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

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Abstract

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

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

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

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

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

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

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

The Emotion of Awe

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

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

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

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

Restoration and Awe

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

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

The Present Study

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

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

Research Design

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

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

Method

Phase I: Standardization and Selection of Pictorial Stimuli

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

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

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

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

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

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

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

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

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

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

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

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

TABLE 1 ABOUT HERE

FIGURE 1 HERE

Phase II: Main Study

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

Materials employed.

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

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

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

scale has gone through extensive psychometric validation. The adjective version of the scale was used, and participants had to indicate to what extent they experienced each adjective on a scale from 1 (*not at all*) to 5 (*extremely*). The adjectives were: relaxed, calm, tranquil, placid, at rest. Cronbach's alphas for the scale were adequate (αT0 = .77; αT1=.81).

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

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

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

Procedure

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

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

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

Results

Effects on Awe and Familiarity

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

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

TABLE 2 ABOUT HERE

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

Effects on Reported Restoration

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

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

Effects on Actual Restoration

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

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

FIGURE 2 ABOUT HERE

Effects on Positive Affect

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

FIGURE 3 ABOUT HERE

Discussion

Research on restoration has long examined different benefits of exposure to everyday natural environments, compared to built environments (Hartig et al., 2003). People are also attracted to awe-evoking scenes and phenomena (Van Cappellen & Saroglou, 2012), and the positive psychological effects of such experiences have been acknowledged (Suedfeld, 2012). However, as far as we know, the possible restorative effects of exposure to awe-evoking scenes have not been systematically addressed. We present here a study that makes two novel contributions to the existing literature. First, we explored the restorative effects of exposure to awe-evoking scenes compared to mundane (i.e., everyday) scenes. Second, previous experimental studies on the positive effects of exposure to awe-evoking (vs. mundane) scenes included only natural (Joye & Bolderdijk, 2015) or only built (Joye & Dewitte, 2016) stimuli, precluding any examination of differential positive effects between awe-evoking natural versus built environments. Following the general approach of restoration research (e.g., Berto, 2005; Kaplan & Berman, 2010), the present study compared natural and built scenes. That strategy allowed us to discover whether the restorative effects suggested by previous studies, in which nature was the main awe elicitor (e.g., Joye & Bolderdijk, 2015; Williams & Harvey, 2001), were mostly linked to the scenes' awe-evoking characteristics, or their natural origin. Three different aspects of restoration were considered: reported restoration, attentional performance, and positive affect.

Comparison with Earlier Research, and This Study's Main Contributions

As in previous studies, awe was elicited by showing participants a series of images (Joye & Bolderdijk, 2015; Rudd et al., 2012). Experimental conditions were carefully controlled to minimize potentially confounding variables. Our experimental

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

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

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

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

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

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

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

Practical Implications

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

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

Limitations and Future Directions for Research

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

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

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

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

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

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

Notes

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

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

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

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

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

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Table 1

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)

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

Table 2

Means and Standard Deviations of Awe, Familiarity, and Reported Restoration in Each Condition

	Built Mundane		Natural Mundane		Built Awe-evoking		Natural Awe-evoking		Control (Natural Awe-evoking)	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
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

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

Figure captions

Figure 1. Sample pictures from each slideshow condition.

Figure 2. Pre- and post-slideshow digit span scores, as a function of slideshow condition (error bars represent 95% confidence interval). *Note*. Possible minimum and maximum scores are zero and 30, respectively. $^{**}p < .001$, $^{*}p < .05$

Figure 3. Pre- and post-slideshow pleasant deactivation scores as a function of slideshow condition (error bars represent 95% confidence interval). *Note*. Responses were given on a seven-point scale, from 1= *strongly disagree* to 7= *strongly agree*. $^{**}p < .001$

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**

Reported Restoration

After watching the slideshow …	Stronlgy 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**

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