcendent character.  
11 Another difference between the two frameworks lies in the idea that fear is part of the  
12 awe experience. For Keltner and Haidt (2003), fear is mainly experienced when the  
13 new, extraordinary scene cannot incorporate into the person's mental schemas, whereas  
14 Halstead and Halstead (2004) conceive of fear as being inherent to awe and, hence,  
15 inseparable from awe-evoking experiences. While acknowledging the potential for fear  
16 in some awe-evoking experiences, we will focus on the positive side of this complex  
17 emotion, because we intend to explore restoration, one of various known positive  
18 effects of human-environment transactions (Kaplan & Kaplan, 1989; Ulrich et al.,  
19 1991).

20           We know relatively little about the causes and consequences of awe (Vining &  
21 Merrick, 2012). The scarce empirical evidence accumulated to date has shown that  
22 natural scenes and phenomena (e.g., tornadoes, panoramic views, the ocean, and the  
23 forest) are among the main elicitors of awe (Keltner & Haidt, 2003; Shiota et al., 2007;  
24 Van Elk, Karinen, Specker, Stamkou, & Baas, 2016; Williams & Harvey, 2001). As  
25 Keltner and Haidt (2003) mentioned, not all natural environments are necessarily awe-

1 evoking. Extraordinary natural views and phenomena seem to induce awe more easily  
2 and intensely than everyday nature (Joye & Bolderdijk, 2015; Keltner & Haidt, 2003).  
3 In addition, exposure to human-made scenes like large cathedrals (Keltner & Haidt,  
4 2003; Vining & Merrick, 2012) and exceptionally high structures (Joye & Dewitte,  
5 2016) also trigger awe. As in the case of natural scenes, not all human-made creations  
6 are awe-evoking, only those with the characteristics Keltner and Haidt (2003) described.

### 7 **Restoration and Awe**

8         ART conceptualizes directing attention as a capacity, and a resource to be  
9 replenished. Accordingly, restoration requires an antecedent condition of depleted  
10 directed attention, or attentional fatigue. Restorative environments help people recover  
11 their attentional capabilities by engaging another mode of attention: involuntary  
12 attention (Kaplan & Kaplan, 1989). Because of its effortless character, using  
13 involuntary attention allows directed attention to rest and recover. Kaplan and Kaplan  
14 (1989) refer to involuntary attention as soft fascination, which they consider one of the  
15 four characteristic components of restorative environments. The other components are  
16 *being away* (i.e., mentally escaping everyday thoughts and concerns), *extent* (i.e., the  
17 environment is rich and coherent enough to constitute an entirely new world), and  
18 *compatibility* (i.e., the environment is in agreement with one's purpose and  
19 inclinations). According to ART, fascination can be provoked by the content of a scene,  
20 including wild animals, panoramic views, strange things, and unusual architectural  
21 features (Kaplan, 1995; Kaplan & Berman, 2010). Since awe is experienced when one  
22 faces stimuli that are unusual, extraordinarily beautiful, vast, or requiring psychological  
23 accommodation (Adler & Fagley, 2005; Keltner & Haidt, 2003), awe-evoking stimuli  
24 might be especially attention-grabbing. Supporting this idea, some of the positive  
25 psychological effects of awe-evoking experiences are quite close to what are generally

1 understood as restorative outcomes, for example, feelings of leaving everyday worries  
2 behind, fascination, novelty, absorption, relaxation, and compatibility with the  
3 environment (Vining & Merrick, 2012; Williams & Harvey, 2001). However, the  
4 relation between exposure to awe-evoking stimuli and restoration does not seem simple.  
5 For example, it is also conceivable that awe-evoking scenes and phenomena are deeply  
6 fascinating or, in Kaplan and Kaplan's (1989) terms, hard-fascinating, and so they  
7 attract people's attention. Meanwhile, one might require cognitive resources to mentally  
8 process such stimuli, thereby hindering the restoration process. Nevertheless, the fact  
9 that a stimulus strongly attracts our attention does not necessarily preclude a process of  
10 restoration (Joye & Dewitte, 2018). Unfortunately, no studies to date have  
11 experimentally examined the restorative potential of exposure to awe-evoking scenes.  
12 Hence, the question of whether exposure to awe-evoking scenes is restorative remains  
13 unanswered.

#### 14 **The Present Study**

15 Building on previous studies on awe (Joye & Bolderdijk, 2015; Joye & Dewitte,  
16 2016; Piff, Dietze, Feinberg, Stancato, & Keltner, 2015; Williams & Harvey, 2001), our  
17 primary aim is to contribute to the research in this area by taking a closer look at a  
18 specific, positive psychological effect of exposure to awe-evoking scenes, namely, its  
19 restorative effect. In doing so, we examine the possible restorative effect of exposure to  
20 awe-evoking natural and built scenes, compared to mundane natural and built scenes.  
21 Previous studies examining the positive psychological effects of exposure to awe-  
22 evoking (vs. mundane) scenes have used only natural (Joye & Bolderdijk, 2015) or only  
23 built (Joye & Dewitte, 2016) images. This makes it impossible to investigate whether  
24 there are differences in the restorative effects of awe-evoking versus mundane natural or  
25 built environments. Nature is generally thought to be one of the most powerful awe



1 elicitors (Keltner & Haidt, 2003; Piff et al., 2015; Shiota et al., 2007). Moreover,  
2 restoration theories support the premise that natural environments are generally more  
3 restorative than non-natural settings (Kaplan & Kaplan, 1989; Ulrich et al., 1991).  
4 Considering these two facts, we believe it is necessary to explore whether possible  
5 restorative effects of awe-evoking experiences are primarily due to awe itself, or to the  
6 fact that the scenes depict natural elements. In other words, does exposure to natural  
7 awe-evoking scenes have a uniquely restorative effect compared to built awe-evoking  
8 scenes? As described above, the outcomes of awe experiences resemble some of the  
9 environment-person transactions that Kaplan and Kaplan (1989) consider necessary for  
10 an environment to be restorative, such as being away from everyday worries,  
11 compatibility, and extent (Vining & Merrick, 2012; Williams & Harvey, 2001). With  
12 that in mind, we expect awe-evoking scenes to be more restorative than mundane scenes  
13 (Hypothesis 1, H1), and natural environments to be more restorative than non-natural  
14 environments when awe does not vary (Hypothesis 2, H2). Note that the inherent  
15 characteristics of awe (vastness and accommodation) may require the use of cognitive  
16 resources, which might hinder the restoration of attentional capacity. We favor H1 and  
17 H2 because several prior studies on exposure to awe-evoking scenes have reported  
18 outcomes that might be categorized as restorative, and the taxing attentional load that  
19 exposure to awe-evoking stimuli could have on cognitive resources has been suggested  
20 only hypothetically (Joye & Dewitte, 2018).

## 21 **Research Design**

22       Guided by the experimental approach used in previous psychological studies of  
23 awe (Joye & Dewitte, 2016; Piff et al., 2015; Rudd et al., 2012), we exposed  
24 participants to visual awe-evoking and mundane scenes, and examined restorative  
25 outcomes. The study was conducted in two phases: 1. Standardization and selection of

1 pictorial stimuli; 2. Examination of the possible restorative effects of exposure to awe-  
2 evoking and mundane scenes, compared to a control group. The experiment had a  
3 between-subjects design. Restorative outcomes were recorded by means of three  
4 different measures: reported restoration (i.e., one's perception of how restored s/he felt  
5 after watching the slideshow), actual restoration (performance on an attentional task  
6 pre- and post-slideshow), and positive affect (pre- and post-slideshow).

## 7 **Method**

### 8 **Phase I: Standardization and Selection of Pictorial Stimuli**

9 The objective of this phase was to obtain a set of pictures that could be sorted  
10 according to origin (natural vs. built) and awe-evoking potential (awe-evoking vs.  
11 mundane), for use in the experimental phase. To achieve this objective, we followed  
12 three steps: 1) picture gathering and initial screening; 2) picture rating; and 3) final  
13 picture selection.

14 **Picture gathering and initial screening.** We started by borrowing awe-evoking  
15 pictures used in previous studies (Joye & Bolderdijk, 2015). Then, four undergraduate  
16 students were asked to search for awe-evoking pictures on the Internet. After reviewing  
17 the psychological literature on awe (Keltner & Haidt, 2003; Shiota et al., 2007), we  
18 instructed them to search for pictures with notable vastness, which is typically  
19 associated with large physical scale and size (Keltner & Haidt, 2003). Vastness can also  
20 be elicited by extraordinarily elaborate architectural ornament and/or the significant  
21 effort a construction would have required (e.g., the Egyptian pyramids) (Joye &  
22 Verpooten, 2013).

23 They were also instructed to look for pictures that are mundane, as described by  
24 Joye and Bolderdijk (2015) (i.e., everyday natural/built small-scale scenes). Small-scale  
25 scenes seem especially well suited to this purpose, because they lack the vastness and

1 overwhelming elements that characterize awe-evoking scenes (Joye & Bolderdijk,  
2 2015). With those parameters in mind, the students collected a total of 150 pictures,  
3 which were then screened by this paper's authors to ensure the angle each picture was  
4 taken from, and the light, were constant across the picture set. Following the initial  
5 screening, 128 images were selected and randomly assigned to four PowerPoint  
6 presentations. Each presentation contained 32 images that qualified as awe-evoking or  
7 mundane, and natural or built.

8 **Picture rating.** The pictures were rated on an individual basis, in a large  
9 auditorium with a 12x5 meter projection screen. Forty-four volunteers 17 to 49 years  
10 old (68% females) took part in this phase of the study. The experimenter (E) ushered  
11 each participant to his/her seat and gave him/her a paper-and-pencil questionnaire and a  
12 remote control to operate the PowerPoint presentation. The screen, seven meters away,  
13 remained black while the participant received instruction. S/he sat comfortably in a  
14 chair and had an unobstructed view of the screen. The room was dimly lit, and the  
15 temperature was set at 22 degrees Celsius. The participant started by rating a practice  
16 slide in terms of awe, beauty, naturalness, and familiarity. If no problems were  
17 encountered during this stage, the participant would continue and rate the 32 pictures.  
18 S/he was allowed to control the time spent viewing each picture. On average,  
19 participants looked at each picture for approximately 85 seconds, such that each rating  
20 session lasted about 45 minutes. The instruments employed to rate each image were:

21 **Awe scale.** In previous studies, researchers directly asked participants how much  
22 "awe" they felt after the intervention (slideshow or video; e.g., Joye & Dewitte, 2016,  
23 Piff et al., 2015; Shiota et al., 2007). We were reluctant to follow that example, because  
24 it might put them in a specific frame of mind. Instead, we decided to adapt a scale used  
25 to detect transcendent experiences in forest environments (Williams & Harvey, 2001).

1 Considering the literature on awe (Joye & Bolderdijk, 2015; Keltner & Haidt, 2003;  
2 Shiota et al., 2007; Vining & Merrick, 2012; Williams & Harvey, 2001), our scale  
3 included 10 items to cover a broad range of components of awe that were explored in  
4 prior work, such as a sense of smallness, humility, respect (Piff et al., 2015), spirituality  
5 (Keltner & Haidt, 2003), perception of time (Rudd et al., 2012), and awe-evoking  
6 properties such as vastness (Keltner & Haidt, 2003) – for instance, “This image makes  
7 me feel insignificant.” The images were rated on a seven-point Likert scale ranging  
8 from 1 (*strongly disagree*) to 7 (*strongly agree*). An exploratory factor analysis was  
9 conducted to determine the scale’s dimensionality. According to our results<sup>2</sup>, the best  
10 solution was one-dimensional. Cronbach’s  $\alpha$  was .83. Please refer to Appendix A for the  
11 complete scale.

12 **Beauty.** Beauty was rated by answering the question: “How beautiful do you  
13 think the picture shown is?” Responses ranged from 1 (*not beautiful at all*) to 7 (*very*  
14 *beautiful*).

15 **Naturalness.** The respondent provides information about the picture’s origin by  
16 answering: “How natural do you think this picture is?” Responses ranged from 1 (*not*  
17 *natural at all*) to 7 (*very natural*).

18 **Familiarity.** This was measured by an item that was used in previous studies:  
19 “The environment shown in this picture is familiar to me” (Collado, Staats, & Sorrel,  
20 2016). Responses ranged from 1 (*strongly disagree*) to 7 (*strongly agree*).

21 **Final picture selection.** Stimuli employed in previous studies to examine the  
22 positive effects of nature have largely varied in terms of beauty. Therefore, when  
23 exposure to nature is linked to restoration or other psychological benefits, it has been  
24 difficult to attribute the effects to the stimulus’s natural quality. Given that the natural  
25 images (e.g., a forest) used in previous studies (Berto, 2005; Hartig & Staats, 2006)

1 seem more beautiful to us than man-made ones (e.g., cities), it is conceivable that  
2 beauty acted as a mediating variable and accounted for benefits traditionally attributed  
3 to nature. In an attempt to control for beauty, we selected pictures for use in the  
4 experiment according to both beauty and awe, using a randomized block design (Keppel  
5 & Wickens, 2004). We first calculated the mean for beauty ( $M = 5.04$ ,  $SD = 1.13$ ) and  
6 selected the pictures that were within one standard deviation of it (i.e., beauty could be  
7 considered equal). That yielded 80 pictures. The mean for awe was then calculated ( $M =$   
8  $3.77$ ,  $SD = 1.01$ ), and a second categorization was made. Awe-evoking pictures were  
9 those rated at least one standard deviation above the mean, and mundane pictures were  
10 those rated at least one standard deviation below the mean. The resulting awe-evoking  
11 and mundane pictures were then divided into natural or built scenes, depending on their  
12 content. This produced 14 pictures in the built, mundane category, and 14 pictures were  
13 selected for each of the other three categories (i.e., natural, mundane; built, awe-  
14 evoking; natural, awe-evoking). The means for beauty and awe in each group appear in  
15 Table 1.

16 TABLE 1 ABOUT HERE

17 FIGURE 1 HERE

## 18 **Phase II: Main Study**

19 **Participants.** This experiment had 250 participants aged 17 to 52 years old (50  
20 per experimental condition) ( $M_{age} = 22.48$ ,  $SD = 6.87$ ). Of those, 64% were female, and  
21 59% were students. Students were encouraged to participate by offering extra credit of  
22 0.25 on their final grades in a particular course. The other participants did not receive any  
23 compensation for participating.

## 24 **Materials employed.**

1           ***Raven's Advanced Progressive Matrices test (APM; Raven, 1981)***. This test was  
2 used to produce mental fatigue in participants. The APM requires respondents to  
3 complete two-dimensional matrices (typically  $3 \times 3$ ) of geometric figures, by selecting  
4 an additional figure to fulfill the pattern. To select the correct target figure to complete  
5 the matrix, the respondent must extract abstract information from visuospatial relations.  
6 The APM is considered an IQ-test that relies on inductive reasoning and fluid intelligence  
7 (Cattell, 1971; 1987). To motivate participants to try their best, they were told that the  
8 APM was an IQ-test, and they could write down their email address to receive the results.

9           ***Digit Span Forward (DSF) and Backward (DSB) test***. The DSF and DSB have  
10 been widely used in restoration research to measure participants' capacity to direct their  
11 attention (Berman, Jonides, & Kaplan, 2008; Cimprich, 1993; Cimprich & Ronis, 2003;  
12 Ottosson & Grahn, 2005; Tennessen & Cimprich, 1995). It is a standardized measure of  
13 attention (Lezak, 1983; Wechsler, 1997) consisting of two parts. In the first (DSF), the  
14 researcher reads aloud a series of numbers, which the participant has to repeat in the same  
15 order. In the second part (DSB), the researcher reads aloud a series of numbers, and the  
16 participant has to repeat them in reverse order. In both cases, the number of digits to  
17 repeat increases as the participant correctly responds to digit series, starting with two  
18 digits and continuing up to nine, with two repetitions of each sequence length. For the  
19 present study's purposes, we used total test score (i.e., the sum of correct answers on the  
20 DSF and the DSB, which could range from 0 to a maximum score of 30) as a measure of  
21 participants' attentional capability. A participant's difference in score on the DSF and  
22 DSB test before and after watching the slideshow was used as a measure of actual  
23 restoration.

24           ***Pleasant deactivation subscale***. Positive affect was measured by administering  
25 the pleasant deactivation subscale developed by Yik, Russell, and Steiger (2011). The

1 scale has gone through extensive psychometric validation. The adjective version of the  
2 scale was used, and participants had to indicate to what extent they experienced each  
3 adjective on a scale from 1 (*not at all*) to 5 (*extremely*). The adjectives were: relaxed,  
4 calm, tranquil, placid, at rest. Cronbach's alphas for the scale were adequate ( $\alpha_{T0} = .77$ ;  
5  $\alpha_{T1} = .81$ ).

6 ***Awe scale.*** The experience of awe after watching the slideshow was measured  
7 using the same scale as in Phase I (see Appendix A). This time, however, the items  
8 referred to watching the whole slideshow (e.g., "Watching this slideshow made me feel  
9 insignificant"). The scale's internal consistency was adequate ( $\alpha = .84$ ).

10 ***Reported restoration scale.*** Participants reported how restored they felt after  
11 watching the slideshow by responding to eight items considered to be indicative of  
12 restoration (Staats, Kieviet, & Hartig, 2003). For example, "After watching the slideshow,  
13 my energy has been renewed." Responses ranged from 1 (*strongly disagree*) to 7 (*strongly*  
14 *agree*). Cronbach's alpha was .80. Items were averaged to compute one's Reported  
15 Restoration score (Appendix A).

16 ***Familiarity.*** How novel the slideshow felt was measured by slightly modifying  
17 the familiarity item from Phase I. The item used here was "Overall, the images shown in  
18 this slideshow are familiar to me." Responses ranged from 1 (*strongly disagree*) to 7  
19 (*strongly agree*).

## 20 **Procedure**

21 The same procedure employed in Phase I was used here. There were five  
22 experimental groups, with 50 participants per group. We included four mentally-fatigued  
23 groups and one group that was not. In the interest of clarity, we shall refer to the four  
24 mentally fatigued groups as experimental groups, and the fifth as the control group.  
25 Participants were tested individually and told that their results would be confidential. At

1 the beginning of the experiment, participants in the four experimental groups were asked  
2 to solve as many APM matrices as possible for 30 minutes, and they were encouraged to  
3 be accurate. While the participant worked on the APM, the experimenter (E) moved to an  
4 adjacent room to discreetly monitor the procedure. After 30 minutes, E returned and asked  
5 the participant to fill out the pleasant deactivation scale (T0). Immediately thereafter, E  
6 administered the Digit Span Forward and Backward test (T0). Next, E instructed the  
7 participant to sit quietly and watch one of the four slideshows for seven minutes, and left  
8 the room. Once the slideshow was over, E re-entered the room and asked the participant  
9 to complete the pleasant deactivation scale a second time (T1), and her/his performance  
10 on the Forward and Backward test was recorded (T1). Finally, the participant was  
11 instructed to fill out the awe scale and reported restoration scale, and then rate his/her  
12 familiarity with the slideshow presented.

13 Participants in the control group<sup>3</sup> followed the same procedure as their  
14 experimental counterparts, except that the APM was not administered at the beginning of  
15 the session. Instead, following Hartig and Staats' (2006) approach, they took part in the  
16 experiment early in the morning, before classes started. They did not have an exam or  
17 paper due in the next three days, so attentional fatigue was minimal. Participants in the  
18 control group viewed the slideshow of natural, awe-evoking scenes.

## 19 Results

### 20 Effects on Awe and Familiarity

21 We conducted two one-way ANOVAs with slideshow condition (i.e., natural/built  
22 awe-evoking; natural/built mundane; control) as the between-subjects factor, and the  
23 emotion of awe/familiarity as dependent variables. Our results show differences in awe  
24 among the five groups,  $F(4, 245) = 15.10, p < .001, \eta^2_p = 0.20$ . Bonferroni post hoc  
25 analyses showed that participants in the built, awe-evoking condition reported greater



1 feelings of awe than those in the built, mundane condition ( $p < .001$ ). Moreover, exposure  
2 to natural, awe-evoking images enhanced feelings of awe more than natural, mundane  
3 images did ( $p < .001$ ). No differences in awe experience were detected between natural  
4 and built environments, independent of their awe-evoking potential (see Table 2).

5 TABLE 2 ABOUT HERE

6  
7 In the case of familiarity, significant differences between groups were found,  $F$   
8  $(4, 245) = 23.31, p < .001, \eta^2_p = 0.27$ . Bonferroni post hoc analyses showed that built,  
9 mundane images were more familiar than built, awe-evoking images ( $p < .001$ ).  
10 Similarly, participants were more familiar with natural, mundane scenes than with  
11 natural, awe-evoking scenes ( $p < .001$ ). There were no differences in familiarity scores  
12 between exposure to mundane natural and built environments; nor between exposure to  
13 awe-evoking natural and built environments. These results suggest that our selection of  
14 stimuli was appropriate.

15 **Effects on Reported Restoration**

16 A third one-way ANOVA was conducted, this time with slideshow condition as  
17 the between-subjects factor and reported restoration as the dependent variable.  
18 Differences were found among the five groups,  $F(4, 245) = 14.20, p < .001, \eta^2_p = 0.20$ .  
19 Looking at the four experimental conditions where participants completed the APM,  
20 Bonferroni post hoc analyses showed that people exposed to natural, awe-evoking  
21 scenes reported greater restoration than those exposed to mundane scenes (both natural  
22 and urban),  $p < .001$ . When only the two awe-evoking slideshows were compared, no  
23 statistical differences were found between exposure to the natural versus built scenes,  $p$   
24  $= .09$ . Meanwhile, participants exposed to the natural, mundane slideshow reported  
25 higher restoration than those who viewed the built, mundane slideshow,  $p = .01$ . When  
26 only the natural slideshows were compared, differences were detected between groups,

1 with participants who viewed the natural, awe-evoking slideshow reporting the highest  
2 restorative outcomes of all,  $p < .001$ . See Table 2.

### 3 **Effects on Actual Restoration**

4 First, we conducted a one-way ANOVA with slideshow condition as the  
5 between-subjects factor, and Digit Span score at T0 the dependent variable. No  
6 differences registered between the five groups,  $F(4, 245) = 0.41, p = .77, \eta^2_p = 0.01$ .  
7 Next, we used a two-way repeated-measures ANOVA with one factor to examine the  
8 possible influence of slideshow condition on attentional task outcomes<sup>4</sup>. Time of  
9 measurement (i.e., pre-or post-slideshow) was entered as the within-subject variable,  
10 slideshow condition was the between-subjects variable, and total Digit Span score was  
11 the dependent variable. There was a main effect of time on Digit Span outcomes,  $F(1,$   
12  $245) = 77.13, p < .001, \eta^2_p = 0.24$ , showing overall improvement in Digit Span from pre-  
13 to post-slideshow. Furthermore, a significant interaction was found between Digit Span  
14 measurement time and slideshow,  $F(4, 245) = 6.40, p < .001; \eta^2_p = 0.10$ , such that Digit  
15 Span changes varied according to slideshow condition. Specifically, there were  
16 significant increases in the two awe-evoking conditions (nature and built), the natural,  
17 mundane condition, and the control group (natural, awe-evoking:  $F(1, 49) = 79.24, p <$   
18  $.001, \eta^2_p = 0.62$ ; built, awe-evoking:  $F(1, 49) = 26.30, p < .001, \eta^2_p = 0.35$ ; natural,  
19 mundaen:  $F(1, 49) = 14.41, p < .001, \eta^2_p = 0.23$ ; control:  $F(1, 49) = 5.24, p = .026, \eta^2_p =$   
20  $0.10$ ). Conversely, Digit Span scores were constant over time in the built, mundane  
21 condition,  $F(1, 49) = 0.39, p = .53, \eta^2_p = 0.00$ . Another significant interaction effect  
22 occurred between Digit Span measurement time and slideshow when only the two built  
23 conditions were compared,  $F(1, 98) = 10.40, p < .01, \eta^2_p = 0.10$ , with steeper Digit Span  
24 improvement pre- to post-slideshow in the built, awe-evoking condition than the built,  
25 mundane condition. Similarly, there was a marginally significant interaction when we

1 considered just the two experimental conditions involving nature exposure,  $F(1, 98) =$   
2  $3.75, p = .05, \eta^2_p = 0.04$ , with steeper Digit Span improvement pre- to post-slideshow in  
3 the natural, awe-evoking condition than the natural, mundane condition. Finally, there  
4 was no significant interaction when the two awe-evoking slideshows were compared,  
5 that is, no difference in Digit Span improvement,  $F(1, 98) = 2.58, p = .11, \eta^2_p = 0.02$ .  
6 See Figure 2.

7 **FIGURE 2 ABOUT HERE**

### 8 **Effects on Positive Affect**

9 First, we conducted a one-way ANOVA with slideshow condition as the  
10 between-subjects factor, and pleasant deactivation at T0 as the dependent variable. No  
11 differences were found among the five groups,  $F(4, 245) = 1.50, p = .11, \eta^2_p = 0.02$ .  
12 Results from a two-way repeated-measures ANOVA with one factor showed a  
13 significant effect of time on the pleasant deactivation measure,  $F(1, 245) = 6.92, p =$   
14  $.01, \eta^2_p = 0.03$ . There was also a significant interaction effect of time and slideshow,  $F$   
15  $(4, 245) = 3.69, p < .001, \eta^2_p = 0.06$ . Specifically, in the two experimental conditions  
16 with nature exposure, there was improvement in pleasant deactivation pre- to post-  
17 slideshow (natural, mundane:  $F(1, 49) = 11.18, p < .001, \eta^2_p = 0.19$ ; natural, awe-  
18 evoking:  $F(1, 49) = 7.43, p < .001, \eta^2_p = 0.13$ ), whereas pleasant deactivation scores  
19 were stable over time in the built conditions (built, mundane:  $F(1, 49) = 1.52, p = .22,$   
20  $\eta^2_p = 0.03$ ; built, awe-evoking:  $F(1, 49) = 0.85, p = .36, \eta^2_p = 0.01$ ) and the control  
21 group,  $F(1, 49) = 0.10, p = .76, \eta^2_p = 0.01$ . Comparing just the two experimental groups  
22 with nature exposure, there was still a main effect of time,  $F(1, 98) = 17.59, p < .001,$   
23  $\eta^2_p = 0.15$ , but the interaction effect was no longer significant,  $F(1, 98) = 0.02, p = .89,$   
24  $\eta^2_p = 0.00$ , meaning that participants' exposure to natural scenes (either awe-evoking or  
25 mundane slideshows) improves pleasant deactivation. See Figure 3.



1 design and selection of stimuli were consistent with what three recent critical reviews of  
2 ART define as appropriate for testing restoration – from inducing attentional fatigue and  
3 using a control group, to clearly distinguishing among different stimuli and using  
4 standardized cognitive tests (Hartig & Jahncke, 2017; Joye & Dewitte, 2008; Stevenson,  
5 Schilhab, & Bentsen, 2018). Our first objective was to explore whether exposure to  
6 awe-evoking scenes was more restorative than exposure to mundane scenes. Based on  
7 the previous literature on restoration (Kaplan, 1995; Ulrich et al., 1991) and awe, in  
8 both natural (Joye & Bolderdijk, 2015; Piff et al., 2015; Rudd et al., 2012; Williams &  
9 Harvey, 2001) and built (Joye & Dewitte, 2016) environments, our first hypothesis was  
10 that exposure to awe-evoking scenes would be more restorative than exposure to  
11 mundane scenes (H1). We also hypothesized that if awe is constant, exposure to natural  
12 scenes would be more restorative than exposure to built scenes (H2).

13         Contrary to expectations, participants in the experimental and control conditions  
14 did not differ in their performance on the Digit Span test at T0, suggesting that our  
15 depletion task (AMP) did not in fact deplete participants' attentional resources. Thus,  
16 we cannot claim that attentional restoration took place. We can merely speculate about  
17 why the APM did not have a detrimental effect on participants' performance at T0.  
18 First, the attentional resources used to solve the APM may differ from those deployed  
19 on the Digit Span test, such that any detrimental effect of trying to solve the APM  
20 would not impact participants' performance on Digit Span. In restoration research,  
21 using tasks to induce attentional depletion and tasks to measure cognitive performance  
22 that in fact requires different attentional resources is a common error, and one we might  
23 have made (Hartig & Jahncke, 2017; Joye & Dewitte, 2018). Second, it is possible that  
24 participants simply did not try as hard to solve the matrices as we expected, and  
25 therefore, the task was not as taxing as anticipated.

1           Even though we did not find differences in terms of resource depletion between  
2 the experimental groups and the control group, viewing some of the slideshows,  
3 especially the awe-evoking ones, did yield positive effects in our participants. These  
4 results are consistent with what Hartig (2007) defines as *instoration* (i.e., beneficial  
5 changes produced by exposure to certain environments that are not necessarily  
6 restorative). The term is a broad one, leaving room for different explanations about why  
7 exposure to environments with certain characteristics promote positive benefits. Our  
8 results are aligned with the proposition that exposure to nature can “improve directed  
9 attention capabilities” (Kaplan & Berman, 2010, p. 52), as well as with previous  
10 research showing that exposure to nature is beneficial not only when resources are  
11 depleted, but also when they are not (Beute & Kort, 2014; Hartig, Böök, Garvill,  
12 Olsson, & Gärling, 1996). According to our findings, participants perceived that they  
13 were more restored following two awe-evoking conditions, compared to those exposed  
14 to mundane conditions. On the other hand, participants’ Digit Span performance at T1  
15 was significantly better following the awe-evoking conditions. Though participants in  
16 the natural, mundane condition also improved their performance, the increase was  
17 significantly smaller than in the awe-evoking conditions. Furthermore, participants in  
18 the natural, awe-evoking condition showed a pre- to post-slideshow increase in pleasant  
19 deactivation (e.g., they felt more relaxed), whereas no significant improvements were  
20 found in the built, awe-evoking condition.

21           Our findings show improved Digit Span performance from T0 to T1 that cannot  
22 be attributed to a recovery of attentional resources and, therefore, does not support  
23 ART. We propose alternative explanations for these results. One plausible explanation  
24 for the rise in performance from T0 to T1 may relate to natural and awe-evoking  
25 stimuli’s ability to enhance attention. Perhaps natural settings, as well as awe-evoking

1 stimuli, possess specific characteristics that are especially suited to grabbing and  
2 sustaining our attention. The mechanism underlying this phenomenon could be  
3 increased activation of the ascending pathway to the reticular formation, which would  
4 translate to heightened arousal and vigilance, and make one more alert and ready to face  
5 the Digit Span test at T1 (Kinomura, Larsson, Gulyás, & Roland, 1996). Fascinating  
6 and interesting scenes can also lead to higher task motivation (Silvia, 2008), which, in  
7 turn, would result in better performance on the Digit Span test. Conversely, the  
8 mundane, built scenes used in the current study are rather ordinary, which would  
9 probably lead to a lack of interest and not foster attention as much as the other  
10 slideshows. Yet another explanation is that we discarded highly awe-inspiring scenes  
11 early on, in an attempt to keep beauty constant across awe-evoking and mundane  
12 scenes. As a result, participants were probably not exposed to the images that,  
13 theoretically, would more profoundly draw their attention. It would be worthwhile to  
14 examine the possible effects of the most acutely awe-evoking experiences on tasks that  
15 require directed attention. For instance, would highly awe-evoking scenes that might  
16 require greater mental accommodation deplete directed attention, and thus, hinder  
17 restoration?

18 Partly consistent with the second hypothesis, our findings indicate that when  
19 awe and beauty are equally matched across conditions, everyday natural environments  
20 have a more positive effect than everyday built ones. These results are congruent with  
21 previous research on the positive effects of exposure to nature (Kaplan, 2001; Kaplan &  
22 Berman, 2010; Hartig et al., 2003; Kelz et al., 2015). The fact that, overall, stronger  
23 effects were not observed in participants in the natural, awe-evoking condition  
24 compared to those in the built, awe-evoking condition might stem from the novelty of  
25 the scenes in our participants' awe-evoking conditions. Familiarity dampens the positive

1 effects of nature exposure by diminishing the sense of being away from everyday  
2 routines (Collado et al., 2016; Von Lindern, 2015; Von Lindern, Bauer, Frick,  
3 Hunziker, & Hartig, 2013). In light of the differential positive effects we observed  
4 between natural and built mundane scenes, maybe built mundane scenes remind people  
5 of their daily responsibilities through a Pavlovian associative mechanism, constraining  
6 their feelings of being away and, in turn, positive outcomes. In contrast, natural  
7 mundane environments are leisure settings for most people, and likely enhance feelings  
8 of being away (Von Lindern, 2015). Following this line of reasoning, the scenes shown  
9 in the two awe-evoking conditions (nature and built) were quite distinct from  
10 participants' everyday environments, which could generate a strong feeling of being  
11 away from everyday worries. That might, in turn, enhance positive outcomes like  
12 perceived restoration, regardless of whether the scenes are natural or built. Although  
13 beyond the scope of the present study, further examination of the factors that foster or  
14 thwart positive outcomes after exposure to awe-evoking scenes is needed, to deepen our  
15 understanding of the benefits of awe experiences.

## 16 **Practical Implications**

17 Our findings concur with previous findings of positive effects of exposure to  
18 different visual stimuli (e.g., Berto, 2005; Faber Taylor, Kuo, & Sullivan, 2002; Felsten,  
19 2009), and, as such, they have practical implications. Natural awe-evoking images, for  
20 instance on large posters and screens, are probably being used in places where people's  
21 attentional resources are often depleted (e.g., workplaces, schools, and hospitals).  
22 Considering our results, built awe-evoking scenes could also be used when seeking to  
23 enhance people's attentional resources. Given that people are attracted to scenes outside  
24 their everyday environment, practitioners should consider people's everyday  
25 surroundings when choosing scenes to place in settings where attentional resources are



1 especially needed. For instance, a large cathedral might be more awe-evoking for people  
2 in North America than for a European. In contrast, extraordinarily high and modern  
3 buildings may evoke a stronger feeling of awe in people living in areas where low and  
4 medium/sized buildings are common. Future studies will ascertain whether these  
5 speculations are sound. It is also plausible that exposure to awe-evoking scenes on a  
6 regular basis leads to other positive outcomes, such as prosociality (Piff et al., 2011) and  
7 well-being (Rudd et al., 2012). Examining the positive outcomes of regular exposure to  
8 awe-evoking scenes seems a promising line of research.

### 9 **Limitations and Future Directions for Research**

10 We now turn our attention to the limitations of this study, and propose the bases  
11 for future lines of research. First, we attempted to control for beauty across  
12 experimental conditions. However, awe-evoking scenes have been described as very  
13 beautiful (Keltner & Haidt, 2003; Shiota et al., 2007), making it difficult to select a set  
14 of awe-evoking natural and built stimuli that were equally beautiful to mundane stimuli.  
15 With that in mind, it cannot be concluded from our results and those of previous authors  
16 (Joye & Bolderdijk, 2015; Piff et al., 2015; Rudd et al., 2012) that it was the  
17 slideshows' awe-evoking quality, and not their extreme beauty, or a combination of  
18 both, that was responsible for the positive effects we found.

19 A second limitation, mentioned above, is that highly awe-inspiring pictures were  
20 left out of the study, hence the effect of exposure to such images remains unknown. We  
21 are under the impression that awe is regarded in the scientific literature as an all-or-  
22 nothing phenomenon, which admits no gradients. As an emotional response, however,  
23 we would expect it to have some kind of gradient. The different effects that low,  
24 medium, and highly awe-evoking experiences may have on people's attentional  
25 resources should be further examined in the awe and restoration research.

1           Third, the awe scale we used is not a standardized measure. In this study, as in  
2 previous research (Joye & Bolderdijk, 2015; Joye & Dewitte, 2016; Williams &  
3 Harvey, 2011), the experience of awe was measured with ad hoc tools based on the awe  
4 literature. That precludes comparisons across studies, and further efforts to develop and  
5 validate an instrument to measure the emotion of awe are certainly needed.

6           Fourth, these results were based on a single experiment, so more studies are  
7 needed to establish the replicability of our findings, and aid in their generalization. For  
8 example, built stimuli were chosen according to their vastness – in terms of physical  
9 size as well as elaborate architectural ornamentation and the energy it would have taken  
10 to construct a given building (Joye & Verpooten, 2013). Thus, stimuli included pictures  
11 of the Egyptian pyramids and the Taj Mahal, among others. Those might have a specific  
12 sociocultural meaning that would differ from one culture to the next. Sociocultural  
13 aspects of awe, and their effects on how people experience different settings, await  
14 future examination.

15           One last limitation, also mentioned above, is that our manipulation task was  
16 ineffective in producing mental fatigue in participants. Like many previous restoration  
17 researchers, we designed our experiment based on some assumptions that are  
18 problematic in practice, for instance, the idea that the depletion task would require the  
19 same set of cognitive resources as the outcome measure, and that no learning effect  
20 would occur (Hartig & Jahncke, 2017). From our findings, it is impossible to claim that  
21 the positive effects observed were due to a restorative process, so they cannot be  
22 explained by ART. Meanwhile, the fact that the most positive effect was produced by  
23 exposure to awe-evoking images – which are theoretically profoundly attention-  
24 grabbing – also contradicts ART’s claims that soft fascinating stimuli elicit the most  
25 positive effects. In line with Joye and Dewitte’s (2018) inspiring critical review of ART,

1 we encourage researchers to carefully design their experiments to test ART, as well as  
2 broaden their scope, and systematically examine alternate explanations for the positive  
3 effects that nature exposure has on people.

#### 4 Notes

5 1. The authors used the term “transcendent” in their study. Considering that the terms  
6 awe, sublime, and transcendent are closely related (Vining & Merrick, 2012; Williams  
7 & Harvey, 2001), and that elucidating differences among these terms is beyond the  
8 scope of the present study, we decided to use the term “awe” throughout the paper, for  
9 the sake of clarity.

10  
11 2. An exploratory factor analysis (EFA) was run using principal axis factoring as an  
12 extraction method, with oblique (oblimin) rotation to allow for correlations among  
13 constructs (Kaiser-Mayer-Okim [KMO] = .835, Bartlett (45) = 725.192,  $p < .001$ ). Two  
14 eigenvalues greater than one were found (3.92 and 1.23). As suggested by EFA experts  
15 (Damásio, 2012; Fabrigar, Wegener, MacCallum, & Strahan, 1999; Henson & Roberts,  
16 2006; Sakaluk & Short, 2017), we considered the following criteria when deciding how  
17 many factors to retain: factor loadings in pattern and structure matrices, parallel analysis  
18 (PA) results, internal consistency, and parsimony. Factor loadings in the pattern matrix  
19 indicated a two-factor structure, with one factor formed by seven items and a second  
20 one formed by three (items 2, 3 & 7). However, the structure matrix showed that two of  
21 the three items that would have comprised the second dimension correlated moderately  
22 or strongly with the first factor ( $r > .40$ ). According to the structure matrix, nine out of  
23 10 items were moderately or highly correlated with the first factor  $r \geq .32$  (Tabachnick  
24 & Fidell, 1996). In addition, PA results indicate that the two first eigenvalues in our  
25 dataset are greater than the two eigenvalues in a simulated dataset (1,000 replications).  
26 However, the difference between the second eigenvalue in our dataset and the simulated  
27 one was less than 0.1, and PA sometimes overestimates the number of factors to be  
28 extracted (Sakaluk & Short, 2017). Moreover, the 10-item scale has high internal  
29 consistency ( $\alpha = .83$ ), which is a good indicator of its one-dimensionality (Schmitt,  
30 1996). Omitting item 7 decreases the scale’s internal consistency. Taking into  
31 consideration the results as well as parsimony, we consider it best to treat the scale as  
32 one-dimensional.

33  
34 3. This control group was added at the suggestion of one of the reviewers, after this  
35 manuscript’s first revision. Having an extra control group per experimental condition  
36 would mean testing 200 extra participants (50 assigned to each of the four slideshows),  
37 which would be highly time- and energy-consuming. We devised an intermediate  
38 solution: we identified the slideshow that elicited the most positive benefits in  
39 participants (i.e., the natural awe-evoking slideshow) and showed it to participants in  
40 the control group. This solution offers the most stringent proof of restoration in the  
41 experimental groups.

42  
43 4. We also checked for a possible mediating effect of awe between exposure to the  
44 different slideshows and improved performance on the Digit Span test. To do so, we  
45 used Preacher and Hayes’ bootstrap method for testing mediation, employing the SPSS  
46 macro PROCESS, model 4, developed by Hayes (2013). Digit Span improvement

1 scores were entered as the dependent variable, slideshow condition (awe-evoking;  
2 mundane) as the independent variable, and awe as the mediator. Results showed that the  
3 bias-corrected 95% confidence interval for the indirect effect of slideshow condition,  
4 via awe, included zero (-0.26 to 0.25), indicating an insignificant indirect effect.  
5  
6

1 **References**

- 2 Abdulkarim, D., & Nasar, J. L. (2014). Are livable elements also restorative? *Journal of*  
3 *Environmental Psychology*, 38, 29-38. doi:10.1016/j.jenvp.2013.12.003
- 4 Adler, M. G., & Fagley, N. S. (2005). Appreciation: Individual differences in finding  
5 value and meaning as a unique predictor of subjective well-being. *Journal of*  
6 *Personality*, 73, 79-114. doi: 10.1111/j.1467-6494.2004.00305.x
- 7 Berman, M. G., Jonides, J., & Kaplan, S. (2008). The cognitive benefits of interacting  
8 with nature. *Psychological Science*, 19, 1207-12012. doi: 10.1111/j.1467-  
9 9280.2008.02225.x
- 10 Berto, R. (2005). Exposure to restorative environments helps restore attentional  
11 capacity. *Journal of Environmental Psychology*, 25, 249-259.  
12 doi:10.1016/j.jenvp.2005.07.001
- 13 Beute, F., & de Kort, Y. A. W. (2014). Natural resistance: Exposure to nature and self-  
14 regulation, mood, and physiology after ego-depletion. *Journal of Environmental*  
15 *Psychology*, 40, 167-178. doi: 10.1016/j.jenvp.2014.06.004
- 16 Cattell, R. B. (1971). *Abilities: Their structure, growth, and action*. Boston: Houghton  
17 Mifflin.
- 18 Cattell, R. B. (1987). *Intelligence: Its structure, growth, and action*. New York:  
19 Elsevier.
- 20 Chang, C. Y., & Chen, P. K. (2005). Human response to window views and indoor  
21 plants in the workplace. *HortScience*, 40, 1354-1359.
- 22 Cimprich, B. (1993). Development of an intervention to restore attention in cancer  
23 patients. *Cancer Nursing*, 16, 83-92.
- 24 Cimprich, B., & Ronis, D. L. (2003). An environmental intervention to restore attention  
25 in women with newly diagnosed breast cancer. *Cancer Nursing*, 26, 284-292.

- 1 Collado, S., Staats, H., Corraliza, J. A., & Hartig, T. (2016). Restorative environments  
2 & health. In O. Navarro, G. Fleury-Bahi, & E. Pol (Eds.), *Handbook of*  
3 *environmental psychology and quality of life research* (pp. 127-148). New York:  
4 Springer.
- 5 Collado, S., Staats, H., & Sorrel, M. A. (2016). A relational model of perceived  
6 restorativeness: Intertwined effects of obligations, familiarity, security and parental  
7 supervision. *Journal of Environmental Psychology, 48*, 24-32. doi:  
8 10.1016/j.jenvp.2016.08.004
- 9 Damásio, B. F. (2012). Uso da análise fatorial exploratória em psicologia [Uses of  
10 exploratory factor analysis in Psychology]. *Avaliação psicológica, 11*, 213-228.
- 11 Faber Taylor, A., Kuo, F. E., & Sullivan, W. C. (2002). Views of nature and self-  
12 discipline: Evidence from inner city children. *Journal of Environmental*  
13 *Psychology, 22*, 49-63. doi: 10.1006/jevp.2001.0241
- 14 Fabrigar, L. R., Wegener, D. T., MacCallum, R. C., & Strahan, E. J. (1999). Evaluating  
15 the use of exploratory factor analysis in psychological research. *Psychological*  
16 *Methods, 4*, 272-299. doi:10.1037/1082-989x.4.3.272
- 17 Felsten, G. (2009). Where to take a study break on the college campus: An attention  
18 restoration theory perspective. *Journal of Environmental Psychology, 29*, 160-167.  
19 doi: 10.1016/j.jenvp.2008.11.006
- 20 Guéguen, N., & Stefan, J. (2014). 'Green altruism': Short immersion in natural green  
21 environments and helping behavior. *Environment & Behavior, 48*, 324-342. doi:  
22 10.1177/0013916514536576
- 23 Haidt, J., & Keltner, D. (1999). Culture and facial expression: Open-ended methods find  
24 more expressions and a gradient of recognition. *Cognition & Emotion, 13*, 225-266.  
25 doi: 10.1080/026999399379267

- 1 Halstead, J. M., & Halstead, A. O. (2004). Awe, tragedy and the human condition.  
2 *International Journal of Children's Spirituality*, 9, 163-175. doi:  
3 10.1080/1364436042000234369
- 4 Hartig, T. (2004). Restorative environments. In C. Spielberger (Ed.), *Encyclopedia of*  
5 *applied psychology* (pp. 273-279). San Diego: Academic Press. doi: 10.1016/B0-  
6 12-657410-3/00821-7
- 7 Hartig, T. (2007). Three steps to understanding restorative environments as health  
8 resources. In C. Ward Thompson & P. Travlou (Eds.), *Open space: People space*  
9 (pp. 163-179). London: Taylor and Francis.
- 10 Hartig, T., Böök, A., Garvill, J., Olsson, T., & Gärling, T. (1996). Environmental  
11 influences on psychological restoration. *Scandinavian Journal of Psychology*, 37,  
12 378-393.
- 13 Hartig, T., Evans, G. W., Jamner, L. D., Davis, D. S., & Gärling, T. (2003). Tracking  
14 restoration in natural and urban field settings. *Journal of Environmental*  
15 *Psychology*, 23, 109-123. doi: 10.1016/S0272-4944(02)00109-3
- 16 Hartig, T., & Jahncke, H. (2017). Letter to the editor: Attention restoration in natural  
17 environments: Mixed mythical metaphors from meta-analysis. *Journal of*  
18 *Toxicology and Environmental Health, Part B*, 20, 305-315. doi:  
19 10.1080/10937404.2017.1363101
- 20 Hartig, T., Mitchell, R., De Vries, S., & Frumkin, H. (2014). Nature and health. *Annual*  
21 *Review of Public Health*, 35, 207-228. doi: 10.1146/annurev-publhealth-032013-  
22 182443
- 23 Hartig, T., & Staats, H. (2006). The need for psychological restoration as a determinant  
24 of environmental preferences. *Journal of Environmental Psychology*, 26, 215-226.  
25 doi: 10.1016/j.jenvp.2006.07.007

- 1 Hayes, A. F. (2013). *An introduction to mediation, moderation, and conditional*  
2 *process analysis: A regression-based approach*. New York: The Guilford  
3 Press.
- 4 Henson, R., & Roberts, J. K. (2006). Use of exploratory factor analysis in published  
5 research. *Educational and Psychological Measurement*, 66, 393-416.  
6 doi:10.1177/0013164405282485
- 7 Herzog, T. R., Ouellette, P., Rolens, J. R., & Koenigs, A. M. (2010). Houses of worship  
8 as restorative environments. *Environment & Behavior*, 42, 395-419. doi:  
9 10.1177/0013916508328610
- 10 Jefferies, K., & Lepp, A. (2012). An investigation of extraordinary experiences. *Journal*  
11 *of Park and Recreation Administration*, 30, 37-51. doi:10.1177/0047287510385467
- 12 Joye, Y., & Bolderdijk, J. W. (2015). An exploratory study into the effects of  
13 extraordinary nature on emotions, mood, and prosociality. *Frontiers in Psychology*,  
14 5, 1577. doi: 10.3389/fpsyg.2014.01577
- 15 Joye, Y., & Dewitte, S. (2018). Nature's broken path to restoration. A critical look at  
16 Attention Restoration Theory. *Journal of Environmental Psychology*, 59, 1-8. doi:  
17 10.1016/j.jenvp.2018.08.006
- 18 Joye, Y., & Dewitte, S. (2016). Up speeds you down: Awe-evoking monumental  
19 buildings trigger behavioral and perceived freezing. *Journal of Environmental*  
20 *Psychology*, 47, 112-125. doi: 10.1016/j.jenvp.2016.05.001
- 21 Joye, Y., & Verpooten, J. (2013). An exploration of the functions of religious  
22 monumental architecture from a Darwinian perspective. *Review of General*  
23 *Psychology*, 17, 53-68. doi: 10.1037/a0029920
- 24 Kaplan, R. (2001). The nature of the view from home: Psychological benefits.  
25 *Environment & Behavior*, 33, 507-542. doi: 10.1177/00139160121973115



- 1 Kaplan, S. (1995). The restorative benefits of nature: Toward an integrative framework.  
2 *The Journal of Environmental Psychology, 15*, 169-182. doi: 10.1016/0272-  
3 4944(95)90001-2
- 4 Kaplan, R., & Kaplan, S. (Eds.). (1989). *The experience of nature: A psychological*  
5 *perspective*. Cambridge: Cambridge University Press.
- 6 Kaplan, S., & Berman, M. G. (2010). Directed attention as a common resource for  
7 executive functioning and self-regulation. *Perspectives on Psychological Science,*  
8 *5*, 43-57. doi: 10.1177/1745691609356784
- 9 Karmanov, D., & Hamel, R. (2008). Assessing the restorative potential of contemporary  
10 urban environment(s): Beyond the nature versus urban dichotomy. *Landscape &*  
11 *Urban Planning, 88*, 15-25. doi: 10.1016/j.landurbplan.2008.01.004
- 12 Keltner, D., & Haidt, J. (2003). Approaching awe, a moral, spiritual, and aesthetic  
13 emotion. *Cognition & Emotion, 17*, 297-314. doi:10.1080/02699930302297
- 14 Kelz, C., Evans, G. W., & Röderer, K. (2015). The restorative effects of redesigning the  
15 schoolyard: A multi-methodological, quasi-experimental study in rural Austrian  
16 middle schools. *Environment & Behavior, 47*, 119-139. doi:  
17 10.1177/0013916513510528
- 18 Keppel, G., & Wickens, T. D. (2004). *Design and analysis: A researcher's handbook*  
19 (4<sup>th</sup> ed.). Englewood Cliffs, NJ: Prentice-Hall.
- 20 Kinomura, S., Larsson, J., Gulyás, B., & Roland, P. E. (1996). Activation by attention  
21 of the human reticular formation and thalamic intralaminar nuclei. *Science, 271*,  
22 512-515.
- 23 Kuo, F. E., & Sullivan, W. C. (2001a). Environment and crime in the inner city: Does  
24 vegetation reduce crime? *Environment & Behavior, 33*, 343-367. doi:  
25 10.1177/00139165013333002

- 1 Kuo, F. E., & Sullivan, W. C. (2001b). Aggression and violence in the inner city:  
2 Effects of environment via mental fatigue. *Environment & Behavior*, *33*, 543-571.
- 3 Laumann, K., Gärling, T., & Stormark, K. M. (2001). Rating scale measures of  
4 restorative components of environments. *Journal of Environmental Psychology*, *21*,  
5 31-44. doi: 10.1006/jevp.2000.0179
- 6 Laumann, K., Gärling, T., & Stormark, K. M. (2003). Selective attention and heart rate  
7 responses to natural and urban environments. *Journal of Environmental*  
8 *Psychology*, *23*(2), 125-134.
- 9 Lezak, M. D. (1983). *Neuropsychological assessment*. New York: Oxford University  
10 Press.
- 11 Ottosson, J., & Grahn, P. (2005). A comparison of leisure time spent in a garden with  
12 leisure time spent indoors: On measures of restoration in residents in geriatric care.  
13 *Landscape Research*, *30*, 23-55. doi: 10.1080/0142639042000324758
- 14 Ouellette, P., Kaplan, R., & Kaplan, S. (2005). The monastery as a restorative  
15 environment. *Journal of Environmental Psychology*, *25*, 175-188. doi:  
16 10.1177/0013916508328610
- 17 Piff, P. K., Dietze, P., Feinberg, M., Stancato, D. M., & Keltner, D. (2015). Awe, the  
18 small self, and prosocial behavior. *Journal of Personality and Social Psychology*,  
19 *108*, 883-899. doi: 10.1037/pspi0000018
- 20 Raven, J. (1981). *Manual for Raven's Progressive Matrices and Vocabulary scales*.  
21 *Research supplement no.1: The 1979 British standardisation of the Standard*  
22 *Progressive Matrices and Mill Hill Vocabulary Scales, together with comparative*  
23 *data from earlier studies in the UK, US, Canada, Germany and Ireland*. San  
24 Antonio, TX: Harcourt Assessment.

- 1 Rudd, M., Vohs, K. D., & Aaker, J. (2012). Awe expands people's perception of time,  
2 alters decision making, and enhances well-being. *Psychological Science*, *23*, 1130-  
3 1136. doi: 10.1177/0956797612438731
- 4 Ryan, R. M., Weinstein, N., Bernstein, J., Brown, K. W., Mistretta, L., & Gagne, M.  
5 (2010). Vitalizing effects of being outdoors and in nature. *Journal of*  
6 *Environmental Psychology*, *30*, 159-168. doi: 10.1016/j.jenvp.2009.10.009
- 7 Sakaluk, J. K., & Short, S. D. (2017). A methodological review of exploratory factor  
8 analysis in sexuality research: Used practices, best practices, and data analysis  
9 resources. *The Journal of Sex Research*, *54*, 1-9.  
10 doi:10.1080/00224499.2015.1137538
- 11 Schmitt, N. (1996). Uses and abuses of coefficient alpha. *Psychological Assessment*, *8*,  
12 350-353. doi: 10.1037/1040-3590.8.4.350
- 13 Shiota, M. N., Keltner, D., & Mossman, A. (2007). The nature of awe: Elicitors,  
14 appraisals, and effects on self-concept. *Cognition & Emotion*, *21*, 944-963. doi:  
15 10.1080/02699930600923668
- 16 Silvia, P. J. (2008). Interest--the curious emotion. *Current Directions in Psychological*  
17 *Science*, *17*, 57-60. doi: 10.1111/j.1467-8721.2008.00548.x
- 18 Staats, H. (2012). Restorative environments. In S. Clayton (Ed.), *The Oxford handbook*  
19 *of environmental and conservation psychology* (pp. 445-458). New York: Oxford  
20 University Press. doi: 10.1093/oxfordhb/9780199733026.013.0024
- 21 Staats, H., Kieviet, A., & Hartig, T. (2003). Where to recover from attentional fatigue:  
22 An expectancy-value analysis of environmental preference. *Journal of*  
23 *Environmental Psychology*, *23*, 147-157. doi: 10.1016/S0272-4944(02)00112-3
- 24 Stevenson, M. P., Schilhab, T., & Bentsen, P. (2018). Attention Restoration Theory II:  
25 A systematic review to clarify attention processes affected by exposure to natural

- 1 environments. *Journal of Toxicology and Environmental Health, Part B*, 21, 227-  
2 268. doi: 10.1080/10937404.2018.1505571
- 3 Suedfeld, P. (2012). Extreme and unusual environments: Challenges and Responses. In  
4 S. Clayton (Ed.), *The Oxford handbook of environmental and conservation*  
5 *psychology* (pp. 445-458). New York: Oxford University Press. doi:  
6 10.1093/oxfordhb/9780199733026.013.0019
- 7 Tabachnick, B. G., & Fidell, L. S. (1996). *Using multivariate statistics* (3rd ed.). New  
8 York: Harper Collins College Publishers.
- 9 Tennessen, C. M., & Cimprich, B. (1995). Views to nature: Effects on attention.  
10 *Journal of Environmental Psychology*, 15, 77-85. doi: 10.1016/0272-  
11 4944(95)90016-0
- 12 Ulrich, R. S., Simons, R. F., Losito, B. D., Fiorito, E., Miles, M. A., & Zelson, M.  
13 (1991). Stress recovery during exposure to natural and urban environments. *Journal*  
14 *of Environmental Psychology*, 11, 201-230. doi:10.1016/S0272-4944(05)80184-7
- 15 Van Cappellen, P., & Saroglou, V. (2012). Awe activates religious and spiritual feelings  
16 and behavioral intentions. *Psychology of Religion and Spirituality*, 4, 223-236. doi:  
17 10.1037/a0025986
- 18 Van Elk, M., Karinen, A., Specker, E., Stamkou, E., & Baas, M. (2016). ‘Standing in  
19 awe’: The effects of awe on body perception and the relation with absorption.  
20 *Collabra*, 2, 1-16. doi: 10.1525/collabra.36
- 21 Vining, J., & Merrick, M. S. (2012). Environmental epiphanies: Theoretical foundations  
22 and practical applications. In S. Clayton (Ed.), *The Oxford handbook of*  
23 *environmental and conservation psychology* (pp. 485-509). New York: Oxford  
24 University Press. doi: 10.1093/oxfordhb/9780199733026.013.0026

- 1 Von Lindern, E. (2015). Setting-dependent constraints on human restoration while  
2 visiting a wilderness park. *Journal of Outdoor Recreation and Tourism, 10*, 29-37.  
3 doi: 10.1016/j.jort.2015.06.001
- 4 Von Lindern, E., Bauer, N., Frick, J., Hunziker, M., & Hartig, T. (2013). Occupational  
5 engagement as a constraint on restoration during leisure time in forest settings.  
6 *Landscape & Urban Planning, 118*, 90-97. doi:10.1016/j.landurbplan.2013.03.001
- 7 Williams, K., & Harvey, D. (2001). Transcendent experience in forest environments.  
8 *Journal of Environmental Psychology, 21*, 249-260. doi: 10.1006/jevp.2001.0204
- 9 Wechsler, D. (1997). *Wechsler Memory Scale* (3<sup>rd</sup> ed). San Antonio, TX: Psychological  
10 Corporation.
- 11 Weinstein, N., Przybylski, A. K., & Ryan, R. M. (2009). Can nature make us more  
12 caring? Effects of immersion in nature on intrinsic aspirations and generosity.  
13 *Personality and Social Psychology Bulletin, 35*, 1315-1329. doi:  
14 10.1177/0146167209341649
- 15 Yang, Y., Yang, Z., Bao, T., & Liu, Y., & Passmore, H. A. (2016). Elicited awe  
16 decreases aggression. *Journal of Pacific Rim psychology, 10*, 1-13. doi:  
17 10.1017/prp.2016.8
- 18 Yik, M., Russell, J. A., & Steiger, J. A. (2011). A 12-point circumplex structure of core  
19 affect. *Emotion, 11*, 705-731. doi: 10.1037/a0023980  
20

## 1 Table 1

2 *Beauty and Awe Means (Standard Deviations), by Origin*

	Awe-evoking		Mundane	
	Natural	Built	Natural	Built
Awe	4.77 (0.78)	4.68 (1.02)	2.70 (0.51)	2.76 (0.47)
Beauty	5.92 (0.41)	5.70 (0.62)	4.05 (0.37)	4.08 (0.46)

3 *Note.* Responses were given on a seven-point scale, from 1= *strongly disagree* to 7=  
4 *strongly agree*.

1 Table 2  
 2 *Means and Standard Deviations of Awe, Familiarity, and Reported Restoration in Each*  
 3 *Condition*

	Built Mundane		Natural Mundane		Built Awe-evoking		Natural Awe-evoking		Control (Natural Awe-evoking)	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Awe	2.65	0.82	2.98	0.60	3.64	0.97	3.61	0.78	3.56	0.83
Familiarity	4.66	1.22	4.16	1.03	3.14	0.88	3.44	0.78	3.22	0.84
Reported restoration	3.58	1.03	4.28	1.12	4.55	1.37	5.07	0.86	4.73	0.76

4 *Note.* Responses were given on a seven-point scale, from 1= *strongly disagree* to 7=  
 5 *strongly agree*.

**Figure captions**

- 1  
2 *Figure 1.* Sample pictures from each slideshow condition.  
3  
4 *Figure 2.* Pre- and post-slideshow digit span scores, as a function of slideshow  
5 condition (error bars represent 95% confidence interval). *Note.* Possible minimum and  
6 maximum scores are zero and 30, respectively. **\*\* $p < .001$ , \* $p < .05$**   
7  
8 *Figure 3.* Pre- and post-slideshow pleasant deactivation scores as a function of  
9 slideshow condition (error bars represent 95% confidence interval). *Note.* Responses  
10 were given on a seven-point scale, from 1= *strongly disagree* to 7= *strongly agree*. **\*\* $p$**   
11 **< .001**



1  
2  
3

Appendix A  
Awe and Reported Restoration Scales

**Awe**

Image 1	Strongly disagree						Strongly agree
1. This image makes me feel insignificant	1	2	3	4	5	6	7
2. This image makes me feel respect	1	2	3	4	5	6	7
3. This image makes me feel humble	1	2	3	4	5	6	7
4. This image is overwhelming	1	2	3	4	5	6	7
5. This image is extraordinary, uncommon	1	2	3	4	5	6	7
6. When I look at this image, it feels as if time stopped.	1	2	3	4	5	6	7
7. This image makes me feel a bit fearful	1	2	3	4	5	6	7
8. This image awakens my spirituality	1	2	3	4	5	6	7
9. This image makes me feel that I'm part of something much larger than myself	1	2	3	4	5	6	7
10. This image is fascinating	1	2	3	4	5	6	7

4

**Reported Restoration**

After watching the slideshow ...	Strongly disagree						Strongly agree
1. I feel at rest	1	2	3	4	5	6	7
2. My energy has been renewed	1	2	3	4	5	6	7
3. I have become myself again	1	2	3	4	5	6	7
4. I am free of tension	1	2	3	4	5	6	7
5. I can order my thoughts again	1	2	3	4	5	6	7
6. I can put everything behind me	1	2	3	4	5	6	7
7. I have regained the ability to concentrate	1	2	3	4	5	6	7
8. I can deal with my daily experiences	1	2	3	4	5	6	7

6

1  
2 **Silvia Collado** is an assistant professor in the Department of Psychology and Sociology  
3 at the Universidad de Zaragoza, Spain. She is interested in the study of the restorative  
4 effects of natural and built environments, environmental preferences, and the factors  
5 shaping the development and change of environmental behaviors.

6 **Héctor Marín Manrique** is an assistant professor in the Department of Psychology and  
7 Sociology at the Universidad de Zaragoza, Spain. He was trained as a psychobiologist  
8 and then specialized in comparative psychology. His postdoctoral research involved  
9 experimental studies on great apes at Leipzig's Max-Planck Institute for Evolutionary  
10 Anthropology.