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Up speeds you down. Awe-evoking monumental buildings trigger behavioral and perceived freezing

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ABSTRACT

Since the dawn of large-scale civilizations, humans have built exceptionally tall architectural structures. We tested whether exposing individuals to images of very tall buildings would produce feelings of awe in them, and would lead to a behavioral response frequently associated with this emotion, namely "freezing". Across four studies participants reported to feel more awestruck (Pilot 1a, Study 1a) and more bodily immobile after having seen pictures of high versus low buildings (Study 1b). In addition to perceived immobility, we also found that participants responded slower on a manual clicking task in the face of high as opposed to low buildings (Pilot 1b, Study 1b). This effect was mediated by perceived bodily immobility, suggesting that slow clicking after seeing high buildings indeed reflected behavioral freezing. Overall, our findings suggest that very tall buildings can be a trigger of awe, and that experiencing this emotion can involve a state of behavioral freezing.

1. Introduction

Monumental buildings or structures, ranging from cathedrals, to pyramids, temples, and – in modern times – skyscrapers, are an inherent and age-old part of the building repertoire of large-scale societies, and are often considered among the pinnacles of human architecture and technical craftsmanship. Whereas in the past monumental architecture[1] was often built to signal the exceptional power of leaders or leading ideologies (Neiman, 1998; Trigger, 1990), in recent times monumentally tall buildings are also often – if not mostly – constructed to fulfil a direct pragmatic function, i.e., to concentrate residential and working space on a small patch of land. Such "vertical packing" – or even entire "vertical cities" (Wong, 2004) – will most probably increase in the next few decades (Frenkel, 2007), as by 2050 more than half of the world's population will be concentrated in densely populated urban(ized) areas (United Nations, 2014) where living and working space is often scarce and land is expensive.

Despite the historic prevalence and cultural value of monumentally tall buildings (Smith, 2007), and their importance as a contemporary and future dwelling type, to this day relatively little research has investigated how visual exposure to such buildings can psychologically affect individuals. Most environmental psychology research on the effects of tall buildings has not so much focused on the direct psychological and behavioral effects of sheer building size and tallness, but more on how building height can affect psychology and behavior through certain intermediate processes or phenomena (consider, e.g., compact living in high-rises, which, through crowding, can lead to psychological stress; Gifford, 2007). The little work on the direct psychological effects of building height has revealed that building height can negatively affect the perceived likelihood for restoration (Lindal & Hartig, 2013), and can increase individuals' feelings of enclosure (Stamps, 2005).

With the current research we aimed to address the lack of environmental psychological research into the direct psychological effects of building height. Based on the fact that instances of monumental architecture have been considered as emotionally charged environments (Alcorta & Sosis, 2005; Joye & Verpooten, 2013), or even as "affective weapons" (Gordillo, 2014), we set out to investigate how such buildings would emotionally affect individuals, and what kind of physical/motor behavior would be

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[1] While we are aware that the notion "monumental" has different connotations (e.g., it can have a commemorative component), in agreement with archeological theorizing, in the current paper we use the notion to refer to the large scale of buildings, and especially to their tallness (Osborne, 2014).

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associated with the emotional impact of such buildings.

1.1. Awe as an emotional response to architectural vastness

Inspired by the work of Keltner and Haidt (2003), in this paper we expected that *awe* would be one of the primary emotional responses towards exceptionally tall architectural structures. While bearing a family relationship with (aesthetic) emotions such as fascination, wonder, or delight (Scherer, 2005), awe differs from the latter in that it is typically triggered by stimuli or events that are characterized by "vastness" (i.e., by stimuli/events that are "… much larger than the self, or the self's ordinary level of experience or frame of reference" (Keltner & Haidt, 2003, p. 303)).

Vastness is thus the main (physical) elicitor of awe, and while it is typically associated with large physical scale and size, it can also refer to social size (cfr., socially dominant, famous, or prestigious individuals) or to size "in time, number, in complexity of detail" (Shiota, Keltner, & Mossman, 2007, p. 945). Vastness should furthermore not only be understood in terms of absolute vastness/size of a stimulus, but rather stands for vastness compared to a particular frame of reference (Keltner & Haidt, 2003).

Besides vastness, another central concept in Keltner and Haidt's (2003) account of awe is that the experience of awe is often characterized by "a need for accommodation" (Keltner & Haidt, 2003; Shiota et al., 2007). This means that due to its atypical vastness, the awe-evoking stimulus can challenge an individual's current mental frameworks, thereby leading to a need to adjust or transform the latter. For example, the sight of the 828 m high *Burj Khalifa* (Dubai) might challenge or overthrow an individual's notion of what is possible in terms of human constructive and creative accomplishments, thus triggering an adaptive need to mentally update one's existing mental structures.

Since Keltner and Haidt's seminal paper on awe (Keltner & Haidt, 2003), different strands of psychological research have uncovered some of the downstream effects of awe experiences. It has for example been shown that experiencing awe makes individuals more spiritual (Saroglou, Buxant, & Tilquin, 2008), induces feelings of oneness with other people and the world (Shiota et al., 2007), increases perceived time availability (Rudd, Vohs, & Aaker, 2012), and leads to an increased tendency to attribute agency to random events (Valdesolo & Graham, 2014). Different studies have also confirmed that episodes of awe can make individuals more prosocially oriented and generous (Joye & Bolderdijk, 2015; Piff, Dietz, Feinberg, Stancato, & Keltner, 2015), an effect that has been attributed to the self-diminishing effects of awe (Piff et al., 2015).

It has been suggested that in its primordial form awe can be traced back to a subordinate's emotional response to a dominant and powerful individual (Keltner & Haidt, 2003). While potentially thus having social origins, awe can also be elicited by nonsocial stimuli, inasmuch as these are characterized by (physical) vastness. In psychological studies on awe, pictures and clips of vast natural scenes and phenomena (e.g., grand waterfalls, huge mountain ranges) are often used to provoke awe (Joye & Bolderdijk, 2015; Piff et al., 2015; Rudd et al., 2012; Saroglou et al., 2008), and experiences of nature have been listed as amongst the most frequent elicitors of awe (Shiota et al., 2007). Given their enormous scale and height it should come as no surprise that instances of monumental architectural structures (e.g., cathedrals) are also often pinpointed as potential man-made elicitors of awe (Díaz-Vera, 2015; Joye & Verpooten, 2013; Keltner & Haidt, 2003; Piff et al., 2015).

1.2. Awe, architectural vastness and behavioral immobility

Based on the characterization of awe as an emotional response to vastness leading to a need for accommodation, the first aim of the current research was to test whether very tall architectural (i.e., monumental) structures would indeed trigger awe and associated feelings (e.g., smallness) in individuals. Related to this, our second aim was to shed light on the kind of behavioral response that would accompany such a building-induced awe episode. These two interlocking aims should be considered against the background of componential theories of emotions (e.g., Scherer, 2005), according to which emotion episodes are typically characterized by different components, including a particular behavioral component.

Within environmental psychology, behavioral responses towards environments or environmental features are frequently researched, but these studies have traditionally focused on approach and avoidance behavior as typical behavioral outcomes (Gilboa & Rafaeli, 2003; Russell & Mehrabian, 1978; Stamps, 2005; Vartanian et al., 2013, 2015). We hypothesize that awe-evoking monumental architecture can actually lead to another type of behavioral response than approach or avoidance, namely behavioral *immobility*.

Within the recent literature on awe, different researchers have hinted at the immobilizing potential of awe and awe-evoking stimuli. In particular, awe has been linked to a state of "freezing" (Griskevicius, Shiota, & Neufeld, 2010), "paralysis" (Solomon, 2002), "stillness" (Haidt & Keltner, 2002), "passivity" (Fuller, 2008; Keltner & Haidt, 2003), and "immobility" (Shiota, Neufeld, Yeung, Moser, & Perea, 2011). Recent linguistic research also shows that old English notions for awe have been metonymically used to express "sluggishness" and "physical paralysis" (Díaz-Vera, 2015). Inasmuch as emotion labels can be diagnostic of the emotion's associated behavioral response (Scherer, 2001), this tentatively suggests that (at least in earlier times) people experienced immobility as part and parcel of awe episodes.

Importantly, throughout history some builders of monumental architecture have recognized and deliberately exploited architecture's potential immobilizing effects (Gordillo, 2014). It is for example well-known that certain monumental Nazi buildings were so designed to make individuals both physically and psychologically helpless and small, in an effort to weaken (potential) resistance against Nazism. The sheer length and vastness of the hallways in the *Neue Reichskanzlei* (Berlin, Albert Speer), for instance, served to dwarf and fatigue visitors and dignitaries, whereas its slippery polished marble floors made it precarious for them to go fast (Boyd Whyte, 1998). Scholars have consequently speculated that part of the function(s) of such monumental buildings was to "… *decrease* the body's capacity for action by overwhelming it, stunning it, numbing it, making it malleable and, in short, politically passive" (Gordillo, 2014, n.p.). This thus suggests that in addition to being physical obstacles, there might also exist a psychological pathway through which instances of monumental architecture discouraged individuals or groups from undertaking action against its builders.

1.3. Behavioral immobility reflects freezing

Of course, the hypothesis that awe-evoking architecture can immobilize raises the question which precise mechanism underlies this proposed phenomenon. We speculate that behavioral immobility associated with awe reflects a well-known defensive response to a threatening stimulus, namely freezing (we will also use the notion "freezing" in the remainder of our article). Freezing is – besides fight and flight – one of the main stages of the defense cascade in both human and nonhuman animals (Hagenaars, Oitzl, & Roelofs, 2014; Marx, Forsyth, Gallup, Fuse, & Lexington, 2008), and specifically occurs when a threat has been first detected and/or encountered (Marx et al., 2008).

Freezing prepares the organism for escape or defensive fighting by optimizing visual and attentional processes to the threat (Hagenaars et al., 2014; Marx et al., 2008). Freezing is typically characterized by hyper-vigilance towards a threatening stimulus or environment (Öhman & Wiens, 2003), and crucially implies a state of general immobility, evident from a tense body posture and muscle stiffness (Hagenaars et al., 2014). In addition, by staying immobile, the threatened organism avoids being discovered, or further drawing the threatening agent's attention, thereby reducing the risk of being captured and killed (Bracha, 2004). Note that freezing is commonly differentiated from tonic immobility (also known as "playing dead"), which is one of the last stages in the defense cascade, and occurs when fight or flight have become futile. While freezing implies a kind of "alert motionlessness", tonic immobility entails a "catatonic-like motionlessness" (Marx et al., 2008).

In experimental research on human behavioral freezing, freezing responses are mainly provoked by exposure to biological threats, such as pictures of mutilated bodies and corpses (Hagenaars, Stins, & Roelofs, 2012), angry faces (Roelofs, Hagenaars, & Stins, 2010) or threatening animals (e.g., spiders; Sagliano, Cappuccio, Trojano, & Conson, 2014). However, also threatening man-made objects, such as firearms, have been found to trigger behavioral freezing (Fernandes et al., 2013). In research on human freezing, freezing has been found to be evident from bradycardia (i.e., decreased heart rate; Roelofs et al., 2010), decreased response times (Sagliano et al., 2014; Fernandes et al., 2013), and also from decreased body sway (Roelofs et al., 2010).

The primary reason why vast/monumental architectural structures – as an elicitor of awe – might trigger freezing, is that for many species (including humans) physical vastness is actually a threat cue[2]. Specifically, throughout the animal kingdom many organisms are biased to associate vastness in size and height with power (Joye & Verpooten, 2013; Schubert, 2005) and formidability (Holbrook, Fessler, & Navarrete, 2016). Animals exploit this bias in so-called dominance/threat displays, where they attempt to threat and ward off rivals through self-aggrandizement (e.g., by extending arms and legs, by pilo-erection; De Waal, 1982). Recent research has interpreted certain instances of monumental architecture as built threat displays (Joye & Verpooten, 2013), through which rulers and elites sought to intimidate potential rivals and to consolidate their superior position with respect to commoners (Neiman, 1998).

Given that height can be perceived as threatening because signaling power and formidability, organisms will tend to display a distinct defensive response when confronted with vast, huge displays of power (i.e., fight, flight or freeze; Judge & Cable, 2004; Fessler & Holbrook, 2013). In much the same way, we assume that exceptionally high architecture can exploit this "height = power/formidability" bias in human individuals, and can trigger a freeze, fight or flight response. Although throughout history high buildings have been constructed without a threat effect in mind (e.g., skyscrapers) they might still elicit defensive responses, merely because of the fact that they fulfil the input conditions of this defensive response (Sperber & Hirschfeld, 2004).

In our account, feeling awe and freezing are two interrelated emotion components (i.e., respectively the feeling and behavioral components) that can be triggered by displays of formidable power. There are a number of conditions under which freezing is more likely to occur than fight or flight. Specifically, psychological research has shown that freezing not only occurs during the initial encounter with a threat (Hagenaars et al., 2014; Marx et al., 2008), but that it will persist under the condition of threat imminence and unavoidability (Hagenaars et al., 2014; Löw, Weymar, & Hamm, 2015). Based on this, we predict that freezing is especially likely to occur when a monumental building does not only look overwhelmingly high, but when it also creates the impression of being impossible to flee from – by its proximate position, for example.

1.4. The current research

Based on the foregoing review and arguments, we hypothesize that exposure to monumentally high architecture can give rise to feelings typically associated with exceptional vastness (e.g., awe, fear, feeling small) and lead to the particular behavioral counterpart of those feelings, namely freezing. We conducted two pilot studies and two full studies to test our hypotheses. In all four studies participants saw images of either high or low buildings (artificial or real ones). In the pilot studies, we also manipulated building distance to validate our assumption that proximity of high buildings would moderate the freezing effect, and associated feelings (Löw et al., 2015).

In Pilot 1a and Study 1a we verified whether images of monumentally high buildings would trigger feelings that are typically caused by exceptional vastness (i.e., feeling awe-struck, small, and fearful), and in Pilot 1b and Study 1b we tested whether the associated behavioral component – freezing – would be evident from reduced response speed on a simple manual clicking task (Pilot 1b and Study 1b) and from perceived freezing (Study 1b). In Study 1b we additionally tested whether there was a positive relationship between feeling awe and response speed on the clicking task. The rationale for conducting the pilot studies was to preliminarily test our freezing hypothesis, as well as to validate the stimulus material and the methodology to capture freezing (i.e., a mouse clicking task). The full studies, developed from these preparations, were aimed at replicating the freezing effect with a larger and more diverse set of buildings and with a more varied population of respondents.

Overall, our expectations were that, after exposure to monumental buildings, participants would feel more fearful, small and awestruck than after having seen low buildings (Pilot 1a, Study 1a) and would also display the highest levels of behavioral and perceived freezing (Pilot 1b, Study 1b). We expected that these effects would especially apply for high buildings that appeared to stand close to the participants, because these create a sense of inescapability/unavoidability.

2. Pilot study 1a

In this study we explored whether visual exposure to images of high versus low buildings would trigger feelings typically associated with exceptionally vast stimuli in participants. Participants first had to watch a picture of either a high or a low building, which appeared to stand either very close-by or somewhat further away. After this, we measured the extent to which they had experienced awe, feelings of smallness, fear and particular aesthetic emotions (e.g., wonder). Because the impression of vastness is most pressing for the high building standing close-by, we expected that this building would consequently trigger the highest level of awe, feelings of smallness and fear.

2.1. Methods

2.1.1. Participants and design

Hundred and thirteen students (48 females; age: $M = 20.93$, $SD = 2.49$) from a large European university participated in this lab

[2] Nowadays awe is often considered as a positive emotion (Saroglou et al., 2008), whereas in the past this notion was often connected to negative emotional states such as threat, dread, terror and fear (Díaz-Vera, 2015; Haidt & Seder, 2009). Still note that in Plutchik's wheel of emotions, awe is described as a mix of surprise and fear (Plutchik, 2001).

study in exchange for course credit or a small fee. This study was a 2 by 2 design, with Height and Distance as the between-subjects variables.

2.1.2. Stimuli

The stimuli were four building pictures (see Fig. 1), which each showed the facade of a modern standalone building. While we are aware that in actual built settings tall buildings vary on more dimensions than height (e.g., shape, spatial structure, ornamentation), in this exploratory phase of our experiment, we opted to use only "schematic" computer-generated pictures as stimuli (designed with AutoCAD©). This setup was chosen to keep constant possible historical or ideological factors, and to be able to isolate the emotional and behavioral effects of height only.

Each of the pictures corresponded to one experimental condition, namely High – Far, Low – Far, High – Close and Low – Close. The buildings from the Far condition were identical to the close buildings, except that they were located on a slightly more distant position. Distance was manipulated to validate our conceptualization in terms of freezing, as freezing is more likely to occur when a threatening stimulus is unavoidable (Hagenaars et al., 2014; Löw et al., 2015). The facades of the two high buildings respectively covered 89% and 41% of the images in the Close and Far condition, whereas the two low buildings respectively made up 87% and 48% of the total image surface in the Close and Far condition. The high buildings were one hundred stories high, whereas the low ones consisted of three stories. For the two high buildings the lowermost stories were not visible on the picture due to the upward gaze implied in the pictures.

2.1.3. Procedure and measures

Participants conducted this lab study in private on a personal computer in a semi-enclosed cubicle. After asking for personal details (i.e., age, gender, and student number), we informed participants that they were about to be shown a series of building pictures. We mentioned that it was of crucial importance to pay close attention to the pictures, and to imagine that they were standing near the building depicted. Participants were then randomly assigned to one of the four building conditions.

In a first phase of the study, we showed participants a large picture of one of the four possible building images during 10 s (size: 1000 × 1000 pixels; building color: gray). After this, a smaller (size: 400 × 400 pixels) but colored version of the same building picture was displayed and participants had to evaluate the building on a particular visual or functional attribute (sample items: "I like the colors of this building", "I would like to work in this building"; scored from 1 = "totally disagree" to 5 = "totally agree"). Within each condition, participants had to evaluate a total of twenty-five (differently colored) building images, each on one particular visual or functional attribute. The purpose of this evaluation task was to expose participants sufficiently long to one and the same building type.

After the viewing and evaluation tasks, we presented participants a battery of emotion statements, and asked them to indicate how much they had felt each emotion while watching the building images (single items, which were always presented in the same order and were scored from: 1 = "very little" to 7 = "very much"). Specifically we probed how small participants had felt (items: "small", "puny", "humble", "overwhelmed", "insignificant" and "being in the presence of something bigger than myself"; Cronbachs $\alpha = 0.81$) and how much they had experienced "awe". We additionally measured how "afraid" participants had felt, and the extent to which they had experienced (aesthetic) emotions that are sometimes associated with awe, namely "wonder", "fascination" and "delight"[3].

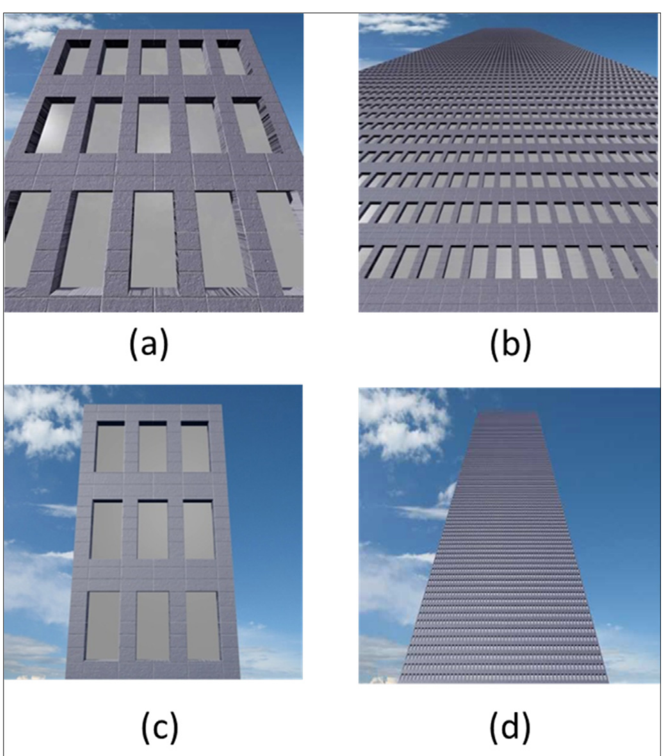

Fig. 1. The four computer generated buildings that were created for the studies, with (a) Low – Close, (b) High – Close, (c) Low – Far, (d) High – Far. In Pilot 1a and Pilot 1b we used all four pictures. We only used the upper two pictures in Study 1a and Study 1b.

2.2. Results and discussion

Detailed results of the statistical analyses performed on all items (i.e., two-way ANOVA), as well as descriptives, are provided in Table 1. The most important finding was a significant main effect of Height on the items "awe" and "wonder", and on the smallness index. Specifically, across the Far and Close conditions, seeing high buildings made respondents feel more awe and wonder than seeing low buildings, and also induced a sense of smallness. While there was no significant Height by Distance interaction for these three items, planned contrasts revealed that the effect of Height was more pronounced in the Close building condition than in the Far condition. We did not find a significant main effect of Height or Distance, nor a significant Height by Distance interaction for the items "fascination", "delight" and "afraid". In sum, the higher and the closer the buildings appeared to be, the more participants reported to have experienced feelings that are typically triggered by exceptionally vast stimuli, i.e., awe and feelings of smallness. In the next study we wanted to test whether pictures of the high, close-by building would also lead to the most pronounced freezing behavior.

3. Pilot study 1b

The goal of Pilot 1b was to preliminarily test whether visual exposure to high (versus low) buildings could lead to behavioral

[3] In the psychological literature on awe, awe is often measured using a single item (e.g., Joye & Bolderdijk, 2015; Piff et al., 2015; Shiota et al., 2007). Note that in our studies we have taken additional measurements that are less relevant for the current research, but that are available upon request.

Table 1
Mean scores and statistics (including planned comparisons) for the emotions measured in Pilot 1a.

	Height			Distance			Height × distance			Close					Far				
	F	*p*	η_p^2	*F*	*p*	η_p^2	*F*	*p*	η_p^2	High	Low	*F*	*p*	η_p^2	High	Low	*F*	*p*	η_p^2
Awe	4.07	0.046	0.04	0.19	0.663	0.00	0.34	0.563	0.00	3.64 (1.62)	2.88 (1.40)	2.96	0.088	0.03	3.34 (1.74)	2.93 (1.11)	1.20	0.276	0.01
Smallness	8.42	0.004	0.07	0.86	0.356	0.01	0.72	0.398	0.01	3.86 (1.45)	2.99 (1.11)	6.17	0.015	0.05	3.45 (1.24)	2.98 (1.04)	2.45	0.120	0.02
Fascination	1.66	0.200	0.02	0.05	0.832	0.00	1.57	0.213	0.01	3.41 (1.50)	2.65 (1.16)	2.84	0.095	0.03	2.97 (1.85)	2.96 (1.43)	0.00	0.978	0.00
Delight	0.29	0.591	0.00	0.93	0.338	0.01	0.70	0.406	0.01	2.18 (1.30)	2.12 (1.18)	0.04	0.845	0.00	2.21 (1.14)	2.52 (1.09)	1.10	0.298	0.01
Wonder	11.34	0.001	0.09	1.18	0.279	0.01	2.20	0.141	0.02	4.32 (1.39)	2.92 (1.38)	10.33	0.002	0.09	3.58 (1.65)	3.04 (1.45)	2.06	0.154	0.02
Afraid	0.04	0.848	0.00	0.01	0.935	0.00	0.82	0.367	0.01	2.14 (1.21)	1.88 (1.31)	0.53	0.469	0.01	1.95 (1.11)	2.11 (1.19)	0.30	0.587	0.00

freezing in participants. Based on the finding that reduced response speed is a reliable indicator of freezing (cfr., Sagliano et al., 2014; Fernandes et al., 2013) we operationalized freezing in terms of the speed with which participants clicked a series of radio buttons using their computer mouse. We expected that clicking radio buttons would be slowest in the face of the high building situated close-by. Not only had these buildings triggered the highest levels of awe in Pilot 1a, in this condition the closeness of the building could also create a feeling of inescapability/unavoidability (Löw et al., 2015).

3.1. Methods

3.1.1. Participants and design

Ninety-eight students (60 females) from a large European university participated in this lab study in exchange for course credit or a small fee (age was recorded, but not saved due to a programming error). This study was a 2 by 2 design, with Height and Distance as the between-subjects variables.

3.1.2. Materials

We used the four building pictures from Pilot 1a as fixed computer desktop backgrounds (horizontally oriented screen; resolution: 1920 × 1080 pixels). Given that hand movements can be diagnostic of mental processing (Freeman, Dale, & Farmer, 2011), we decided to capture behavioral freezing by means of a manual clicking task, consisting of clicking on-screen radio buttons as fast as possible with the computer mouse. Because manipulating a computer mouse requires delicate motor/muscle control (Freeman et al., 2011), and freezing is associated with muscle stiffness (Hagenaars et al., 2014; Sagliano et al., 2014), we reasoned that freezing would be evident from reduced clicking speed on a clicking task. Note that this expectation is consistent with the finding that people from older age groups, who generally have reduced muscle flexibility, score worse on tests with input devices (like a computer mouse) than younger individuals (for a review: Taveira & Choi, 2009).

The clicking task was performed on a so-called button screen. A button screen measured 1000 by 400 pixels, and appeared on the lower half of the computer screen (Fig. 2). The button screen consisted of a collection of twenty-three randomly distributed radio buttons that could be clicked. The position of the buttons was identical across the four conditions. Because the button screen did not entirely cover the desktop background, the upper part of the building picture remained visible during the entire clicking task.

3.1.3. Procedure

Participants entered the lab, and were randomly assigned to one of the semi-enclosed cubicles. Each personal computer within a cubicle had a desktop background that corresponded to one of the four building conditions. After asking for personal details (i.e., age, gender, and student number), the experiment began with an on-screen instruction, requesting participants to click all the radio buttons on the next screen (i.e., the button screen) as fast and accurately as possible. When participants clicked "next" on this instruction screen, the button screen appeared. We recorded the speed with which each individual button was clicked and the number of buttons clicked. Although participants had the option to end the clicking task before having clicked all buttons by clicking "next" on the button screen, our results showed that virtually all participants clicked all buttons (i.e., 97 percent of all clicking tasks was fully completed).

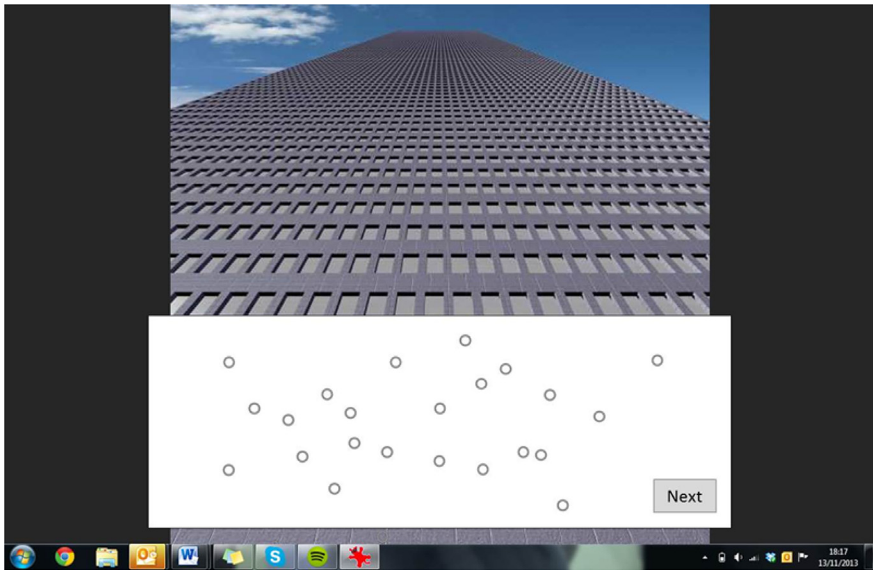

Fig. 2. Schematic representation of the clicking task performed in Pilot 1b.

3.2. Results and discussion

Average clicking time per button was log-transformed because its distribution was positively skewed. We removed one participant because of an outlying value for log-transformed average clicking time (using the MAD procedure described by Leys, Ley, Klein, Bernard, and Licata (2013)). A two-way ANOVA with building Height and Distance as the between-subjects variables, and (log-transformed) average clicking time per button as the dependent variable, revealed no statistically significant main effects of Distance, $F(1, 93) = 0.38$, $p = .540$, $\eta_p^2 = 0.00$, nor of Height, $F(1, 93) = 1.93$, $p = 0.168$, $\eta_p^2 = 0.02$. There was, however, a significant Height by Distance interaction, $F(1, 93) = 4.00$, $p = 0.048$, $\eta_p^2 = 0.04$ (see Fig. 3, displaying untransformed mean clicking times in milliseconds).

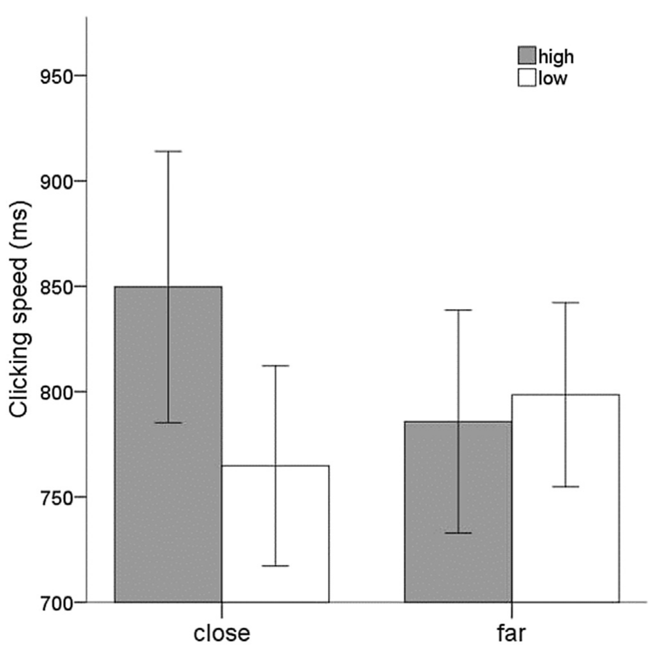

Fig. 3. Clicking speed (in milliseconds) as a function of Height and Distance (Pilot 1b). Error bars represent 95% confidence intervals.

Contrast analyses showed that, within the Close condition, participants clicked buttons significantly slower in the High ($M = 850$, $SD = 130$) than in the Low building condition ($M = 765$, $SD = 104$), $F(1, 93) = 4.80$, $p = 0.031$, $\eta_p^2 = 0.05$. By contrast, in the Far condition, there was virtually no difference between the High ($M = 786$, $SD = 134$) and the Low building condition ($M = 799$, $SD = 119$) on clicking speed, $F(1, 93) = 0.23$, $p = 0.631$, $\eta_p^2 = 0.00$.

The finding that participants' clicking behavior was slowest for the high close-by building not only parallels the results on smallness and awe from Pilot 1a, but it is also consistent with the view that freezing becomes more likely when an overwhelming threat is situated close-by, and hence unavoidable (Löw et al., 2015; Sagliano et al., 2014; Öhman & Wiens, 2003). Given that the results from our two pilot studies confirmed that images of monumentally high buildings can trigger motor behavior and feelings associated with exceptional vastness (i.e., freezing; awe and smallness), we decided to more stringently test for these effects in two further studies.

4. Study 1a

The current study aimed to verify whether watching pictures of exceptionally high buildings would trigger feelings that are typically evoked by vast stimuli (i.e., awe, fearfulness, smallness), as compared to low buildings or a control condition. To increase ecological validity, we no longer only used the schematic, "frame-like" buildings from the pilot study, but also showed participants photos of actual buildings. In addition, the sample of participants was demographically more varied than the student population from Pilot 1a. We generally expected that participants would feel most awestruck, fearful and small in the face of high (as opposed to low) buildings, and the control condition.

4.1. Methods

4.1.1. Design and participants

Two-hundred and forty four individuals (59 women; age: $M = 32.24$, $SD = 8.97$). The study was designed in *Qualtrics* and we used *Amazon Mechanical Turk* to recruit participants (they received

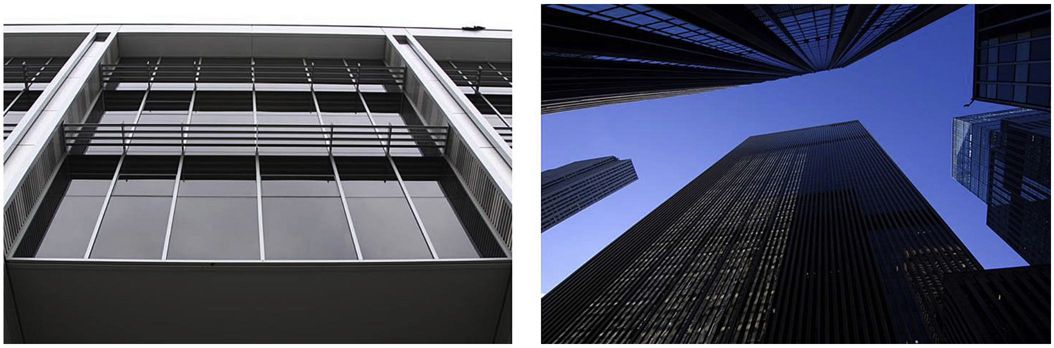

Fig. 4. Sample stimuli of the low (left; credits: Kenneth Bailey) and high (right; copyright holder: Chris Eason – Creative Commons by 2.0) buildings used in Study 1a and Study 1b (for all images, see the Supplementary Online Material).

0.37 dollar upon finishing the study)[4]. The study was a between-subjects design, with Height as the between-subjects factor (i.e., High versus Low buildings, and a Control condition). To compensate for a potentially high dropout rate (which is common for MTurk studies) we recruited more participants per condition than is usual for experiments on human freezing (i.e., fifty participants; e.g., Roelofs et al., 2010).

4.1.2. Materials

In the study, participants had to watch one of three possible picture slideshows, each corresponding with one experimental condition: two building conditions (High versus Low condition), and the Control condition. The building slideshows showed images of either high ($n = 5$) or low buildings ($n = 5$), whereas the Control condition consisted of pictures ($n = 5$) of neutral objects (e.g., a ladder or cardboard box[5]). The original images were resized to a maximum of 800 by 800 pixels to ensure that the entire image would be fully displayed on the (computer) screen of all participants. The *Qualtrics* output showed that screen resolution of the devices which participants had used for this study ranged from 360 by 640 pixels to 2560 by 1440 pixels. Only five participants used a device with a screen resolution lower than 1024 by 600 pixels, which suggests that for most participants screen size was sufficiently large to adequately perform the study.

Within each building condition, four building pictures were color photographs of real buildings collected from the Internet (see Fig. 4 for sample images), whereas the fifth building picture was the computer-generated building picture of a high or low building that had been used in the two pilot studies (only from the Close condition; Fig. 1). All four building photographs within each condition had been taken from very close-by, creating the impression of steeply looking up at the building. We made sure that the angle at which the buildings were photographed was largely similar across the High and Low condition, thus minimizing the possibility that potential differences on the dependent measures would be a byproduct of differences in (implied) body posture or head tilt. The buildings were chosen in such a way that they were devoid of any unusual architectural or stylistically prominent features. The four (actual) low buildings occupied on average 83% of the entire image, whereas their high counterparts made up 74% of the total image.

4.1.3. Procedure

After asking participants for personal details (i.e., gender and age), they were randomly assigned to one of the three possible slideshows. For each slideshow, we instructed them to watch each of the five pictures for about 10 s. Picture presentation was randomized, and each picture refreshed automatically after 20 s. After this, we asked participants to rate how much they had experienced the following feelings while watching the building pictures: "awe", "small", "humble", "fear", "delight", and "wonder" (scored from 1 = "strongly disagree" to 7 = "strongly agree"; items were always presented in the same order, and were taken from: Joye & Bolderdijk, 2015).

4.2. Results and discussion

Twelve participants (5%) were dropped from the study either because they had not performed the feeling rating ($n = 3$), because they had not watched any of the building pictures ($n = 1$), or because they had flat-lined for all feeling items ($n = 8$). We performed a one-way ANOVA with Height as the between-subjects variable and the feeling items as the dependent variables. Full results are shown in Table 2.

While there were statistically significant differences between the three conditions for the items "awe", "small", "fear", and "wonder", planned comparisons revealed that there was only a statistically significant difference between the two building conditions for awe. In agreement with a freezing account, and with the results from Pilot 1a, participants reported to have felt significantly more awe while viewing high as opposed to low buildings or no buildings. For "fear" and "wonder", the two building conditions (both High and Low) led to higher scores than the control condition. The fact that the effects between the High and Control condition were overall stronger than between the Low and Control condition, supports our interpretation that height had produced the psychological effects. In sum, like in Pilot 1a, we found that in the High building condition participants reported to have experienced feelings associated with exceptional vastness, i.e., awe.

5. Study 1b

In this study, we again showed participants photos of actual high versus low buildings and tested whether high buildings would lead to both behavioral and perceived freezing. Besides measuring freezing, we also measured the extent to which they had experienced awe, feelings of smallness, and certain aesthetic emotions (e.g., wonder). We expected that high (as opposed to low) buildings would lead to the strongest freezing response and to the highest levels of awe and feelings of smallness. Because in our account

[4] Note that the study was part of a larger unpublished study in which we measured the effects of awe-evoking buildings on prosocial behavior.

[5] It could be argued that the objects depicted in the control images were not entirely neutral, because they differed in terms of size (e.g., ladder versus box). Despite these size variations, the size of the neutral objects was still modest, and surely unlike the huge size that is typical of awe-evoking stimuli.

Table 2
Mean scores and statistics (including planned comparisons) for the emotions measured in Study 1a.

	F	*p*	High	Low	Control	*t* [H − L]	*p* [H − L]	Cohen's *d*	*t* [H − C]	*p* [H − C]	Cohen's *d*	*t* [L − C]	*p* [L − C]	Cohen's *d*
Awe	7.49	0.001	4.35 (1.81)	3.69 (1.78)	3.24 (1.76)	2.27	0.024	0.37	3.85	0.000	0.62	1.59	0.113	0.25
Fear	7.00	0.000	3.76 (1.65)	3.29 (1.93)	2.71 (1.65)	1.61	0.111	0.26	3.95	0.000	0.64	2.05	0.043	0.33
Wonder	7.43	0.001	5.05 (1.46)	4.78 (1.48)	4.14 (1.60)	1.11	0.270	0.18	3.74	0.000	0.60	2.66	0.008	0.42
Delight	1.31	0.272	4.39 (1.58)	4.09 (1.61)	3.99 (1.57)	1.16	0.248	0.19	1.56	0.119	0.25	0.41	0.686	0.07
Small	4.53	0.012	4.09 (2.18)	4.14 (1.95)	3.33 (1.50)	0.14	0.887	0.02	2.52	0.013	0.41	2.92	0.004	0.47
Humble	0.62	0.538	4.00 (1.57)	3.83 (1.66)	3.71 (1.64)	0.64	0.526	0.10	1.11	0.267	0.18	0.48	0.631	0.08

feeling awe and freezing are two components of the same emotional response to vastness, we furthermore expected a positive association between feelings of awe and (perceived) freezing.

5.1. Methods

5.1.1. Participants and design

In this online study, hundred and forty-two participants (96 women; age: $M = 32.75$, $SD = 10.25$) were recruited via *Amazon Mechanical Turk* and received 0.35 dollar upon finishing the study. The study was a between-subjects design, with Height as the between-subjects factor (i.e., High versus Low buildings). The experiment was presented to participants as a webpage with the task flow controlled by JavaScript code running locally in their web browser. Like in Study 1a we recruited more participants per condition than is usual for experiments on human freezing (i.e., fifty participants; Roelofs et al., 2010).

5.1.2. Materials and measures

Building pictures. We used the (non-resized) building pictures of Study 1a. The study was so designed that the size of the building picture was automatically fitted to the size of participants' screens. Because the study was not programmed in *Qualtrics* we were unable to obtain any information on participants' screen size. However, the random assignment of participants to each condition should have precluded any important differences in screen size between the two conditions.

Clicking task. We again operationalized freezing in terms of the speed with which participants clicked radio buttons on button screens. In the current study, button screens were white windows consisting of a cloud of twenty randomly distributed radio buttons that could be clicked by participants. For this study, we used six button screens per condition: one button screen to assess participants' baseline clicking speed, and five button screens to assess clicking speed after building exposure. The position of the radio-buttons varied between the six button screens to prevent habituation, but we made sure that identical button screens were used across the High and the Low condition.

Perceived FFF. In addition to the behavioral measure of freezing (i.e., speed of clicking buttons), we measured participants' perceived freezing, asked them about their tendency to fight and flight, and about their feelings of entrapment while watching the building pictures (items were randomly presented, and scored from 1 = "completely disagree" to 7 = "completely agree"). We created a freeze (items: "I felt motionless", "My muscles felt stiff", 'It felt like my thoughts and body were "frozen"', Cronbach's $\alpha = 0.81$), fight (items: "I felt aggressive", "I felt like yelling at somebody", "I felt like smashing something", Cronbach's $\alpha = 0.87$), and flight index (items: "I wanted to escape", "I wanted to get out of this place", Cronbach's $\alpha = 0.87$). Feelings of entrapment were assessed with the item "While watching the building images I felt being put into a tight corner".

Emotion measurement. While the main goal of the current study was to look at the effect of building height on (perceived) freezing behavior, we also asked participants how much the emotions "awe", "wonder", "delight", "fascination", "small", "humble", and "submissive" applied to them at that moment (scored from 1 = "does not apply at all" to 7 = "applies very much"; all emotion items were randomized). We created a smallness index from the items "small" and "submissive" (Cronbach's $\alpha = 0.61$; the item "humble" was not included in this index because it yielded very low internal consistency, i.e. Cronbach's $\alpha = 0.42$).

Control measurements. Because we used pictures of actual buildings in this study, we checked whether or not the depicted buildings belonging to each condition differed on other visual dimensions than height. Specifically, we asked participants to indicate for each building image how much they agreed with the following three statements: "the building I just saw was complex", "the building I just saw was beautiful", and "the building I just saw was attention grabbing" (all items scored from 1 = "completely disagree" to 7 = "completely agree"). We created a complexity (Cronbach's $\alpha = 0.82$), beauty (Cronbach's $\alpha = 0.86$) and attention (Cronbach's $\alpha = 0.85$) index by averaging all five items for these three measures within each condition.

5.1.3. Procedure

After asking participants for personal details (i.e., gender and age), they were randomly assigned to one of the two building conditions. The study began with a baseline measurement of clicking speed, to control for variation in computer system speed and clicking/mouse behavior. After this, participants had to perform a total of five clicking trials (see Fig. 5 for a schematic representation of the clicking trials). The first clicking trial always showed the (high or low) artificial building, whereas in the other four trials the pictures of actual buildings were displayed in random order. Each clicking trial began with a building appearing on the screen for fifteen seconds, and participants were asked to watch the building carefully and to imagine that they were at the place depicted in the picture. After this, an on-screen instruction appeared, requesting participants to click all the buttons on the next screen (i.e., the button screen) as fast and as accurately as possible. After clicking "next" on this instruction screen, the button screen appeared. We recorded the speed with which each individual button was clicked and calculated the average clicking speed per button over all five clicking trials. Participants had the option to exit the button screen before having clicked all buttons by clicking "next". Seventy-two percent of all participants clicked all buttons associated with the five clicking tasks that followed the building pictures. After each individual clicking trial we carried out the control measurements (i.e., beauty, attention grabbing, and complexity), and when all clicking trials were finished we probed for participants' perceived fight, flight or freeze tendencies, and perceived feelings of entrapment. At the very end of the study we undertook the emotion measurement.

5.2. Results

We removed seventeen participants from the analyses (12%)

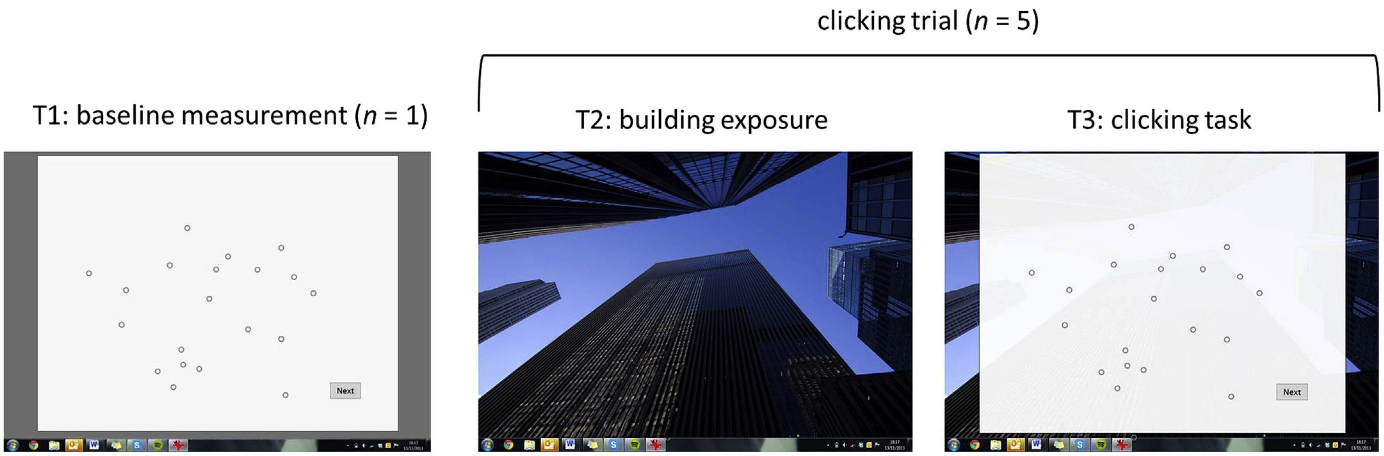

Fig. 5. Schematic representation of the clicking tasks performed in Study 1b (copyright holder of the building image: Chris Eason – Creative Commons by 2.0).

because they either had consistently clicked very few buttons over all five clicking trials (i.e., more than 50% unclicked; $n = 11$) or because they had flat-lined for all self-report items taken in the study ($n = 6$).

5.2.1. Behavioral and perceived freezing

Height and clicking speed. Because of their positive skewed distribution, we log-transformed the average clicking speed of all five clicking trials. Overall clicking time per button was then calculated by averaging the (log-transformed) clicking speed per button for each of the five clicking trials. An outlier analysis on overall clicking time per button using the MAD method yielded two outliers (Leys et al., 2013)[6].

We performed a one-way ANOVA with Height as the between-subjects variable, and average log-transformed clicking time per button as the dependent variable. We display untransformed means in milliseconds for readability. The analysis revealed a significant main effect of Height, $F(1, 121) = 5.23$, $p = 0.024$, $\eta_p^2 = .04$[7], showing that participants clicked buttons significantly slower after having seen high ($M = 1055$, $SD = 227$) as opposed to low buildings ($M = 969$, $SD = 188$). Fig. 6 shows the results for overall clicking speed as a function of building height (6a), as well as the results associated with each of the five individual buildings (6b).

Height and perceived FFF. We conducted a one-way ANOVA with Height as the between-subjects variable, and scores on the entrapment item, and the freezing, fight and flight indices as the dependent variables. Participants reported that their body felt significantly more immobile (as indicated by the freezing index) in the High ($M = 3.54$, $SD = 1.66$) than in the Low condition ($M = 3.00$, $SD = 1.42$), $F(1, 123) = 3.91$, $p = 0.050$, $\eta_p^2 = 0.03$, and scored higher on the flight index in the High ($M = 3.27$, $SD = 2.00$) versus Low building condition ($M = 2.61$, $SD = 1.61$), $F(1, 123) = 4.25$, $p = 0.041$, $\eta_p^2 = 0.03$. For the fight index, we found no statistically significant differences between both building conditions (Low: $M = 2.40$, $SD = 1.44$; High: $M = 2.71$, $SD = 1.66$), $F(1, 123) = 1.28$, $p = 0.261$, $\eta_p^2 = 0.01$. This analysis also showed that participants felt significantly more entrapped (i.e., being put into a tight corner) while watching images of high ($M = 3.87$, $SD = 2.11$) as opposed to low buildings ($M = 3.14$, $SD = 1.71$), $F(1, 123) = 4.56$, $p = 0.035$, $\eta_p^2 = 0.04$.

Mediation analysis. To verify that slow clicking indeed stemmed from muscle/body stiffness, we tested whether perceived freezing mediated the differential effect of building height on response speed. We made use of Preacher and Hayes' bootstrap method for testing mediation, employing the SPSS macro *PROCESS* (Model 4) developed by Hayes (2013). We entered log-transformed response speed as the dependent variable, building condition (High vs. Low) as the independent variable, and perceived freezing as the proposed mediator. The analysis showed that the bias-corrected 95% confidence interval (1000 bootstrap samples) for the indirect effect of building height through perceived freezing did not include zero (0.00–0.02). This is consistent with the interpretation that the decreased response speed caused by the high buildings (as compared to low buildings) indeed stemmed from the bodily immobility which participants had felt while watching high building pictures (see Fig. 7a for the regression coefficients and *p* values).

5.2.2. Emotion measurement

Height and emotions. Contrary to the findings from Pilot 1a and Study 1a, a one-way ANOVA with building height as the independent variable, and the emotion items as the dependent variables yielded no significant results (all p's > 0.163).

Emotions and freezing. Based on the idea that awe implies a state of behavioral immobility, we explored whether awe, and other emotions, correlated with (average log-transformed) clicking speed and perceived freezing. The results, displayed in Table 3, show a significant positive relationship between the items "awe", "smallness", "humble" and perceived freezing and response speed. This suggests that the more participants had experienced awe and had felt small and humble, the slower they had clicked buttons, and the more immobile they had felt while watching the building pictures.

Mediation analysis. We tested whether perceived freezing mediated the positive association between awe and response speed, again using the SPSS macro *PROCESS* (Model 4) developed by Hayes (2013). We entered log-transformed response speed as the dependent variable, awe as the independent variable, and perceived freezing as the proposed mediator. The analysis revealed

[6] Note that for each analysis in which response speed was included as a variable, we removed the two outliers that were also excluded for the main analysis of clicking speed.

[7] We originally planned to use baseline clicking speed as a covariate. However, a substantial number of participants had not clicked any button at all during the baseline measurement, while they had clicked buttons for the actual clicking trials. We therefore decided not to include the covariate in our analyses, as it would have further reduced the number of participants. Note that baseline clicking speed did not differ across the two conditions, $F(1, 114) = 0.29$, $p = 0.594$. Running the ANCOVA with baseline clicking speed as covariate yielded similar results as the original ANOVA, i.e., $F(1, 113) = 5.49$, $p = 0.021$. Note that for this ANCOVA participants for whom we did not have any baseline clicks at all were automatically discarded.

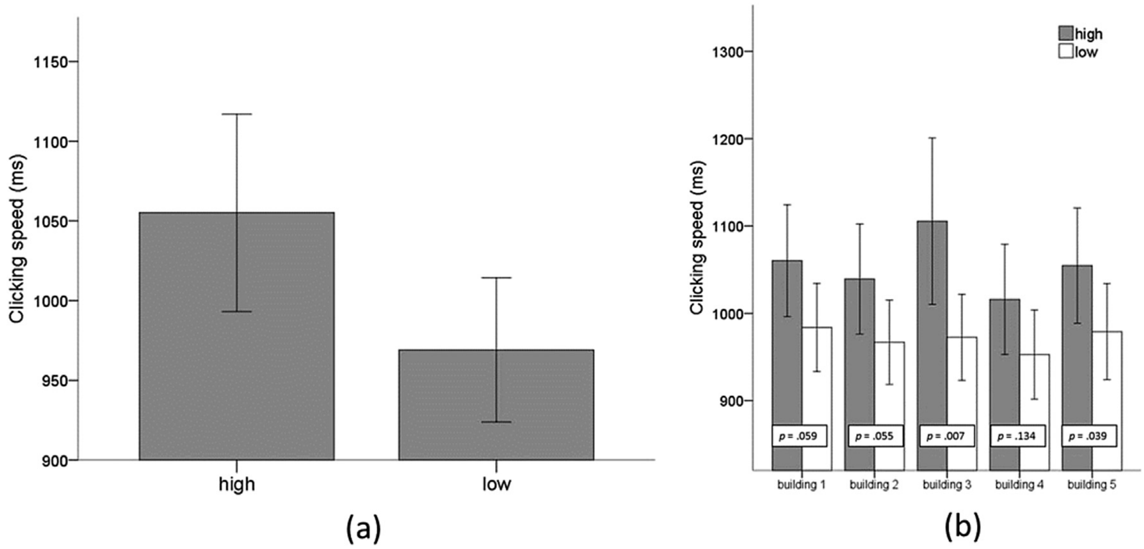

Fig. 6. a–b. Overall clicking speed (6a; in milliseconds) and clicking speed associated with each building picture (6b) as a function of Height (Study 1b). Error bars represent 95% confidence intervals.

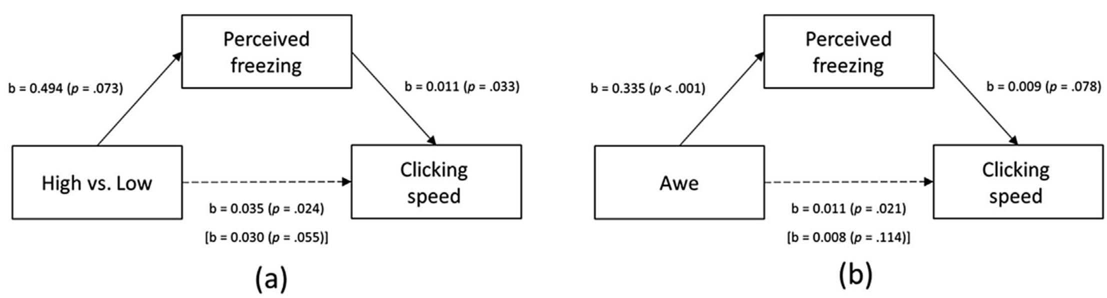

Fig. 7. a -b. Regression coefficients (unstandardized) for the relationship between building height and clicking speed (7a) and for the relationship between awe and clicking speed (7b), as mediated by perceived freezing. The regression coefficient between building height and clicking speed (7a), and between awe and clicking speed (7b), controlling for perceived freezing, are in parentheses.

Table 3
Correlations between log-transformed clicking speed, perceived freezing, and the emotion items from Study 1b.

	Clicking speed	Perceived freezing	Wonder	Delight	Fascination	Humble	Smallness	Awe
Clicking speed	/							
Perceived freezing	0.220*	/						
Wonder	−0.011	0.137	/					
Delight	0.012	0.122	0.339**	/				
Fascination	0.160	0.360**	0.203*	0.150	/			
Humble	0.013	−0.002	0.294**	0.335**	−0.095	/		
Smallness	0.235**	0.480**	0.116	0.276**	0.595**	0.007	/	
Awe	0.209*	0.352**	0.279**	0.198*	0.718**	−0.070	0.632**	/

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

that the bias-corrected 95% confidence interval (1000 bootstrap samples) for the indirect effect of awe through perceived freezing did not include zero (0.00–0.01). This is consistent with the interpretation that the decreased response speed associated with awe indeed reflected bodily immobility (see Fig. 7b for the regression coefficients and *p* values).

5.2.3. Control measurements

A one-way ANOVA with Height as the between-subjects variable, and the three indices as the dependent variables, revealed no statistically significant differences between the High and Low condition on the attention index, $F(1, 123) = 2.30$, $p = 0.132$, $\eta_p^2 = 0.02$ (High: $M = 5.09$, $SD = 1.34$; Low: $M = 4.75$, $SD = 1.16$). High buildings ($M = 4.95$, $SD = 1.23$), on the other hand, were perceived as significantly more complex than low ones ($M = 4.52$, $SD = 1.16$), $F(1, 123) = 4.01$, $p = 0.047$, $\eta_p^2 = 0.03$. While beauty scores were also higher in the High ($M = 5.10$, $SD = 1.30$) than in the Low condition ($M = 4.71$, $SD = 1.26$), this difference was only marginally significant, $F(1, 123) = 2.90$, $p = 0.091$, $\eta_p^2 = 0.02$.

To address the concern that differences in beauty and complexity were underlying the freezing effect, we reran the main ANOVA testing for the effect of building height on (log-transformed) clicking speed, but this time controlling for beauty and complexity. This revealed that the (freezing) effect remained, F(1,

119) = 5.35, $p = 0.022$, $\eta_p^2 = 0.04$. Additionally, we noticed that the differences on beauty and complexity between the two building conditions were actually driven by two building pictures. The freezing effect remained, even when excluding the results of the clicking trials associated with those buildings, $F(1, 121) = 6.38$, $p = 0.013$, $\eta_p^2 = 0.05$.

5.3. Discussion

In sum, our findings show that exposure to images of high versus low buildings can lead to behavioral and perceived freezing, and can create a feeling of entrapment in individuals – the latter being an important environmental determinant of freezing (Hagenaars et al., 2014). The fact that we could not replicate the effect of building height on the emotion awe is probably due to the fact that we did not ask participants to recall how they felt while watching the buildings (like in Pilot 1a and Study 1a), but that we rather asked them about their *current* feelings. Despite this, we still found a moderate, but significant positive correlation between awe and response speed. Importantly, perceived freezing mediated the effect of building height on clicking speed and the association between awe and clicking speed. This suggests that slowing down was indeed driven by bodily immobility, rather than reflecting – for example – the increased perceived time availability associated with awe (Rudd et al., 2012) or the distractive influence of the building stimuli. Although we cannot rule out that certain participants were familiar with some of the buildings, the fact that the freezing effect was consistent and robust for all five building pictures (Fig. 6b) suggests that it is unlikely that the overall result was caused by familiarity. Nevertheless, it might be valuable for future research to include familiarity as a control variable.

6. General discussion

In the current research we tested whether physical vastness, operationalized in terms of monumental architectural structures, would lead to a very particular feeling state and behavioral response in individuals, respectively awe and behavioral immobility. The pilot studies preliminarily confirmed that a high versus low building was associated with the highest scores on feelings of awe and smallness (Pilot 1a), and with the slowest response times on a manual clicking task (Pilot 1b). In Study 1a and Study 1b we tested our hypotheses more rigorously, using a more diverse set of building images and a more varied sample of participants. Again, after having seen monumentally high (versus low) buildings, participants felt most awestruck (Study 1a), displayed the slowest responses times, and reported that their body felt most immobile (Study 1b). In our last integrative study, we tested the effect of building height on both awe and on clicking speed. While we did not find an effect of height on awe (probably due to methodological issues), increased awe was still associated with slower clicking speed, which is consistent with the view that feeling this emotion typically involves a state of paralysis or "sluggishness" (e.g., Díaz-Vera, 2015; Solomon, 2002).

Our findings are of direct relevance to the field of environmental psychology. Over the last few decades environmental psychologists have investigated and charted how different environmental characteristics (e.g., enclosure: Stamps, 2005; environmental order/complexity: Gilboa & Rafaeli, 2003; architectural curvature: Vartanian et al., 2013; ceiling height: Vartanian et al., 2015) can trigger particular behavioral tendencies in individuals, with an emphasis on approach and avoidance behavior. The present studies contribute to this literature in two ways. On the one hand, they suggest that sheer building height can have a direct psychological effect on viewers. On the other hand, they show that environments or environmental structures can also lead to behavioral mobility or freezing, in addition to triggering approach and avoidance behavior.

Despite this proliferation of (social) psychological research on awe, little research has attempted to further unravel the characteristics and nature of this particular emotion. The current research attempted to advance our understanding of awe, as it provided evidence that experiencing awe is accompanied by a particular behavioral component: freezing. In addition, our research shows that also huge architectural constructions are suitable to trigger this emotion, thereby providing an alternative to the common practice of manipulating awe with pictures of natural environments (e.g., Joye & Bolderdijk, 2015).

The finding of building induced-immobility furthermore dovetails with evolutionary theories of architecture (Joye & Verpooten, 2013) and archeological studies into monumental architecture (Neiman, 1998). According to these, one of the important functions of monumental buildings throughout history was defensive. Specifically, by their sheer size and height, such buildings have been interpreted as signs of (political) competitive ability, which intimidated and overawed subordinates and competitors, and thereby discouraged them from taking action against the reigning elite builders (Glatz & Plourde, 2011; Joye & Verpooten, 2013; Neiman, 1998; Trigger, 1990). Our findings tentatively suggest that such inaction might have been partly driven by the awe-evoking, and hence immobilizing character of such structures. Note that this interpretation accords well with the view that awe is an emotion that solidifies social hierarchies (Keltner & Haidt, 2003), and with the finding that emotions related to awe (i.e., admiration) can lead to a state of political passivity (Sweetman, Spears, Livingstone, & Manstead, 2013).

6.1. Limitations

There are of course limitations to our research, notably with regard to the characteristics and presentation of the building stimuli. First, with our stimuli we have manipulated vastness through sheer physical size and height. Vastness can however also be incorporated in other ways in architecture (Keltner & Haidt, 2003). It can for example speak from the extraordinary degree of elaboration of architectural ornament (Joye & Verpooten, 2013), or even from the gargantuan amounts of effort and energy that were necessary to build a certain edifice (cfr., the building process of Egyptian pyramids). Further research is needed to test to what extent architecture embodying expressions of vastness other than height can trigger awe, and the associated behavioral response.

A second issue is that the stimuli used across our four studies varied considerably in their degree of realism. Specifically, the images from the pilot studies were of relatively abstract and schematic buildings, which were not visually integrated in an urban setting. Although the images used in Study 1a and Study 1b depicted real buildings in urban settings, the color, texture, facade properties and amount of built elements differed both across and within the High and Low conditions, which may have somewhat confounded the results. Despite these concerns, the combined use of schematic/abstract and realistic building stimuli had a clear purpose. On the one hand, the schematic stimuli from the pilot studies enabled us to isolate the effects of building height on emotions and behavior, while avoiding many of the visual confounds that almost inevitably go hand in hand with using images of real buildings. On the other hand, by replicating the freezing effect with images of real buildings, we could further assure that it were actually *buildings* that were causing the freezing effect.

Despite the fact that our findings suggest that images of high versus low buildings can trigger awe and behavioral freezing, a third issue is that we exposed participants to *surrogates* of buildings (i.e., computer-generated simulations, and photos of tall buildings). Importantly, there is still ongoing debate about whether such surrogates have external validity (for a review: Sevenant & Antrop, 2011), despite the fact that their use is widespread in the field of environmental psychology (e.g., Kaplan & Kaplan, 1989), also within research on tall buildings (e.g., Heath, Smith, & Lim, 2000). Additionally, research confirming the external validity of environmental surrogates has mainly focused on preference responses to environments (Palmer & Hoffman, 2001; Stamps, 1990), not so much on the particular emotion and behavior we have looked at (i.e., awe and freezing). While beyond the scope of the current paper, further research is necessary to test how people emotionally respond to building height in actual urban/built settings.

We would also like to touch upon some limitations relating to the procedures used in our studies, and more precisely, discuss how those procedures differ from the way in which people interact with actual built environments. First, in our studies participants watched the building pictures in private, and this may not accurately reflect how people actually experience such edifices, i.e., they are often visited collectively. Given that individuals often feel or behave differently when being part of a group (e.g., they might feel stronger in a group but they may also emotionally contaminate each other), the question arises whether collective exposure to tall buildings would change the awe-evoking aspects of the tall buildings, and the associated freezing response.

Second, in three of the four studies, the building pictures were shown only once, and briefly to participants. Such brief one-shot trials obviously deviate from the way in which individuals often experience tall buildings in daily life. People working or living in a high-rise district, for instance, are very regularly exposed to tall buildings. As awe is not so much triggered by absolute vastness of a stimulus, but by (relative) vastness compared to a particular frame of reference (Keltner & Haidt, 2003), regular building exposure might attenuate the initial awe response over time. Follow-up research is therefore needed to test how long the freezing effect persists after multiple exposures to, and familiarization with buildings.

A third issue is that participants' interaction with the buildings mainly involved (forced) passive watching. While this viewing paradigm might be similar to the way in which tourists look up at a grand building, we are aware that people exhibit a far broader behavioral repertoire in cities, which is likely to influence responses to tall buildings in real-world situations. Compared to a tourist, an individual rushing out of the metro in a busy high-rise district might neither have the time nor willingness to pay attention to the surrounding high-rise buildings. Add to this the fact that people typically perceive the lower stories of high-rise buildings within the context of cities and much less so upper stories[8]. On the other hand, even without paying attention to high buildings, their towering presence can still create an oppressive and threatening atmosphere, which might trigger defensive responses. To clarify these issues, future research needs to investigate the extent to which both contextual factors (e.g., exposure time, an individual's goals) and attention moderate the occurrence of freezing behavior.

Note finally that our primary aim was to explore whether tall architecture can indeed trigger behavioral freezing. While our results are consistent with a freezing account, this exploratory focus, and the need for experimental control, obviously limit the applicability of our findings. From an applied perspective, it might for example be interesting to research whether driving through a high-rise (as opposed to low-rise) district will translate in slower responses to sudden and unforeseen traffic situations. Another interesting case could be to investigate whether attending a political gathering in a monumental setting would make individuals behaviorally and mentally more passive, and hence, more receptive to political or ideological messages. Such studies might be executed in a virtual reality setting, where only the height of the buildings would be manipulated. The advantage of a VR environment is that it combines realism and interactivity, while at the same time allowing a deep level of control over the visual environment.

7. Conclusion

In an era where the impact of the built environment on human quality of life is being increasingly recognized (e.g., Van den Berg, Hartig, & Staats, 2007), it is of key-importance to gain insight into how architectural form can affect human wellbeing and functioning. From this perspective, the finding that tall buildings can elicit the emotion of awe and associated freezing behavior may have particular practical and societal relevance. Specifically, our research suggests that monumental architectural structures are able to elicit awe, and can potentially produce similar beneficial effects as awe-evoking natural settings, such as increased prosociality and generosity (e.g., Joye & Bolderdijk, 2015; Piff et al., 2015). Given the ongoing urbanization that is globally taking place, and urbanites' lack of direct and easy access to nature, visiting instances of awe-evoking architecture might be one of the most straightforward ways in which individuals might get a dose of awe. In agreement with the focus of the current paper, awesomeness might be architecturally realized in terms of building height and size, but it can – for instance – also speak from extraordinary architectural craftsmanship (e.g., in terms of ornament and decorations), from an innovative building process, or even from the use of precious and novel building materials (cfr., Joye & Verpooten, 2013).

In modern societies, towering buildings often symbolize corporate power, and are associated with economic proficiency and efficiency. Our results however suggest that when vitality, rapid (professional) action and efficiency are required, close proximity to high built/environmental elements might actually be counterproductive, by slowing individuals down and leading to feelings of smallness. One possible design intervention to dampen the oppressing character of monumental architecture could be to integrate greenery in such built settings, as this has been found to lead to positive affect (Ulrich et al., 1991), increased vitality (Ryan et al., 2010), and to boost the aesthetic appearance of the settings (Van den Berg et al., 2007). On the other hand, in some situations freezing induced by monumental buildings and structures might actually be beneficial. For example, consistent with research showing that high built and natural elements are associated with lower degrees of crime and burglary (Chang, 2011; Donovan & Prestemon, 2012), freezing and general passivity triggered by overpowering built elements might discourage unwanted behavior in individuals. We hope that future research will further unravel the distinct effects of awe-evoking built structures on human psychology, and how these determine people's behavior in actual urban settings.

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[8] We thank one of the anonymous reviewers for pointing this out to us.

Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.jenvp.2016.05.001.

References

Alcorta, C., & Sosis, R. (2005). Ritual, emotion, and sacred symbols: the evolution of religion as an adaptive complex. *Human Nature, 16*, 323–359.
Boyd Whyte, I. (1998). Reflections on a polished floor. Ben willikens and the Reichskanzlei of Albert speer. *Harvard Design Magazine, 6*, 1–8.
Bracha, H. S. (2004). Freeze, flight, fight, fright, faint: adaptationist perspectives on the acute stress response spectrum. *CNS Spectrums, 9*, 679–685.
Chang, D. (2011). Social Crime or Spatial Crime? Exploring the effects of social, economical, and spatial factors on burglary rates. *Environment and Behavior, 43*, 26–52.
De Waal, F. B. M. (1982). *Chimpanzee politics: Power and sex among apes*. London, UK: Jonathan Cape.
Díaz-Vera, J. E. (2015). Exploring the relationship between emotions, language and space: construals of awe in medieval english language and pilgrimage experience. *Studia Neophilologica*, 1–25.
Donovan, G. H., & Prestemon, J. P. (2012). The effect of trees on crime in Portland, Oregon. *Environment and Behavior, 44*, 3–30.
Fernandes, O., Portugal, L. C. L., Alves, R. C. S., Campagnoli, R. R., Mocaiber, I., David, I. P. A., et al. (2013). How you perceive threat determines your behavior. *Frontiers in Human Neuroscience, 7*. article 632.
Fessler, D. M. T., & Holbrook, C. (2013). Friends shrink foes: the presence of comrades decreases the envisioned physical formidability of an opponent. *Psychological Science, 24*, 797–802.
Freeman, J. B., Dale, R., & Farmer, T. A. (2011). Hand in motion reveals mind in motion. *Frontiers in Psychology, 2*. article 59.
Frenkel, A. (2007). Spatial distribution of high-rise buildings within urban areas: the case of the Tel-Aviv metropolitan region. *Urban Studies, 44*, 1973–1996.
Fuller, R. (2008). *Spirituality in the Flesh: Bodily sources of religious experiences*. Oxford: Oxford University Press.
Gifford, R. (2007). The consequences of living in high-rise buildings. *Architectural Science Review, 50*, 2–17.
Gilboa, S., & Rafaeli, A. (2003). Store environment, emotions and approach behaviour: applying environmental aesthetics to retailing. *The International Review of Retail, Distribution and Consumer Research, 13*, 195–211.
Glatz, C., & Plourde, A. M. (2011). Landscape monuments and political competition in late Bronze Age Anatolia: an investigation of costly signaling theory. *Bulletin of the American Schools of Oriental Research, 361*, 33–66.
Gordillo, G. (2014). *Nazi architecture as affective weapon. The funambulist papers* (vol. 2). http://thefunambulist.net/2014/02/02/the-funambulist-papers-47-nazi-architecture-as-affective-weapon-by-gaston-gordillo/.
Griskevicius, V., Shiota, M. N., & Neufeld, S. (2010). Influence of different positive emotions on persuasion processing: a functional evolutionary approach. *Emotion, 10*, 190–206.
Hagenaars, M. A., Oitzl, M., & Roelofs, K. (2014). Updating freeze: aligning animal and human research. *Neuroscience and Biobehavioral Reviews, 47*, 165–176.
Hagenaars, M. A., Stins, J., & Roelofs, K. (2012). Aversive life events enhance human freezing. *Journal of Experimental Psychology: General, 141*, 98–105.
Haidt, J., & Keltner, D. (2002). Awe/responsiveness to beauty and excellence. In C. Peterson, & M. E. P. Seligman (Eds.), *The VIA taxonomy of strengths. Cincinnati*. OH: Valves in Action Institute.
Haidt, J., & Seder, P. (2009). Admiration and awe. In D. Sander, & K. R. Scherer (Eds.), *Oxford companion to affective science* (pp. 4–5). New York: Oxford University Press.
Hayes, A. F. (2013). *Introduction to mediation, moderation, and conditional process analysis: a regression-based approach*. New York: Guilford Press.
Heath, T., Smith, S. G., & Lim, B. (2000). Tall buildings and the urban skyline. The effect of visual complexity on preferences. *Environment and Behavior, 32*, 541–556.
Holbrook, C., Fessler, D. M. T., & Navarrete, C. D. (2016). Looming large in others' eyes: racial stereotypes illuminate dual adaptations for representing threat versus prestige as physical size. *Evolution and Human Behavior, 37*, 67–78.
Joye, Y., & Bolderdijk, J. W. (2015). An exploratory study into the effects of extraordinary nature on emotions, mood, and prosociality. *Frontiers in Psychology, 5*. article 1577.
Joye, Y., & Verpooten, J. (2013). An exploration of the functions of monumental architecture from a Darwinian perspective. *Review of General Psychology, 17*, 53–68.
Judge, T. A., & Cable, D. M. (2004). The effect of physical height on workplace success and income: preliminary test of a theoretical model. *Basic and Applied Social Psychology, 89*, 428–441.
Kaplan, R., & Kaplan, S. (1989). *The experience of nature: A psychological perspective*. New York: Cambridge University Press.
Keltner, D., & Haidt, J. (2003). Approaching awe, a moral, spiritual, and aesthetic emotion. *Cognition and Emotion, 17*, 297–314.
Leys, C., Ley, C., Klein, O., Bernard, P., & Licata, L. (2013). Detecting outliers: do not use standard deviation around the mean, use absolute deviation around the median. *Journal of Experimental Social Psychology, 49*, 764–766.
Lindal, P. J., & Hartig, T. (2013). Architectural variation, building height, and the restorative quality of urban residential streetscapes. *Journal of Environmental Psychology, 33*, 26–36.
Löw, A., Weymar, M., & Hamm, A. O. (2015). When threat is near get out of here: dynamics of defensive behavior during freezing and active avoidance. *Psychological Science, 26*, 1706–1716.
Marx, B. P., Forsyth, J. P., Gallup, G. G., Fuse, T., & Lexington, J. M. (2008). Tonic immobility as an evolved predator defense: implications for sexual assault survivors. *Clinical Psychology: Science and Practice, 15*, 74–90.
Neiman, F. (1998). Conspicuous consumption as wasteful advertising: a Darwinian perspective on spatial patterns in Classic Maya terminal monument dates. In C. M. Barton, & G. A. Clark (Eds.), *Rediscovering Darwin: Evolutionary theory in archaeological explanation* (pp. 267–290). Arlington, VA: American Anthropological Association.
Öhman, A., & Wiens, S. (2003). On the automaticity of autonomic responses in emotion: an evolutionary perspective. In R. J. Davidson, K. R. Scherer, & H. H. Goldsmith (Eds.), *Handbook of affective sciences* (pp. 256–275). New York: Oxford University Press.
Osborne, J. F. (2014). Monuments and monumentality. In J. F. Osborne (Ed.), *Approaching monumentality in archaeology* (pp. 1–19). Albany, NY: SUNY Press.
Palmer, J. F., & Hoffman, R. E. (2001). Rating reliability and representation validity in scenic landscape assessments. *Landscape and Urban Planning, 54*, 149–161.
Piff, P., Dietz, P., Feinberg, M., Stancato, D. M., & Keltner, D. (2015). Awe, the small self, and prosocial behavior. *Journal of Personality and Social Psychology, 108*, 883–899.
Plutchik, R. (2001). The nature of emotions. *American Scientist, 89*, 344–350.
Roelofs, K., Hagenaars, M. A., & Stins, J. (2010). Facing freeze: social threat induces bodily freeze in humans. *Psychological Science, 21*, 1575–1581.
Rudd, M., Vohs, K. D., & Aaker, J. (2012). Awe expands people's perception of time, alters decision making, and enhances well-being. *Psychological Science, 23*, 1130–1136.
Russell, J. A., & Mehrabian, A. (1978). Approach–avoidance and affiliation as functions of the emotion-eliciting quality of an environment. *Environment and Behavior, 10*, 355–387.
Ryan, R. M., Weinstein, N., Bernstein, J., Warren Brown, K., Mistretta, L., & Gagné, M. (2010). Vitalizing effects of being outdoors and in nature. *Journal of Environmental Psychology, 30*, 159–168.
Sagliano, L., Cappuccio, A., Trojano, L., & Conson, M. (2014). Approaching threats elicit a freeze-like response in humans. *Neuroscience Letters, 561*, 35–40.
Saroglou, V., Buxant, C., & Tilquin, J. (2008). Positive emotions as leading to religion and spirituality. *The Journal of Positive Psychology, 3*, 165–173.
Scherer, K. R. (2001). The nature and study of appraisal. A review of the issues. In T. Johnstone, A. Schorr, & K. R. Scherer (Eds.), *Appraisal processes in emotion: Theory, methods, research*. Oxford: Oxford University Press (pp. 396–391).
Scherer, K. R. (2005). What are emotions? and how can they be measured? *Social Science Information, 44*, 693–727.
Schubert, T. (2005). Your highness: vertical positions as perceptual symbols of power. *Journal of Personality and Social Psychology, 89*, 1–21.
Sevenant, M., & Antrop, M. (2011). Landscape representation validity: a comparison between on-site observations and photographs with different angles of view. *Landscape Research, 36*, 363–385.
Shiota, M. N., Keltner, D., & Mossman, A. (2007). The nature of awe: elicitors, appraisals, and effects on self-concept. *Cognition & Emotion, 21*, 944–963.
Shiota, M. N., Neufeld, S. L., Yeung, W. H., Moser, S. E., & Perea, E. F. (2011). Feeling good: autonomic nervous system responding in five positive emotions. *Emotion, 11*, 1368–1378.
Smith, A. (2007). Monumentality in 'capital' cities and its implications for tourism marketing. *Journal of Travel & Tourism Marketing, 22*, 79–93.
Solomon, R. C. (2002). *Spirituality for the skeptic: The thoughtful love of life*. New York: Oxford University Press.
Sperber, D., & Hirschfeld, L. (2004). The cognitive foundations of cultural stability and diversity. *Trends in Cognitive Science, 8*, 40–46.
Stamps, A. E. (1990). Use of photographs to simulate environments: a meta-analysis. *Perceptual Motor Skills, 71*, 907–913.
Stamps, A. E. (2005). Visual permeability, locomotive permeability, safety and enclosure. *Environment and Behavior, 37*, 587–619.
Sweetman, J., Spears, R., Livingstone, A. G., & Manstead, A. S. R. (2013). Admiration regulates social hierarchy: antecedents, dispositions, and effects on intergroup behavior. *Journal of Experimental Social Psychology, 49*, 534–542.
Taveira, A. D., & Choi, S. D. (2009). Review study of computer input devices and older users. *International Journal of Human-Computer Interaction, 25*, 455–474.
Trigger, B. G. (1990). Monumental architecture: a thermodynamic explanation of symbolic behaviour. *World Archaeology, 22*, 119–132.
Ulrich, R. S., Simons, R. F., Losito, B. D., Fiorito, E., Miles, M. A., & Zelson, M. (1991). Stress recovery during exposure to natural and urban environments. *Journal of Environmental, 11*, 201–230.
United Nations, Department of Economic and Social Affairs, Population Division. (2014). *World Urbanization Prospects: The 2014 Revision*. Highlights (ST/ESA/SER.A/352).
Valdesolo, P., & Graham, J. (2014). Awe, uncertainty, and agency detection. *Psychological Science, 25*, 170–178.
Van den Berg, A. E., Hartig, T., & Staats, H. (2007). Preference for nature in urbanized societies: stress, restoration, and the pursuit of sustainability. *Journal of Social Issues, 63*, 79–96.
Vartanian, O., Navarrete, G., Chatterjee, A., Brorson Fich, L., Gonzalez-Mora, J. L.,

Leder, H., et al. (2015). Architectural design and the brain: effects of ceiling height and perceived enclosure on beauty judgments and approach-avoidance decisions. *Journal of Environmental Psychology, 41*, 10–18.

Vartanian, O., Navarrete, G., Chatterjee, A., Fich, L. B., Leder, H., Modrono, C., et al. (2013). Impact of contour on aesthetic judgments and approach-avoidance decisions in architecture. *Proceedings of the National Academy of Sciences USA, 110*(Suppl. 2), 10446–10453.

Wong, K. M. G. (2004). Vertical cities as a solution for land scarcity: the tallest public housing development in Singapore. *Urban Design International, 9*, 17–30.