

Awe-Inducing Interior Space:
Architectural Causes and Cognitive Effects
by
Hanna Negami

A thesis
presented to the University of Waterloo
in fulfilment of the
thesis requirement for the degree of
Master of Arts
in
Psychology

Waterloo, Ontario, Canada, 2016

© Hanna Negami 2016

Author's Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners. I understand that my thesis may be made electronically available to the public.

Abstract

The purpose of the present work was to investigate whether religious monumental architecture facilitates religious feeling by inducing a sense of awe. In order to elucidate how church interiors elicit awe and otherwise shape affective and cognitive processes, we developed a rating scale for the measurement of physical properties of interior spaces in order to determine which architectural properties in an interior space can predict a sense of awe (Experiment 1). By having participants rate affective response to a set of images pre-rated on architectural properties, we were able to establish a predictive relationship between architectural properties and elicited emotion. Properties reflecting immensity and adornment significantly predicted a feeling of awe. The results from Experiment 1 guided the selection of stimuli for Experiment 2, in which we explored the effects of visually priming participants with photographs of high and low awe-inducing architectural interiors on time perception and spirituality, as well as the effects of priming participants with photographs of religious and non-religious building interiors on participant religiousness. Feeling awe led to a greater overestimation of time in a time-estimation task, and religious priming through photographs of church interiors rated low in properties of immensity and adornment led to an increase in religious feeling. This work establishes an initial understanding of cognitive processes underlying affective and social responses to the environmental cues of church interiors.

Acknowledgments

First, I would like to thank my supervisor Dr. Colin Ellard for his support and guidance, and my thesis readers Dr. Roxane Itier and Dr. Daniel Smilek for their revisions and comments. I would also like to thank my fellow lab members, as well as my fellow graduate students and the faculty of the Cognitive Neuroscience area of the Department of Psychology at the University of Waterloo, for their thoughtful feedback and advice on my research. I would also like to extend my gratitude to Richard Marion and Adam Francey for their help with data processing, and Aysha Basharat for her assistance with data collection.

The research presented in this thesis was conducted at the University of Waterloo and was supported by the Social Sciences and Humanities Research Council of Canada.

Table of Contents

Author's Declaration.....	ii
Abstract.....	iii
Acknowledgments.....	iv
Table of Contents.....	v
List of Figures.....	vi
List of Tables.....	vii
Chapter 1: General Introduction.....	1
Chapter 2: Experiment 1.....	4
2.1 Methods.....	5
2.2 Results.....	9
2.3 Discussion.....	22
Chapter 3: Experiment 2.....	24
3.1 Methods.....	25
3.2 Results.....	31
3.3 Discussion.....	50
References.....	58
Appendix B.....	64

List of Figures

Figure 1.....	7
Figure 2.....	7
Figure 3.....	28
Figure 4.....	34
Figure 5.....	35
Figure 6.....	36
Figure 7.....	37
Figure 8.....	42
Figure 9.....	43
Figure 10.....	44
Figure 11.....	49

List of Tables

Table 1	10
Table 2	13
Table 3	13
Table 4	14
Table 5	18
Table 6	21
Table 7	21
Table 8	27

Chapter 1: General Introduction

The aesthetic experience of architectural spaces, such as grand church interiors, can be powerfully moving. Recent work applying a Darwinian perspective to religious monumental architecture (RMA) has argued that by eliciting awe, churches and other RMA structures foster religious openness and facilitate social cohesion (Joye & Verpooten, 2013). Awe is defined as an emotion encompassing both vastness (such as in physical size, power, or social standing) and accommodation, such that experiencing awe necessitates updating current mental models (Keltner & Haidt, 2003). Although awe has been studied substantially in fields such as religion, sociology, and philosophy, it has not yet been studied extensively in psychology; experimental work on awe only has only begun in the past ten or fifteen years, building off of Keltner and Haidt's (2003) seminal work on the subject. Recent work has found that exposure to awe-inducing stimuli increases belief in supernatural control, compared to exposure to amusing stimuli (Valdesolo & Graham, 2014); and that feeling awe, compared to pride, increases spiritual behavioral intention among people who are religious or spiritual (Van Cappellen & Saroglou, 2012). These findings led us to ask whether religious building designs might capitalize on such effects to promote or facilitate religious feeling.

In order to elucidate how church interiors elicit awe and otherwise shape affective and cognitive processes, we first investigated how built spaces induce awe. Specifically, in order to determine which architectural properties in an interior space can predict a sense of awe, we developed a rating scale for the measurement of physical properties of interior spaces (Experiment 1). Our rating scale was used to measure various architectural properties of photographs of interior spaces, and these same spaces were rated for affective quality by study participants. These emotion ratings allowed us to identify a predictive relationship between

architectural properties and elicited emotion. We found that properties including size, age, contour, and ornament significantly predict a feeling of awe.

The results from Experiment 1 guided the selection of stimuli for Experiment 2, in which we explored the effects of visually priming participants with photographs of high and low awe-inducing architectural interiors, as well as the effects of priming participants with photographs of religious and non-religious building interiors. Specifically, we wished to see whether the effects of awe previously obtained with stimuli such as natural scenery, would replicate with visual primes of awe-inducing interior spaces. Based on Valdesolo and Graham (2014) and Van Cappellen and Saroglou's (2012) work suggesting that feeling awe increases belief in supernatural control and spiritual intention, we wished to see whether feeling awe elicited by awe-inducing building interiors would increase participants' spirituality and religiousness. Recent work on awe has also found that those who experience awe will report in a study survey that they feel that they have more time available to them, compared to those who felt another positive emotion such as happiness (Rudd, Vohs, & Aaker, 2012). We thus hypothesized that if building interiors, including churches, are able to elicit awe, they may thus also alter one's subjective experience of time, as well as facilitate religious or spiritual feeling.

The development of Experiment 2 was informed by cognitive psychological research on religious priming, as well as on awe. Religious priming studies have primarily relied on religious words to prime participants with religious concepts (e.g., Van Cappellen, Corneille, Cols, & Saroglou, 2011; Saroglou, Corneille, & Van Cappellen, 2009); we wished to see if some of these effects could be replicated using images of religious architecture as a prime in the place of religious words. The specific effect we sought to replicate with visual religious primes involves informational conformity. Van Cappellen et al. (2011) found that, among those with

dispositional submissiveness, semantic religious primes made people more likely to conform to others' responses on a numerical estimation task. This task was replicated in our experiment in order to test whether effects obtained from semantic religious primes generalize to visual religious primes, as a way to explore the specific cognitive and social-cognitive effects of aesthetically experiencing interior church architecture. Thus, the overall aim of Experiment 2 was to investigate the effects of awe-inducing architecture, using photographic stimuli, on participants' religiosity, spirituality, and time perception; as well as to examine the effects of interior church architecture on informational conformity.

Chapter 2: Experiment 1

To determine which architectural properties in an interior space can predict a sense of awe, we first developed a rating scale for the measurement of physical properties of interior spaces. This rating scale was loosely modeled after the scale developed by Gifford, Hine, Muller-Clemm, Reynolds, and Shaw (2000), The Architectural Coding System (TACS). TACS consisted of 59 objective building features, such as number of stories and fenestration, and was used to score a set of photographs of building exteriors by a group of trained judges. The same photographs were then rated by architects and laypeople on emotion and global impression to determine how these populations differed in preference for and affective response to buildings facades, as predicted by building property (Gifford et al., 2000). Whereas TACS was used to score features of building exteriors, and the rating scale developed in the present experiment was designed to score interior building features, both scales strived to capture objective, physical features of a building space. This goal contrasts with that of past work in psychological response to architectural design. More specifically, several studies have attempted to establish a relationship between general aesthetic qualities of interior spaces and user reactions to these spaces. However, these studies measured qualities of interior environments with adjectives relying on the user's subjective interpretation, such as "friendliness," "harmony," and "activity" (e.g., Wools & Canter, 1970). To our knowledge, there has been no research to date systematically investigating the objective physical properties of interior spaces and their relation to the emotions they elicit in users.

Our rating scale was used to measure 24 architectural properties of 60 different interior spaces. Participants then viewed these 60 pre-rated images on a laboratory computer and self-reported their affective response to each. Skin conductance and heart-rate data were collected

while viewing the images to provide an objective measure of physiological arousal against which to compare participants' survey responses on their affective state; and participants' facial expressions were recorded as a further way to verify survey responses. Participants' self-reported emotion ratings allowed us to identify what architectural properties can elicit different emotions. We found that properties reflecting immensity and adornment significantly predict a feeling of awe.

2.1 Methods

Rating scale development & photo selection. 24 physical properties of interior spaces were chosen to comprise the rating scale. Our selection of properties was partially guided by Joye and Verpooten's (2013) theoretical work on awe elicited by RMA, as well as by Keltner and Haidt's (2003) seminal work on awe. Specifically, the idea that awe is induced by vast or large stimuli led us to include properties reflecting vastness such as in size or skill (e.g., ceiling height, size, ornament, images, sculptures/art objects, age; see Appendix A). Other properties we chose were inspired by past work examining the relationships between isolated properties of interior spaces and preference ratings. We included some of these isolated properties in our rating scale, such as presence of windows (Kaye & Murray, 1982), ceiling height, ceiling shape, ceiling pitch (Baird, Cassidy, & Kurr, 1978), ornateness (Nasar, 1983), age of building, (Stamps, 1991; Stamps, 1994), contour (Vartanian et al. 2013), and presence of water (White et al., 2010), which were all found to be positively related to preference or beauty.

Three judges individually rated a set of 60 photographs of building interiors on the following 24 architectural properties: ceiling height, ceiling shape, ceiling tiering, number of ceiling tiers, ceiling pitch, presence of images on ceiling or wall, symmetry of space, size of space, age of building, windows, column ornateness, number of columns, arches,

doorways/openings, presence of water, religious symbology, ornament, presence of sculpture/art object, contour, extent of natural light, repeating element, furniture/seating, use of natural building materials, and self-similarity. Each property was rated on a scale of 1-7, using a Likert response format, except for number of ceiling tiers and number of columns, which were counted and rated as the number of items which could be seen in the photograph. The scale included a description to anchor the ratings of 1 and 7 for each property (see Appendix A). The judges were recruited from our laboratory and were trained on how to use the rating scale. Training was conducted by the author and involved going over the rating scale until the judges fully understood how to rate each property. All judges used the same computer monitor to rate the image set.

The 60 photographs used in Experiment 1 were downloaded from Flickr, the photo-sharing website (www.flickr.com) and are licensed per the terms of Creative Commons Attribution 2.0. The photographs consisted of various interior spaces, including church interiors. An effort was made to provide a variety of spaces in both function and architectural style. All photos were cropped or scaled down to 1200 x 800 pixels. In addition to the photographs, judges received SketchUp models for height and size comparisons, with a person included in each of the models for reference (see Figures 1 and 2).



Figure 1. Two of the photographic stimuli used in Experiment 1. Photos are from Chris Smith/Flickr and UM Health System/Flickr (left to right).

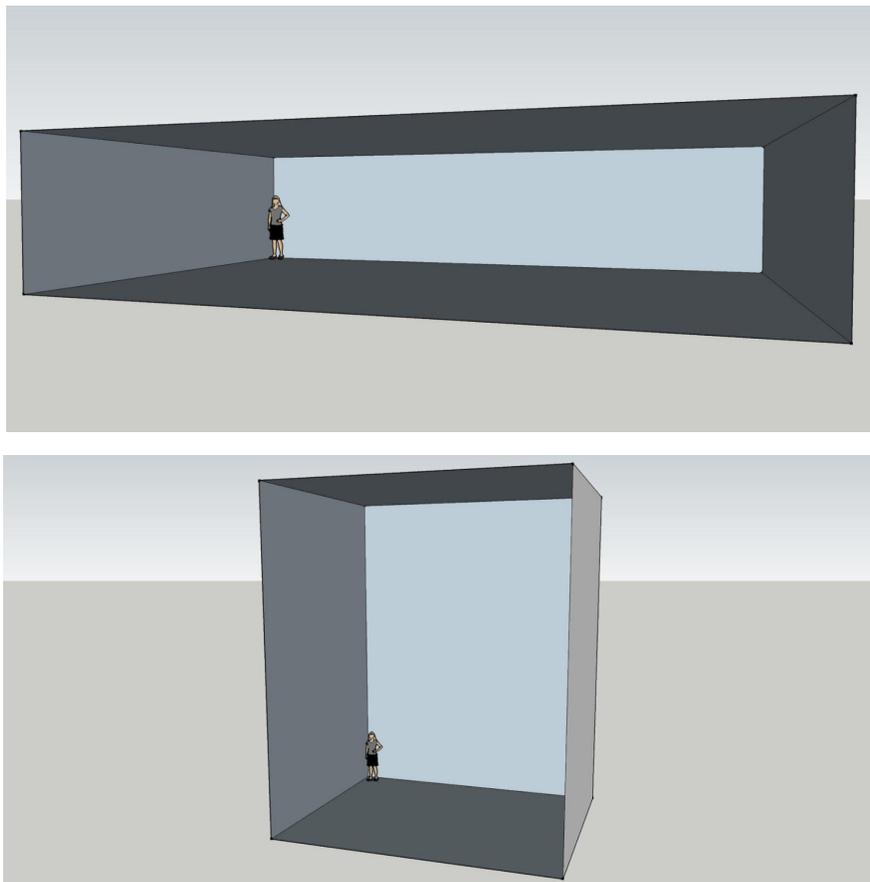


Figure 2. Two of the reference models rendered in Google SketchUp for ceiling height (top) and size of the space (bottom). The top model shows a 1,000 square foot room with a 9-foot ceiling; the bottom model shows a 500 square foot room with a 30-foot ceiling.

Measurement of physiological and affective response to the image set. 23 University of Waterloo undergraduates (13 women, 10 men; M age = 20.65, SD = 2.99) completed the experimental task at a laboratory computer. After giving informed consent, participants were fitted with equipment to measure their physiological arousal. Skin conductance and heart rate were measured using Shimmer, a device that measures skin conductance via two stainless steel sensors and heart rate via a single-point infrared pulse detector attached to the fingers of one hand. Affective responses to photographs were measured using both self-report surveys and by recording facial expressions with a webcam and iMotions FACET computer software. The iMotions FACET software allows for non-invasive recording of participants' facial emotions and is able to capture, classify and output the emotions joy, anger, surprise, fear, sadness, disgust, and contempt, as well as positive, negative, and neutral valences. The iMotions FACET software is derived from the Facial Action Coding System (FACS), which infers emotional expressions from specific combinations of muscle movements. FACS determines emotional expressions through the measurement of Action Units (AUs), which have a roughly one-to-one correspondence to facial muscles. FACET uses 21 AU channels to describe these seven basic emotions, and has been validated against Lucey et al.'s (2010) Cohn-Kanade AU-Coded Facial Expression Database. Like the physiological measures, participants' facial expressions were measured as a way to validate subjective survey responses.

Participants' neutral expressions were recorded as they viewed a gray screen for six seconds to establish a baseline measure of facial expression before stimuli presentation. Once baseline calibration was complete, participants viewed 60 photographs of various interior spaces, 30 seconds at a time. The order of photos was randomized between participants to eliminate possible order effects. Participants were asked to imagine themselves occupying the spaces as

they viewed each image. After viewing each photo, participants completed a brief emotion questionnaire to indicate their emotional state as a response to imagining themselves in that space. The questionnaire prompted participants to rate, on a 1-7 scale (with 1 indicating not at all and 7 indicating very much), how intensely they felt angry, awed, sad, happy, calm, bored, excited, afraid, surprised, and disgusted. The survey additionally asked them to indicate how well they were able to imagine themselves occupying the space they just viewed on a 1-7 scale, with 1 indicating not at all and 7 indicating completely¹. All participants were given a list of definitions of each emotion word they were asked to rate (see Appendix B), and all participants filled out the emotion survey before starting the experiment to ensure that they understood all emotion terms.

2.2 Results

Rating scale reliability. Inter-rater reliability (IRR) was determined by calculating the Intraclass Correlation Coefficient (ICC) for each architectural property across the photo set. A 2-way mixed, consistency, average-measures ICC was run (McGraw & Wong, 1996), with higher ICC values reflecting stronger IRR. See Table 1 for ICC values. Cicchetti (1994) reports one commonly-used key, with ICC values above .75 considered “excellent,” those between .60 and .74 considered “good,” values between .40 and .59 considered “fair,” and those below .40 considered “poor.” As Table 1 shows, most ICC values of the architectural properties are in the good to excellent range. We removed 4 properties below .70, following Gifford et al. (2000).

¹ We asked participants this question in order to compute weighted emotion scores based on how well participants were able to imagine themselves in these spaces. However, after running the experiment, we realized that participants would have already incorporated this information into their emotion intensity ratings when making their responses. Thus, we did not use the ratings of participants’ ability to imagine spaces in any final analyses. Moreover, analyses using weighted emotion ratings in place of raw emotion ratings were not substantially different from those using raw emotion ratings.

These properties were ceiling tiering, number of ceiling tiers, doorways/openings, and self-similarity. We suspect that ceiling tiering, number of ceiling tiers and doorways/openings may have had low IRR due to vague wording in the scale, and that self-similarity may have had low IRR due to the difficulty of observing this construct.

Table 1

ICC values for architectural properties

<u>Building property</u>	<u>ICC (3,k)</u>
Religious symbology	.96
Presence of water [†]	.94
Furniture/seating	.93
Ornament	.92
Arches	.92
Number of columns [†]	.91
Windows	.90
Ceiling shape	.89
Age of building	.89
Size of space	.88
Natural light	.86
Ceiling height [†]	.84
Symmetry	.84
Column ornateness [†]	.83
Images [†]	.77
Sculpture/art object	.76
Contour	.75
Ceiling pitch	.74
Repeating element	.72
Natural building materials	.70
Doorways/openings	.67
Number of ceiling tiers	.54
Ceiling tiering	.39
Self-similarity	.26

[†]These variables have been log transformed.

Next, we calculated average values by photo of the remaining architectural properties whose ICC values were above .70. Normality testing of the architectural property averages showed 6 properties (ceiling height, images, column ornateness, number of columns, water, contour) to be high univariate outliers with z-scores above 3.00. After log transforming these property averages, water was still found to be a high univariate outlier, with z-score > 3.00 and skew > 3.0 (Kline, 1998). No multivariate outliers were found.

ICCs were re-run on the six log-transformed architectural properties, as the log transformation was the final form of these properties for testing (Hallgren, 2012). All of the new ICC values of the log-transformed property ratings remained above .70 (Table 1 shows ICC values of these six properties using their log transformed values).

Rating scale data reduction. A principal component analysis (PCA) was run on all of the variables with acceptable reliability, including the several log-transformed variables, but not including the log transformation of column number, as this variable had 63% of data missing. A principal components, rather than common factors, analysis was run in order to reduce the scale and predict awe using the resulting components; a common factors analysis would be more suitable for understanding the latent factors underlying the data, which was not the goal here. A promax oblique rotation was used rather than a varimax orthogonal rotation, as the components were expected to be theoretically related (see Table 2 for the component correlation matrix, which confirms that the principal components were substantially correlated with one another, all $r > .28$). The Kaiser-Meyer-Olkin measure of sampling adequacy for this initial PCA was .80, suggesting that the set of variables tested is suited for a PCA (Kaiser, 1974). The anti-image correlations were all over .50, except for water, which had a value of .39, indicating that this

property was not suited for a PCA. Thus, we removed water and ran a PCA with the remaining 18 properties (see Table 3).

The final PCA showed a Kaiser-Meyer-Olkin measure of sampling adequacy of .81, and anti-image correlations all over .60, showing that all variables individually and together are suited for a PCA. This final PCA yielded four principal components, together explaining 73.08% of the variance in the data set. All communalities were $> .642$ (see Table 3, last column).

After Promax oblique rotation, the architectural properties comprising component 1 (with values over 0.40) were ceiling height, ceiling shape, ceiling pitch, size of building, contour, and repeating element; thus, this component may be called “immensity.” Architectural properties comprising component 2 were images, age, column ornateness, arches, ornament, and sculpture/art object; this component may be called “adornment.” Properties comprising component 3 were symmetry, windows, natural lighting, and repeating element. Symmetry had a relatively low loading of .40; thus, this component may be called “light and repeating elements.” Properties comprising component 4 were religious symbology, furniture/seating, and use of natural materials; as religious symbology only had a loading of .44, this component may be called “natural materials and seating.” See Table 3 for the pattern matrix.

Table 2

Component Correlation Matrix

Component	1	2	3
1			
2	.66		
3	.37	.29	
4	.49	.55	.29

Note. Extraction method: Principal Component Analysis.

Rotation method: Promax with Kaiser Normalization.

Table 3

Pattern Matrix

	Component				Extraction
	1	2	3	4	h ²
% of variance explained	46.23	11.73	8.23	6.88	
Cumulative %	46.23	57.96	66.20	73.08	
Ceiling height [†]	.86	-.02	.14	-.06	.78
Ceiling shape	.80	.16	-.11	.04	.79
Ceiling pitch	.99	-.26	-.08	.03	.69
Images [†]	-.13	1.03	-.03	-.27	.69
Symmetry	.28	.33	.40	.01	.64
Size	.92	-.04	.05	-.15	.72
Age	-.06	.63	.02	.37	.75
Windows	.01	-.17	.97	.01	.88
Column ornateness [†]	.14	.68	-.11	.16	.71
Arches	.24	.45	.08	.24	.69
Religious symbology	.28	.29	-.10	.44	.67
Ornament	.03	.84	-.06	.06	.78
Sculpture/art object	-.07	1.04	-.03	-.29	.75
Contour [†]	.75	.24	-.13	-.03	.75
Lighting	-.13	-.02	.96	.01	.85
Repeating element	.42	.10	.52	-.02	.69
Furniture/seating	.10	-.39	-.10	.94	.65
Natural materials	-.31	.13	.18	.81	.68

Note. Extraction method: Principal Component Analysis.

Rotation method: Promax with Kaiser Normalization.

Rotation converged in 6 iterations.

[†]These variables have been log transformed.

Survey responses to the image set. In order to examine the relationship between architectural properties and emotional and physiological response, we first examined the emotion survey responses to the image set. Two participants were excluded from analyses for failure to complete the task. After checking the normality of the data, we excluded two participants who were high univariate outliers in the emotions angry and sad. After these exclusions, all z-scores were < 3.00 , skew of all emotions was < 3.00 , and kurtosis < 10.00 , indicating no univariate outliers (Kline, 1998). The largest Mahalanobis distance (15.23) was found to be less than the critical chi-square value, $\chi^2(10, N=19) = 29.59, p < 0.001$, indicating that no remaining participants in the data set had an unusual combination of scores. Average response was then calculated across the remaining 18 participants, by photo, for each emotion. See Table 4 for the mean and range of emotion responses across photos and participants.

Table 4

Range and Mean Emotion Ratings

	Angry	Awe	Sad	Happy	Calm	Bored	Excited	Afraid	Surprised	Disgusted
Min	1	1.26	1.03	1.16	1.59	1.48	1.02	1	1	1.02
Max	1.72	3.98	3.1	4.97	6	5.6	3.51	2.23	2.95	2.11
Mean	1.19	2.34	1.49	2.74	3.79	2.85	2.00	1.31	1.71	1.29

Note. Ratings are averaged across 60 photographs and 21 participants.

Physiological and facial-expression response to the image set.

FACET. Baseline values were created for each participant from their neutral expressions during viewing of the grey baseline slide by taking the median evidence value (evidence values, used and exported by the iMotions software, are scaled logarithmically and range from -4 to 4, and represent the probability of an emotion being present) for each FACET emotion within a segment at which the participant held a neutral expression. A threshold of -0.5 was applied to all facial expression evidence values upon data export in order to capture the subtle responses we expected participants to make while viewing still images. Counts of the number of video frames during which each participant crossed a threshold for each emotion were used to compute median facial expression values for each photo, across subjects. In order to gauge how well the iMotions facial expression data align with participants' emotions as measured through self-reported surveys, these median facial expression values were correlated with participants' survey responses (see Table 5). Awe, as measured through survey report, was found to significantly correlate with the facial expression of disgust, $r(59) = .37, p = .004$, but no other facial expression. This correlation may be due to shared facial AUs between disgust and awe; but as the specific AUs underlying awe are not yet known, this idea remains a speculation.

The four principal components from the PCA were regressed onto each FACET facial expression. We found that adornment predicts less joyful expressions, $B = -2.44, p = .028$; that light and repeating elements predict less angry expressions, $B = -24.98, p = .047$; that adornment predicts expressions of disgust, $B = 4.27, p = .043$; that natural materials and seating predict expressions of sadness, $B = 5.94, p = .015$; and that light and repeating elements predict expressions of less negative valence, $B = -42.41, p = .024$. The principal components did not predict any other emotional expression (surprise, fear, contempt, neutral valence, and positive

valence), all $p > .081$. Thus, in examining our facial-expression data, we found that adornment predicts less joy and more disgust, light and repeating elements predict less anger and less negative valence, and that natural materials and seating predict more sadness.

GSR. One participant with missing galvanic skin response (GSR) data was excluded from analysis. Percentage scores were created for each photo reflecting the percentage of participants who had a peak GSR by dividing the number of participants who had a peak response (in which the phasic signal is extracted from the raw signal by subtracting out the median value for each sample, then finding peak onsets, $> 0.1 \mu\text{S}$, and offsets, $< 0 \mu\text{S}$, within the phasic signal) while viewing each photo, by the total number of participants ($N = 22$). This number was used for all subsequent GSR analysis.

The GSR percentage score was correlated with both the self-reported emotion ratings and the FACET facial-expression data. GSR correlated significantly with facial expressions of neutral valence, $r(59) = -.27$, $p = .034$, but no other emotion (see Table 5).

Heart rate. Heart rate was not recorded for three participants due to equipment malfunction or participant discomfort, and one participant with faulty heart-rate data was excluded from analyses. Interbeat intervals (IBIs) were extracted from photoplethysmogram (PPG) signals measuring heart rate for the remaining nineteen participants by calculating the distance between adjacent R-wave peaks in MATLAB (version R2014b). The PPG signals for each participant were plotted and R-wave peaks were visually inspected to confirm peaks. Two participants with more than 50% of data missing were excluded from further analyses. Heart rate and heart-rate variability (HRV) were calculated through means and standard deviations, respectively, for each participant and photo. One participant was a high outlier in heart rate for most photos and was also excluded.

Average HRV was found for each photo across the remaining sixteen participants, and was correlated with both the self-reported emotion ratings and the FACET facial-expression data. Average HRV correlated significantly with the survey response of surprise, $r(59) = .28, p = .026$ and with facial expressions of joy, $r(59) = .29, p = .025$, and neutral valence, $r(59) = -.28, p = .032$, but no other emotional response (see Table 5).

Table 5

Correlations between emotion survey responses, FACET emotional expressions, and physiological measures.

Response	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1. Angry																					
2. Awe	-.10																				
3. Sad	.78**	-.28*																			
4. Happy	-.50**	.47**	-.57**																		
5. Calm	-.53**	-.13	-.45**	.42**																	
6. Bored	-.13	-.71**	.04	-.51**	.18																
7. Excited	-.31*	.67**	-.43**	.75**	-.04	-.71**															
8. Afraid	.43**	-.12	.55**	-.47**	-.59**	-.19	-.10														
9. Surprised	.25	.68**	.15	.26*	-.46**	-.67**	.59**	.19													
10. Disgusted	.74**	-.13	.66**	-.44**	-.59**	-.23	-.21	.63**	.31*												
11. Joy	-.10	-.09	-.15	.02	.02	.05	.11	-.01	.06	-.04											
12. Anger	.27*	-.02	.25	-.41**	-.42**	-.05	-.20	.46**	.05	.42**	-.12										
13. Surprise	-.09	-.07	-.15	.18	.17	-.14	.21	-.10	-.07	-.11	.17	-.20									
14. Fear	.10	.09	.19	-.17	-.36**	-.18	.13	.43**	.16	.16	-.16	.18	.05								
15. Contempt	-.05	-.11	.05	-.10	.03	.12	-.09	.09	-.18	-.05	.17	-.02	.08	-.06							
16. Disgust	-.05	.37**	-.15	.18	-.13	-.26*	.24	-.15	.27*	-.04	.18	.26*	.07	.02	.03						
17. Sadness	-.10	-.02	-.02	-.16	.03	.12	-.26*	.00	-.25*	-.03	-.16	.11	-.17	.10	.22	-.07					
18. Neutral	.07	.13	.13	-.20	-.27*	.13	-.13	.09	.10	.08	-.30*	.17	-.85**	-.04	-.02	-.12	.22				
19. Positive	-.08	-.05	-.21	.15	.05	.14	.07	-.29*	-.04	-.15	.30*	-.30*	-.05	-.29*	.03	-.09	-.25	.13			
20. Negative	.33*	.16	.32*	-.31*	-.41**	-.15	-.12	.31*	.20	.38**	-.29*	.63**	-.23	.14	.01	.25	.26*	.27*	-.44**		
21. GSR	-.04	-.21	.06	.00	.12	-.09	-.03	.19	-.05	.14	.13	.12	.17	.06	.06	-.02	-.04	-.27*	-.20	.12	
22. HRV	-.01	.10	.01	.08	.03	-.19	.19	.13	.28*	.08	.29*	.09	.19	.07	.12	.24	.02	-.28*	-.01	-.04	.19

Note. N = 61. * $p < .05$. ** $p < .01$. *** $p < .001$. Responses 1 – 10 correspond to emotion survey responses, responses 11 – 20 correspond to FACET facial expressions, and responses 21 – 22 correspond to physiological measures.

Can architectural properties predict awe? A regression of awe on the four principal components extracted from the PCA showed that the first two components (immensity and adornment) were significant predictors of awe ($B = .34, p = .003$ and $B = .47, p < .001$, respectively; see Table 6). A hierarchical regression of awe was also run with all other emotions entered as a first step, and the four principal components entered second. This regression analysis also showed that the first two principal components were significant predictors of awe, after controlling for all other emotions ($B = .22, p = .001$ and $B = .25, p = .001$, respectively), as were the emotions bored ($B = -.40, p = .004$), and surprised ($B = .53, p < .001$) (see Table 7).

Separate regressions of each of the other emotions on the four principal components were also run to see which architectural properties of a building may predict feeling angry, sad, happy, calm, bored, excited, afraid, surprised, or disgusted. A multiple regression of happiness on the four principal components showed that component 3 (light and repeating element) is a significant predictor of feeling happy ($B = .26, p = .007$). A multiple regression of calmness on the four principal components showed that components 1 (immensity, $B = -.21, p = .012$) and 3 (light and repeating element, $B = .28, p < .001$) are significant predictors of feeling less and more calm, respectively. A multiple regression of excitement on the four principal components showed that component 1 (immensity) is a significant predictor of feeling excited ($B = .21, p = .034$). A multiple regression of fear on the four principal components showed that component 3 (light and repeating element) is a significant predictor of feeling less afraid ($B = -.13, p = .006$). A multiple regression of surprise on the four principal components showed that component 2 (adornment) is a significant predictor of feeling surprised ($B = .21, p = .048$). Finally, a multiple regression of disgust on the four principal components showed that component 3 (light and repeating element)

is a significant predictor of feeling less disgust ($B = -.13, p = .031$). No other bivariate regression yielded significant predictors.

Taken together, these results indicate that higher ratings of the architectural properties composing component 1 (immensity) predict higher levels of awe and excitement and lower levels of calmness; higher ratings of the architectural properties composing component 2 (adornment) predict higher levels of awe and surprise; and that higher ratings of the architectural properties composing component 3 (light and repeating element) predict higher levels of happiness and calmness and lower levels of fear and disgust.

Table 6

Regression of Awe on Architectural Properties

Model	Variable	B (Std. Error)	β	ΔR^2
1	(Constant)	2.35(.08)***		.59***
	Immensity	.32(.11)**	.35**	
	Adornment	.48(.12)***	.51***	
	Light & Repeating Elements	.14(.09)	.15	
	Natural materials & Seating	-.16(.10)	-.17	

Note. N = 60. Dependent Variable: average awe ratings.

* $p < .05$. ** $p < .01$. *** $p < .001$.

Table 7

Regression of Awe on Architectural Properties

Model	Variable	B (Std. Error)	β	ΔR^2
1	(Constant)	6.56(1.64)***		.81***
	Average anger ratings	.39(.48)	.10	
	Average sadness ratings	-.70(.32)*	-.26*	
	Average happiness ratings	-.33(.19)	-.24	
	Average calmness ratings	.03(.19)	.02	
	Average boredom ratings	-.91(.16)***	-.70***	
	Average excitement ratings	-.03(.25)	-.02	
	Average fear ratings	-.38(.30)	-.13	
	Average surprise ratings	.65(.17)***	.42***	
	Average disgust ratings	-.76(.23)**	-.36**	
	(Constant)	2.56(1.28)		.92***
	Average anger ratings	.24(.34)	.06	
	Average sadness ratings	-.46(.23)	-.17	
	Average happiness ratings	.15(.15)	.11	
	Average calmness ratings	.08(.15)	.04	
	Average boredom ratings	-.40(.13)**	-.31**	
	Average excitement ratings	-.02(.18)	-.01	
	Average fear ratings	-.03(.22)	-.01	
	Average surprise ratings	.52(.12)***	.34***	
	Average disgust ratings	-.21(.18)	-.10	
	Size & Contour	.22(.06)***	.24***	
	Image & Ornament	.24(.07)***	.27***	
	Lighting	.00(.05)	-.01	
	Furniture & Natural material	-.01(.05)	-.01	

Note. N = 60. Dependent Variable: average awe ratings.

* $p < .05$. ** $p < .01$. *** $p < .001$.

2.3 Discussion

In Experiment 1, we developed a scale to rate 60 photographs of interior spaces on 24 architectural properties each, and measured affective response to each of these spaces. By regressing the emotion responses on the architectural properties, which we reduced to four components in a PCA, we were able to determine which properties predict an awe response. We found that the components capturing both immensity (as reflected in the properties ceiling height, ceiling shape, ceiling pitch, size of building, contour, and repeating element) and adornment (as reflected in the properties images, age, column ornateness, arches, ornament, and sculpture/art object) significantly predict a feeling of awe.

Although our primary focus in the present experiment is on awe, we also found evidence that the architectural properties studied can predict other emotions, namely, excitement, surprise, happiness, fear, disgust, and calmness. Specifically, we found that excitement is predicted by immensity in building structure; that surprise is predicted by high levels of adornment; that happiness is predicted by high levels of light and repeating elements, while fear and disgust are predicted by a lack of light and repeating elements; and finally, that calmness is predicted by the presence of light and repeating elements, and an absence of immensity. Thus, in Experiment 1, we were able to identify what properties of an architectural space can give rise to different emotional states.

Although several facial-expressions correlated with respective (or related) emotion survey responses, indicating that participants' survey responses were a valid measure of their emotional state, we found conflicting results from regressions of the facial expression values onto the four principle components from our PCA, which may have arisen due to the difficulty in detecting subtle emotional expressions while viewing a still image. GSR and HRV did not

correlate with many emotions, either as measured through survey response or through facial expression analysis, which may have been due to these measures not being stable or reliable enough, or to the stimuli set not being arousing enough to reveal an effect of these measures.

While Experiment 1 was able to isolate architectural properties that elicit certain emotions, it is limited in its use of photographs as stimuli. An architectural aesthetic experience cannot be entirely reproduced by looking at a photograph, though we did try to recreate the experience as closely as possible by having participants view the images for 30 seconds at a time, as well as by asking them to imagine themselves occupying each space. The use of photographs as stimuli is also limiting for another reason: the ceiling heights of some very immense spaces cannot be captured in a photograph while also showing the space in its entirety, including the floor. This problem was compounded by the fact that we only selected photographs that were taken from a human-height perspective; that is, we did not include photographs that were taken from an unusual perspective, as we did not want perspective to confound our results (as we supposed that an unexpected or incomprehensible perspective may also give rise to a feeling of awe).

Finally, awe is a subjective experience that is influenced by many factors, including but not limited to other aspects of aesthetic experience (outside the visual domain, for example). While we do not claim to have isolated the only stimuli sufficient for an awe response, we can say that we are able to identify the aspects of architecture that significantly contribute to a feeling of awe.

We use our Experiment 1 findings to create stimuli for Experiment 2, in which we look at the effects of viewing high versus low awe-inducing building interiors.

Chapter 3: Experiment 2

Experiment 2 employed a between-subjects 2 (religious and non-religious spaces) x 2 (high and low awe) design in which we primed participants with either religious or non-religious spaces and with spaces that were predicted to elicit a high or low awe response, based on our Experiment 1 findings, for a total of four experimental conditions. All participants completed a time-estimation task, an informational conformity measure, and surveys on emotion, religiousness, spirituality, and personality. In designing Experiment 2, we had several research questions that we aimed to address. First, we sought to confirm that our photos were able to induce awe as we predicted, based on our findings from Experiment 1. Second, we wished to see whether there existed differences across experimental conditions in time estimation, personal religiousness, spirituality, and conformity. In looking at the time-estimation data, we wished to explore more generally how emotions speed up the experience of the passage of time or slow it down. We also sought to replicate a finding from Van Cappellen et al. (2011). Specifically, we wished to see whether religious priming predicts conformity among submissive individuals. Finally, we wished to see whether churches could facilitate religious feeling.

Our predictions were as follows: First, we predicted that the photos in the high awe condition would elicit a higher feeling of awe in participants than the photos in the low awe condition, based on our findings from Experiment 1. We also predicted that those in the high awe condition would experience the same amount of time as subjectively longer than those in the low awe condition (i.e., that those in the high-awe condition would overestimate time), based on findings from Rudd et al. (2012) which showed that feeling awe expands one's abstract sense of time. We predicted that participants in the religious priming condition would feel more religious than participants in the non-religious priming condition. We predicted that participants in the

high awe condition would feel more spiritual than those in the low awe condition, based on findings from Van Cappellen and Saroglou (2012) which showed that feeling awe (as opposed to feeling pride or a neutral emotion) leads to choosing more spiritual activities among people who self-describe as religious or spiritual. Finally, we predicted that among people who are high in personal submissiveness, those in the religious priming condition would be more likely to conform to others' responses in a numerical estimation task than those in the non-religious priming condition (i.e., we predicted that we would replicate Van Cappellen et al.'s 2011 findings).

3.1 Methods

Participants. 66 University of Waterloo undergraduates (51 women, 13 men, 2 other; M age = 21.68, SD = 3.92) participated for class credit or \$5. In reporting religious affiliation, 32 participants (48.5%) reported no religion/atheist/unspecified, 8 (12.1%) Roman Catholic, 6 (9.1%) agnostic, 6 (9.1%) Muslim, 3 (4.5%) Buddhist, 3 (4.5%) Evangelical Christian, 3 (4.5%) Christian (other), 2 (3.0%) Hindu, 2 (3.0%) Protestant Catholic, and 1 (1.5%) Sikh.

Procedure. We employed a 2 x 2 (awe condition x religious priming condition) experimental design. Participants were randomly assigned to one of four experimental conditions: High awe/religious prime, low awe/religious prime, high awe/non-religious prime, or low awe/non-religious prime. Participants were told that the purpose of the experiment was to measure the influence of a visual display on time perception and numerical estimation. After giving informed consent, all participants completed a time-estimation task, an emotion survey, an informational conformity measure disguised as a numerical estimation task, a demographics form, a survey on personal religiousness, a spirituality survey, and a personal submissiveness survey, in that order. After completing the experimental tasks and surveys, participants were

debriefed and told of the experiment's true purpose. The experiment took approximately one hour and twenty minutes to complete.

Measures.

Photo selection. Photos used in Experiment 2 were downloaded from Flickr, the photo-sharing website (www.flickr.com) and are licensed per the terms of Creative Commons Attribution 2.0. 55 photos were rated by a group of 3 trained judges, just as in Experiment 1, on the 12 architectural properties which comprised the two principal components (immensity and adornment) that were found to significantly predict awe, plus religious symbology and the three properties unique to component 3 (light and repeating element). The properties in component 3 (symmetry, windows and natural lighting) were included because this component was found to significantly predict both happy and calm emotions (see Experiment 1). All ICC values for these 16 properties were above .70, save for repeating elements, which had an ICC value of .62 (see Table 8). Average ratings of all properties except repeating elements of the components reflecting immensity and adornment were computed for each photograph, and the 8 photographs (4 religious and 4 non-religious spaces) with the highest averages were chosen for the high-awe conditions, and the 8 photographs (4 religious and 4 non-religious spaces) with the lowest averages were chosen for the low-awe conditions. These photos were then used as stimuli in the time-estimation task (see Figure 3 for example images).

Table 8

ICC values for architectural properties

<u>Building property</u>	<u>ICC (3,k)</u>
Ceiling height	.92
Ceiling shape	.92
Size of space	.92
Natural light	.90
Images	.89
Arches	.89
Contour	.88
Symmetry	.87
Column ornateness	.87
Sculpture/art object	.87
Age of building	.86
Windows	.86
Ornament	.86
Religious symbology	.75
Ceiling pitch	.71
Repeating element	.62

Note. N = 55. ICC values shown are average measures (averaged across three raters).



Figure 3. Photographic stimuli from each experimental condition in Experiment 2. Clockwise from top left: Religious prime/Low awe, Religious prime/High awe, Non-religious prime/High awe, Non-religious prime/Low awe. Photos are courtesy of Dave Jordano; from Flickr; Miroslav Petrasko/Flickr; and Eric E. Johnson/Flickr (clockwise from top left).

Time-estimation task. The time-estimation task served as a religious or nonreligious prime, as well as an awe induction for those in the high-awe conditions. The time-estimation task was adapted from Klapproth (2007) and was composed of two stages. In the first stage, participants were instructed to attend to the duration of an image presented on screen (participants were instructed not to count internally during this task). When the image disappeared, they were instructed to press the spacebar as quickly as possible. In the second stage of the time-estimation task, participants saw a grey screen in place of the image they just viewed. Here, their task was to press the spacebar again to indicate the length of time they estimated the first image (from stage one) was presented for. In other words, their task was to match the duration of the image in stage two to the duration of the image presented in stage one. These two stages of the time-estimation task repeated ten times. The first and last two trials (every trial being composed of the two stages) showed grey screens with an X through the image and served as a baseline time-estimation measure. The intervening six trials showed six photos from one of the four experimental conditions. These photos were chosen according to a) whether they depicted churches or non-religious interiors for the religious and non-religious prime conditions, and b) whether they depicted building interiors that we predicted would elicit a high or low awe response for the low and high awe conditions, based on our findings from Experiment 1. In other words, participants saw photos that were either in the high awe religious prime condition, high awe non-religious prime condition, low awe religious prime condition, or low awe non-religious prime condition.

The photos and baseline screens in the time-estimation task were presented for 3, 6, or 9 seconds each. We distributed these durations for each participant such that the six photos were shown for each duration twice, and the four baseline trials were shown for 3 seconds once, 6

seconds twice, and 9 seconds once, in a randomized order. To determine the order of the photos and these durations, we randomized strings of 3, 3, 6, 6, 9, 9 and matched these durations to a randomized photo order, such that across all conditions, there was an equal distribution of duration per photo. We also randomized the durations of the four baseline trials.

Emotion survey. The emotion survey served as an awe manipulation check. The survey asked participants to indicate, on a 1-7 Likert-type scale (with 1 indicating “not at all” and 7 indicating “very much”), the extent to which they currently felt each of the following emotions: Angry, awed, sad, happy, calm, bored, excited, and afraid.

Informational conformity measure. The informational conformity measure was disguised as a numerical estimation task and replicated from Van Cappellen et al. (2011). Participants were presented with 16 screens for four seconds each and were asked to estimate the number of the letter “a”s they saw on screen. The actual number of “a”s ranged from 148 to 1,156. After each screen, participants were asked to indicate their response using the number keys at the top of the keyboard. On eight of these screens, participants saw three numbers along the top of the screen, which they were told were estimates provided by previous study participants. Participants were told that they would be free to use these estimates or to ignore them in coming up with their own number. These estimates deviated from the actual number of “a”s by 20, 25 and 30% in either direction. The screens containing estimates alternated with the screens containing no estimates.

Surveys on participant demographics, religiousness, spirituality, and submissiveness. Participants also completed surveys on their demographics, religiousness, spirituality and submissiveness. The demographics questionnaire asked participants to indicate their religious affiliation, as well as distractor questions on their gender, race, and whether or not they were

born in Canada. The religiousness survey is composed of two items, “God is important in my life” and “Religion is important in my life,” measured on a 7-point Likert-type scale, with 1 indicating “not at all important” and 7 indicating “very important.” This 2-item scale has been used in other studies and has been found to be reliable (Van Cappellen, Saroglou, Iweins, Piovesana, & Fredrickson, 2013; Van Cappellen et al., 2011).

Spirituality was measured in 15 items from two subscales (Universality and Connectedness) of Piedmont’s (1999) spiritual transcendence scale, as was used in Van Cappellen and Saroglou (2012). See Appendix C for complete list of items.

The personal submissiveness survey consists of six items selected to measure submissiveness (as measured by subscales on conformity, dependence and dominance from the International Personality Item Pool). Participants were asked to rate the extent to which they: 1. Need the approval of others, 2. Do what others do, 3. Want to form my own opinions (reverse-scored), 4. Want to be different from others (reverse-scored), 5. Am not afraid of providing criticism (reverse scored), and 6. Let myself be influenced by others. This survey replicates the one used in Van Cappellen et al. (2011).

3.2 Results

We excluded one participant who received the same configuration as another of awe and religious priming conditions, order of durations and order of photos in the time-estimation task from all analyses. All remaining participants received unique awe, religious-priming, duration, and photo-order configurations.

Emotion survey. A normality check showed six participants who were high outliers in feeling angry, sad and afraid; these six participants were excluded from further analyses on emotion, leaving 59. A two-way analysis of variance (ANOVA) (awe condition by religious

priming condition) showed no significant main effect of awe condition on awe, $F(1, 55) = 1.22$, $MSE = 1.70$, $p = .27$, $\eta_p^2 = .02$. Thus, for further analyses on the specific effects of felt awe as opposed to awe induced by the buildings in the high and low awe groups, a median split on reported awe was performed to group participants into high and low felt-awe groups. The median reported awe was 1.0; those who responded “1” were placed into the low felt-awe group, and those who responded between 2 and 7 were placed into the high felt-awe group (the responses in the high felt-awe group ranged from 2.0 to 5.0, with a mean response of 3.07).

In comparing high and low felt awe, Levene's test of equality of error variances was found to be violated, $F(1, 57) = 75.14$, $p < .001$, so a t-test not assuming homogeneity of variance was computed. An independent-samples t-test confirmed a significant difference between high ($M = 3.07$, $SD = 1.10$) and low ($M = 1.00$, $SD = .00$) felt awe, $t(28.0) = -10.13$, $p < .001$.

Two-way ANOVAs (awe condition by religious priming condition) on all of the other reported emotions (angry, sad, happy, calm, bored, excited, and afraid) revealed a main effect of religious priming on sadness such that participants in the non-religious priming condition reported significantly higher levels of sadness than those in the religious priming condition, $F(1, 55) = 4.84$, $MSE = .67$, $p = .032$, $\eta_p^2 = .08$ (Figure 1). All other effects and interactions were non-significant, $p > .126$.

Two-way ANOVAs (felt awe by religious priming condition) on all of the other reported emotions (angry, sad, happy, calm, bored, excited, and afraid) showed a significant main effect of felt awe on sadness, $F(1, 55) = 8.95$, $MSE = .56$, $p = .004$, $\eta_p^2 = .14$, and significant main effect of religious priming on sadness, $F(1, 55) = 5.97$, $MSE = .56$, $p = .018$, $\eta_p^2 = .10$, such that participants who felt high awe reported higher levels of sadness than participants who felt low

awe, and participants who viewed non-religious images reported higher levels of sadness than participants who viewed religious images (Figure 2). Two-way ANOVAs also showed a significant interaction between felt awe and religious priming condition on happiness, $F(1, 55) = 5.33$, $MSE = 1.42$, $p = .025$, $\eta_p^2 = .09$, showing that the effect of religious priming condition on happiness depends on the level of awe the participant is experiencing (Figure 3). Follow-up *t*-tests (using a Bonferroni corrected alpha level of $.05/4 = 0.0125$) showed no significant difference in happiness between those feeling low ($M = 4.06$, $SD = 1.18$) and high ($M = 3.20$, $SD = 1.08$) awe among those in the non-religious priming condition, $t(29) = 2.12$, $p = .043$, and no significant difference in happiness between those feeling low ($M = 3.21$, $SD = 1.25$) and high ($M = 3.79$, $SD = 1.25$) awe among those in the religious priming condition, $p = .238$. We also found no significant differences in happiness between those in the religious priming condition and the non-religious priming condition, among those feeling either high ($p = .188$) or low awe ($p = .067$).

Finally, a two-way ANOVA (felt awe by religious priming condition) on fear showed a significant main effect of felt awe on fear, $F(1, 55) = 6.28$, $MSE = .19$, $p = .015$, $\eta_p^2 = .10$, such that participants who felt high awe were also more likely to feel more afraid than participants who felt low awe (Figure 4).

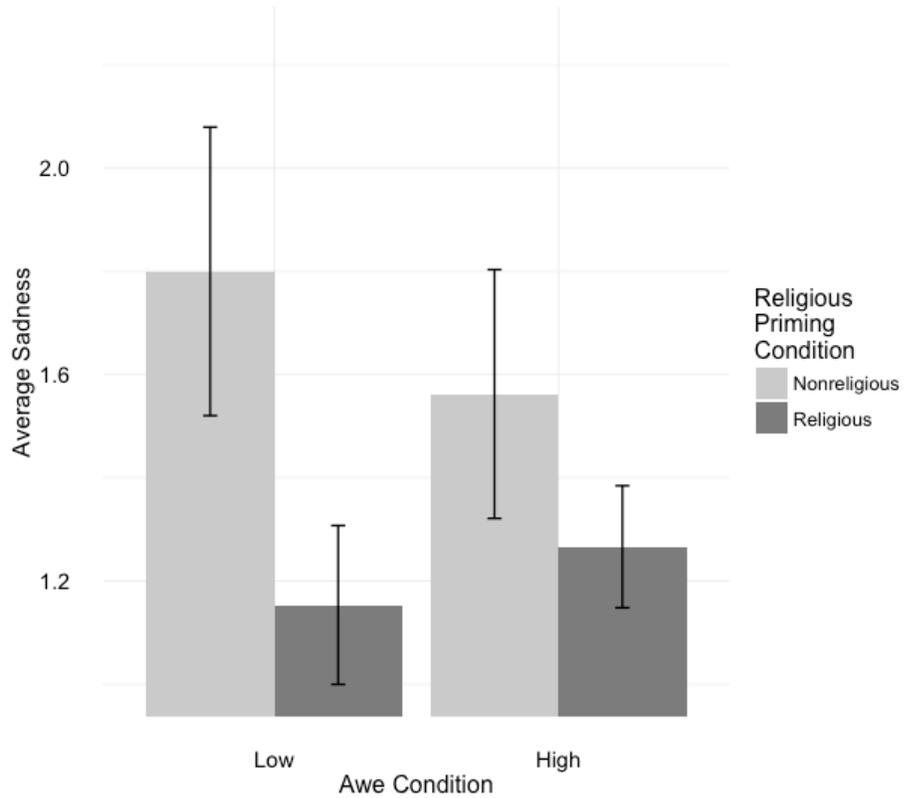


Figure 4. Average ratings of sadness across religious priming and experimental awe conditions.

A significant main effect of religious priming condition showed that participants in the non-religious priming condition were significantly more sad than participants in the religious priming condition. Error bars represent +/- one standard error of the mean.

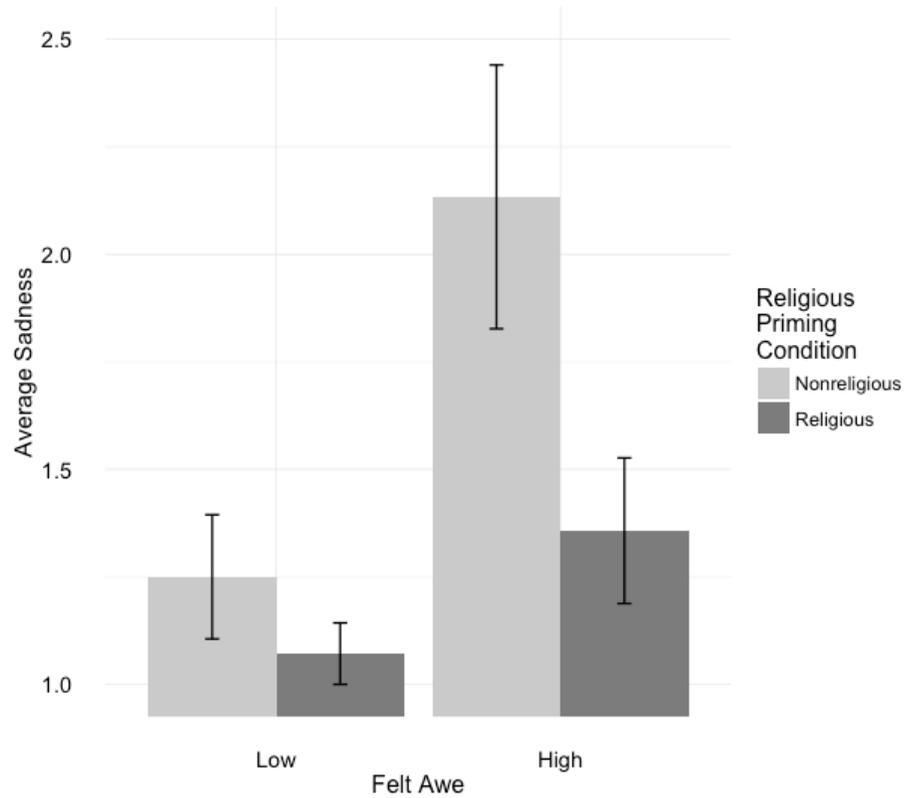


Figure 5. Average ratings of sadness across religious priming conditions and high and low felt awe groups. A main effect of felt awe showed that participants who felt awe were significantly more sad than participants who did not feel awe; and a main effect of religious priming showed that participants who viewed non-religious spaces were significantly more sad than participants who viewed religious spaces. Error bars represent +/- one standard error of the mean.

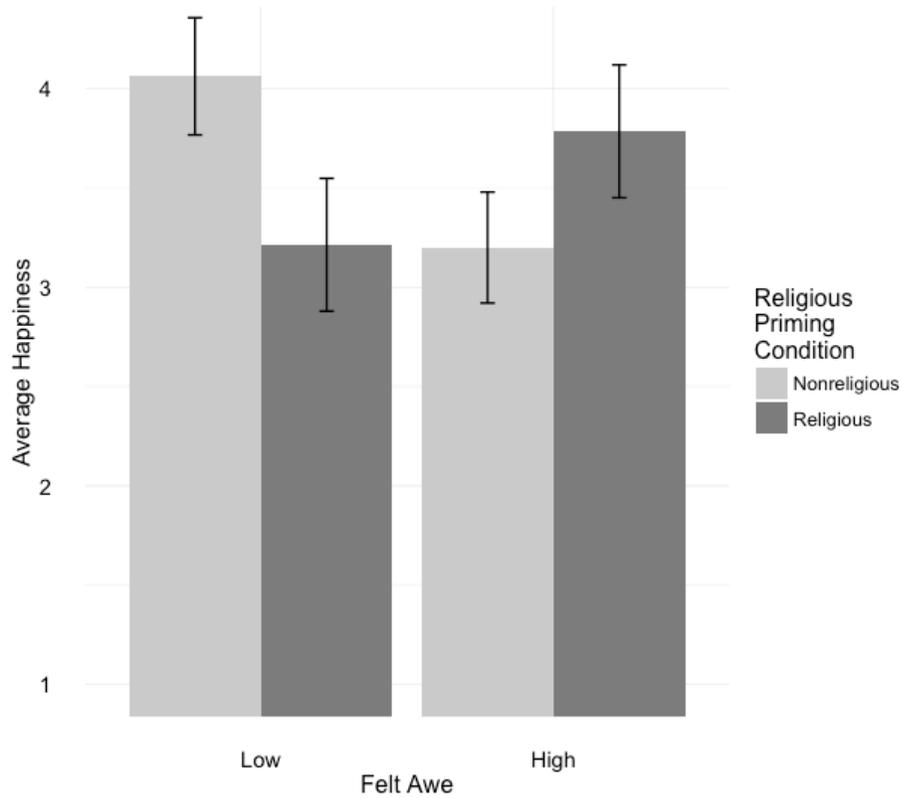


Figure 6. Average ratings of happiness across religious priming conditions and high and low felt awe groups. A significant interaction between felt awe and religious priming condition on happiness was driven by higher ratings of happiness by those who did not feel awe than those who did feel awe, among participants in the non-religious priming condition. Error bars represent +/- one standard error of the mean.

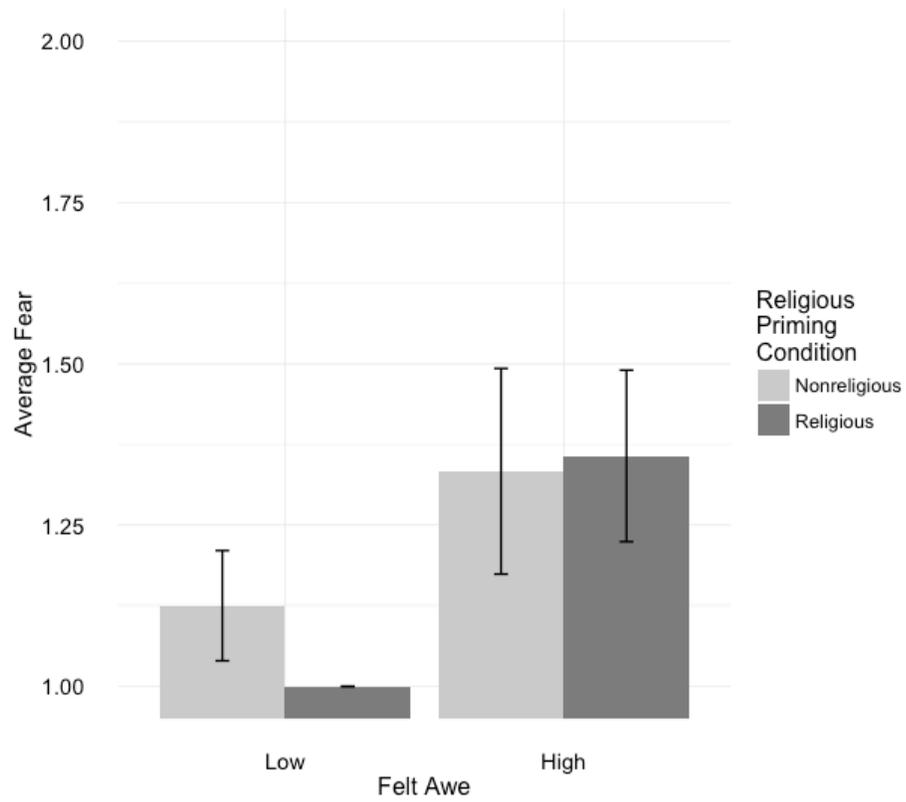


Figure 7. Average ratings of fear across religious priming conditions and high and low felt awe groups. A significant main effect of felt awe on fear showed that participants who felt awe were also more likely to feel more afraid than participants who did not feel awe. Error bars represent +/- one standard error of the mean.

Time estimation. Two participants did not complete the time-estimation task properly and were excluded from all time-estimation analyses. We further excluded from time-estimation analyses 11 more participants who, after they were debriefed on the experiment, reported having counted internally during the time-estimation task, leaving 52 participants for analysis. Tests of normality showed no univariate or multivariate outliers.

We first computed separate time-estimation accuracy terms for the pre-photo baseline trials, photo trials, and post-photo baseline trials, with lower scores indicating higher accuracy and 0 indicating perfect accuracy. The time-estimation accuracy terms were created by taking the average of the absolute values of proportional difference scores, which were created by subtracting each estimate from the actual duration of the stimulus, divided by this actual duration. We examined the effects of both awe condition and felt awe, as well as religious priming condition, on time estimation. Here we report the results of factorial ANOVAs examining the effects of awe condition and religious priming condition first, followed by felt awe and religious priming condition. A two-way factorial ANOVA (awe condition by religious priming condition) on accuracy of time estimation during the pre-photo baseline trials showed no significant effects or interactions, all $p > .22$. A two-way factorial ANOVA (awe condition by religious priming condition) on accuracy of time estimation during the photo trials showed a main effect of awe condition, $F(1, 48) = 5.85$, $MSE = .01$, $p = .019$, $\eta_p^2 = .11$, such that those in high-awe condition were more accurate than those in the low-awe condition; and a significant interaction, $F(1, 48) = 4.94$, $MSE = .01$, $p = .031$, $\eta_p^2 = .09$, showing that the effect of awe condition on accuracy depends on whether participants have been exposed to religious or non-religious photos (Figure 5). Follow-up t-tests (using a Bonferroni corrected alpha level of $.05/4 = 0.0125$) showed that among participants who were in the low awe condition, there was no

significant difference in time estimation accuracy between the religious priming condition ($M = .32, SD = .14$) and the non-religious priming condition ($M = .23, SD = .08$), $p = .065$. Among those who were in the high awe condition, there was no significant difference in time estimation accuracy between the religious priming group ($M = .20, SD = .07$) and the non-religious priming group ($M = .22, SD = .06$), $p = .378$. Among the participants in the non-religious priming condition, no significant difference was found in time estimation accuracy between high awe ($M = .23, SD = .08$) and low awe ($M = .22, SD = .06$) conditions $p = .86$. In comparing those who were in the low awe condition to those who were in the high awe condition among the participants in the religious priming condition, Levene's test of equality of error variances was found to be violated, $F(1, 24) = 4.29, p = .05$, so a t-test not assuming homogeneity of variance was computed. No significant difference was found between high ($M = .20, SD = .07$) and low awe ($M = .32, SD = .14$) religious-priming groups in time estimation accuracy, $t(15.13) = 2.63, p = .019$. Finally, a two-way factorial ANOVA (awe condition by religious priming condition) on time estimation accuracy during the post-photo baseline trials showed no significant effects or interactions, all $p > .21$.

We re-ran the above analyses with our measure of felt awe in the place of awe condition. A two-way factorial ANOVA (felt awe by religious priming condition) on accuracy of time estimation during the pre-photo baseline trials showed no significant differences, all $p > .12$. A two-way factorial ANOVA (felt awe by religious priming condition) on time estimation accuracy during the photo trials showed a main effect of felt awe: Those who felt high awe were more accurate than those who felt low awe, $F(1, 48) = 9.48, MSE = .01, p = .003, \eta_p^2 = .17$ (Figure 6). Finally, a two-way factorial ANOVA (felt awe by religious priming condition) on time estimation during the post-photo baseline trials showed no significant differences, all $p > .30$.

Next, we created deviation scores to reflect participants' over or underestimation of time. Time deviation scores were created by subtracting each participant estimate from the actual presentation duration, dividing this value by actual duration, and taking the average of these proportions, such that negative values reflect underestimation and positive values reflect overestimation of time. Factorial ANOVAs were again run on these deviation scores for pre-photo baseline trials, photo trials, and post-photo baseline trials, first using awe condition and religious priming condition, and then using felt awe and religious priming condition. Both awe condition and felt awe were used because we were interested in the effects of both looking at the different buildings in our high and low awe conditions, as well as to see the effects of different levels of felt awe. A two-way factorial ANOVA (awe condition by religious priming condition) on time deviation during the pre-photo baseline trials showed no significant differences, all $p > .298$. A two-way factorial ANOVA (awe condition by religious priming condition) on time estimation deviation during the photo trials showed no significant differences, all $p > .076$. A two-way factorial ANOVA (awe condition by religious priming condition) on time estimation deviation during the post-photo baseline trials showed no significant differences, all $p > .594$. Neither awe condition nor religious priming condition had any effects on time estimation deviation.

A two-way factorial ANOVA (felt awe by religious priming condition) on time estimation deviation during the pre-photo baseline trials showed no significant differences, all $p > .16$. A two-way factorial ANOVA (felt awe by religious priming condition) on time estimation deviation during the photo trials showed no significant differences, all $p > .10$. Finally, a two-way factorial ANOVA (felt awe by religious priming condition) on time estimation deviation during the post-photo baseline trials showed a significant main effect of awe: Those who felt

more awe were less likely to underestimate time than those who felt less awe, $F(1,48) = 5.41$, $MSE = .04$, $p = .024$, $\eta_p^2 = .10$ (Figure 7). The main effect of religious priming condition and the interaction between felt awe and religious priming condition were both non-significant, $p > .496$.

To explore how different affective states influence time perception, we performed a regression of the different emotions on both time accuracy and deviation scores for the pre-photo baseline, photo stimuli, and post-photo baselines. When regressing time estimation accuracy on all eight emotions (angry, awe, sad, happy, calm, bored, excited, and afraid), we found awe (but no other emotion, all other $p > .078$) to be a significant predictor of time-estimation accuracy during the photo stimuli phase of the experiment, $B = -.02$, $p = .037$, such that feeling awe predicts higher accuracy. We found no significant predictors for the pre or post-photo baselines (all $p > .153$).

When regressing time estimation deviation scores on all eight emotions, we found that feeling happy is a significant predictor of time deviation during the photo stimuli phase of the experiment, $B = -.051$, $p = .027$, indicating that happiness is a significant predictor of underestimating time (all other predictors of time deviation during the photo stimuli phase were non-significant, all $p > .145$). We also found that both awe and sadness are significant predictors of time deviation during the post-photo baseline phase, $B = .049$, $p = .012$ for awe, and $B = .072$, $p = .017$ for sadness, indicating that awe and sadness are significant predictors of overestimating time (all other predictors of time deviation during the post-photo baseline phase were non-significant, all $p > .115$). We found no significant predictors for the pre-photo baseline phase of the experiment, all $p > .249$.

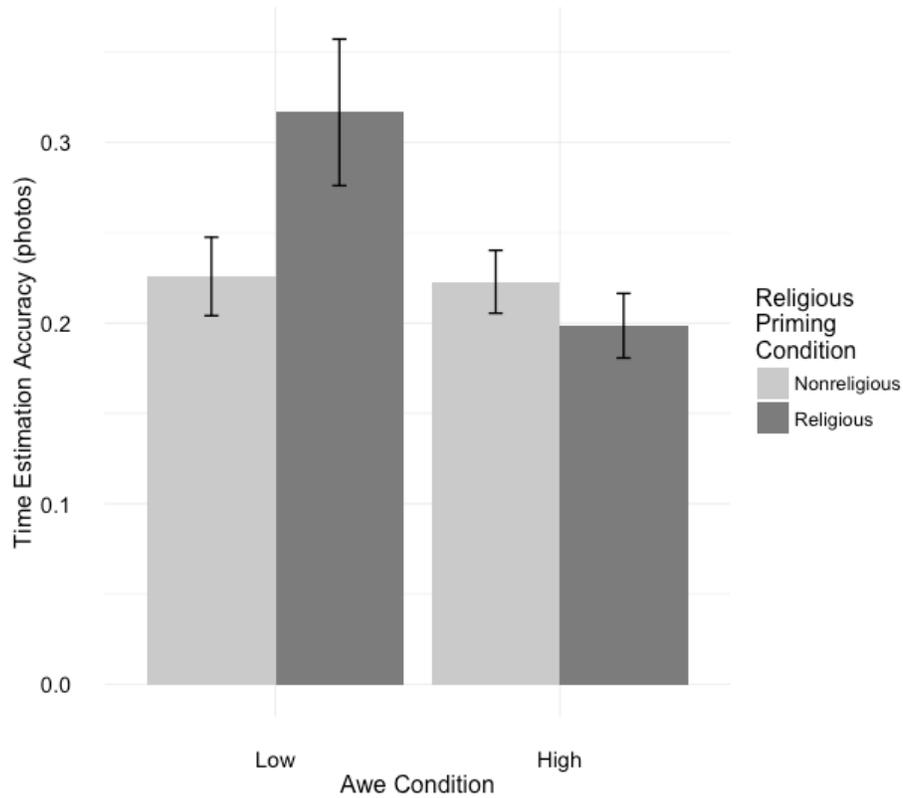


Figure 8. Average time-estimation accuracy during stimulus (photo) presentation across religious priming and experimental awe conditions. A main effect of awe condition showed greater time-estimation accuracies by those in the high-awe conditions than those in the low-awe conditions; and a significant interaction was driven by greater time-estimation accuracies among the religious priming conditions by those in the high awe condition than those in the low awe condition. Error bars represent +/- one standard error of the mean.

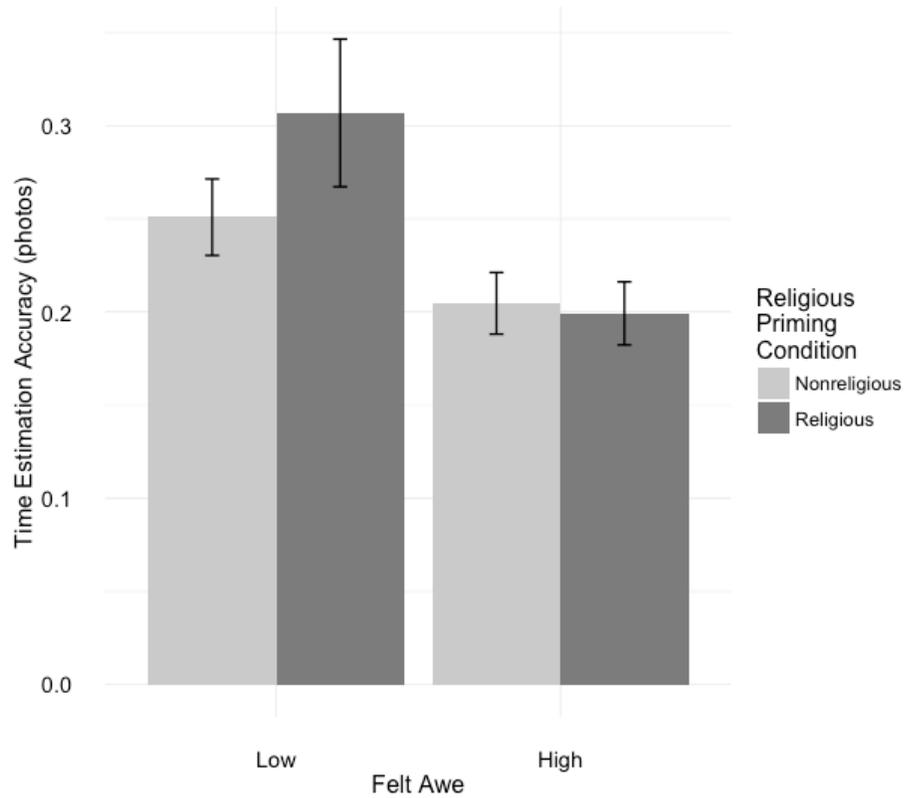


Figure 9. Average time-estimation accuracy during stimulus presentation across religious priming conditions and high and low felt awe groups. A main effect of felt awe showed that those who felt awe were significantly more accurate in estimating time than those who did not feel awe. Error bars represent +/- one standard error of the mean.

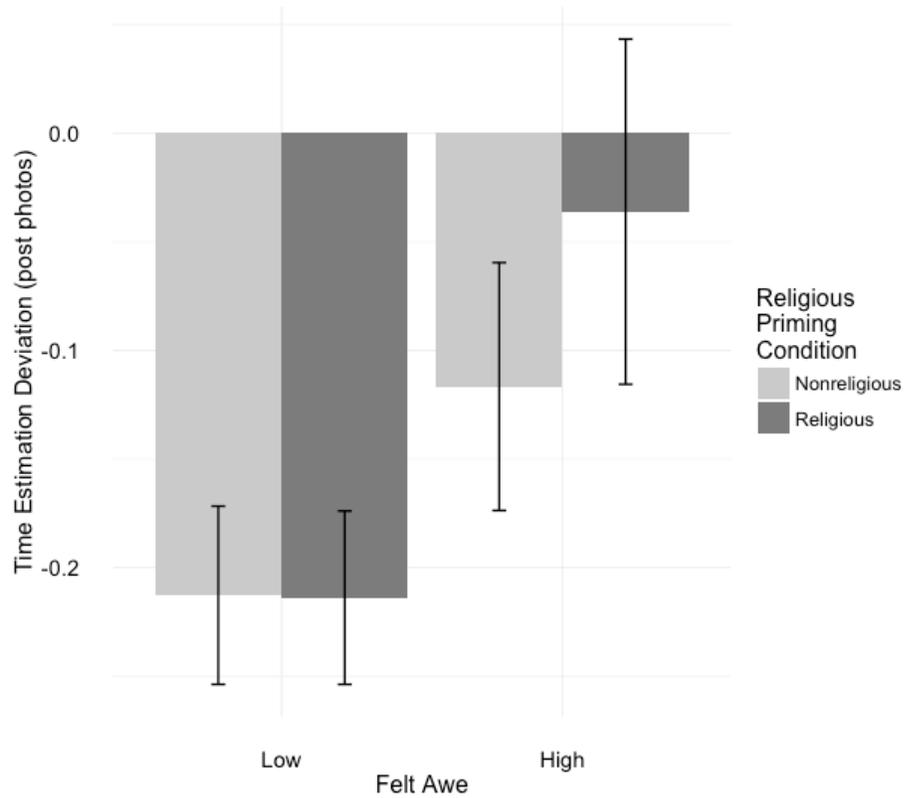


Figure 10. Average time-estimation deviation during a post-stimulus baseline across religious priming conditions and high and low felt awe groups. A main effect of felt awe showed that those who felt awe were significantly less likely to underestimate time than those who did not feel awe. Error bars represent +/- one standard error of the mean.

Informational conformity measure. Four participants who reported at debriefing that they had suspected the estimates on half of the screens were researcher-generated were excluded from further analyses on informational conformity. A normality check on the submissiveness ratings showed one participant who was a low outlier for the item, “Want to form my own opinions.” This participant was also excluded from analyses on conformity, leaving 60 participants for analysis. The analyses that follow replicate those reported in Van Cappellen et al. (2011).

Reliability of the submissiveness scale was acceptable (Cronbach’s $\alpha = .65$). A submissiveness score was created by taking the mean of all responses, after reverse-coding items 3, 4, and 5 (“Want to form my own opinions,” “Want to be different from others,” and “Am not afraid of providing criticism,” respectively). Reliability of the personal religiousness scale was very high (Cronbach’s $\alpha = .94$), and the two items were strongly correlated, $r(56) = .89, p < .001$. Personal religiousness scores were created by taking the mean of the two responses.

Deviation scores (i.e., deviation from the provided estimates) were created by taking the mean of all absolute values of the actual number of “a”s appearing on screen subtracted from each participant estimate and divided by the actual number of “a”s on screen. Lower deviation scores here reflect higher conformity. Numerical estimation accuracy terms were created by computing the mean absolute proportional difference between each participant estimate and the actual number of “a”s appearing on the screen, such that lower scores reflect higher accuracy. 2 participants who were high outliers in numerical estimation accuracy (with z-scores > 3.0) were excluded from further analyses.

Deviation scores were regressed onto religious priming condition (effects coded: non-religious priming = -1, religious priming = 1), personal religiousness (centered) and

submissiveness (centered) to see which of these factors and interactions among them predicted conformity. We found that, contrary to Van Cappellen et al.'s (2011) findings, the interaction between religious priming condition and submissiveness was not significant, $p = .409$, and that submissiveness was not a significant predictor of conformity, $p = .064$.

Van Cappellen et al. (2011) ran a complementary analysis to compare conformity between participants scoring above and below the median in dispositional submissiveness. Consistent with their findings, we found no difference in conformity between religious ($M = .22$, $SD = .18$) and non-religious ($M = .32$, $SD = .16$) priming conditions among those low in dispositional submissiveness, $p > .112$. Unlike Van Cappellen et al. (2011), however, we found no difference in conformity between religious ($M = .18$, $SD = .15$) and non-religious ($M = .19$, $SD = .14$) priming conditions among those high in dispositional submissiveness, $p > .877$.

Van Cappellen et al. (2011) ran a further complementary analysis to determine whether religious primes improved numerical estimation accuracy, and this analysis was repeated here. A regression of accuracy scores on religious priming condition, personal religiousness and submissiveness revealed no significant predictors of accuracy, all $p > .581$, consistent with Van Cappellen et al.'s (2011) findings.

To determine whether there were differences across awe and priming conditions in informational conformity, we ran a two-way factorial ANOVA (awe condition by religious priming condition) on numerical estimation deviation scores and found no significant effects, all $p > .059$, showing no effect of awe or religious priming condition on informational conformity. The same ANOVA was run using felt awe in place of awe condition; this analysis yielded no significant effects, all $p > .197$, showing that neither felt awe nor religious priming condition had any effect on informational conformity.

Participant religiousness, spirituality and submissiveness. To examine the effects of awe and religious priming conditions on participant religiousness, we ran a 2 x 2 (awe condition by religious priming condition) ANOVA on religiousness. We found a significant interaction between awe condition and religious priming condition, $F(1, 55) = 4.19$, $MSE = 4.44$, $p = .046$, $\eta_p^2 = .07$ (Figure 8). However, simple effects analyses (with $\alpha = .0125$, Bonferroni correction) showed no significant difference in religiousness between religious and nonreligious priming conditions among those in the low awe condition, $p > .034$, or the high awe condition, $p > .511$; as well as no significant difference in religiousness between high and low awe conditions among those in the non-religious priming condition, $p > .096$, or the religious priming condition, $p > .238$. Neither the awe condition nor the religious priming main effects were significant, both $p > .271$.

We repeated the above analysis with felt awe in place of awe condition and found no significant effects, all $p > .515$.

Reliability of the spirituality scale was excellent, with Cronbach's $\alpha = .91$. A composite spirituality score was created for each participant by taking the mean of all responses.

To examine the effects of awe condition and religious priming condition on participant spirituality, we ran a 2 x 2 (awe condition by religious priming condition) ANOVA on spirituality. We found no significant effects, all $p > .051$. A 2 x 2 (felt awe by religious priming condition) ANOVA on spirituality also yielded no significant effects, all $p > .318$.

The above analyses on participant religiousness and spirituality were re-done with those who reported having seen religious imagery ($N = 38$) after the experiment versus those who did not ($N = 27$), in place of religious priming condition (all participants were asked at debriefing if

they noticed anything about the photos they saw during the time-estimation task). We found no difference in results.

Like Van Cappellen et al. (2011), we found that the religious priming manipulation did not affect personal religiousness or submissiveness (across awe conditions). There was no difference in personal religiousness between those who received the religious prime ($M = 3.61$, $SD = 2.06$) and those who received the non-religious prime ($M = 3.11$, $SD = 2.09$), $t(63) = -.96$, $p > .338$; and there was no difference in personal submissiveness between those who received the religious prime ($M = 2.57$, $SD = .68$) and those who received the non-religious prime ($M = 2.69$, $SD = .65$), $t(63) = .74$, $p > .461$.

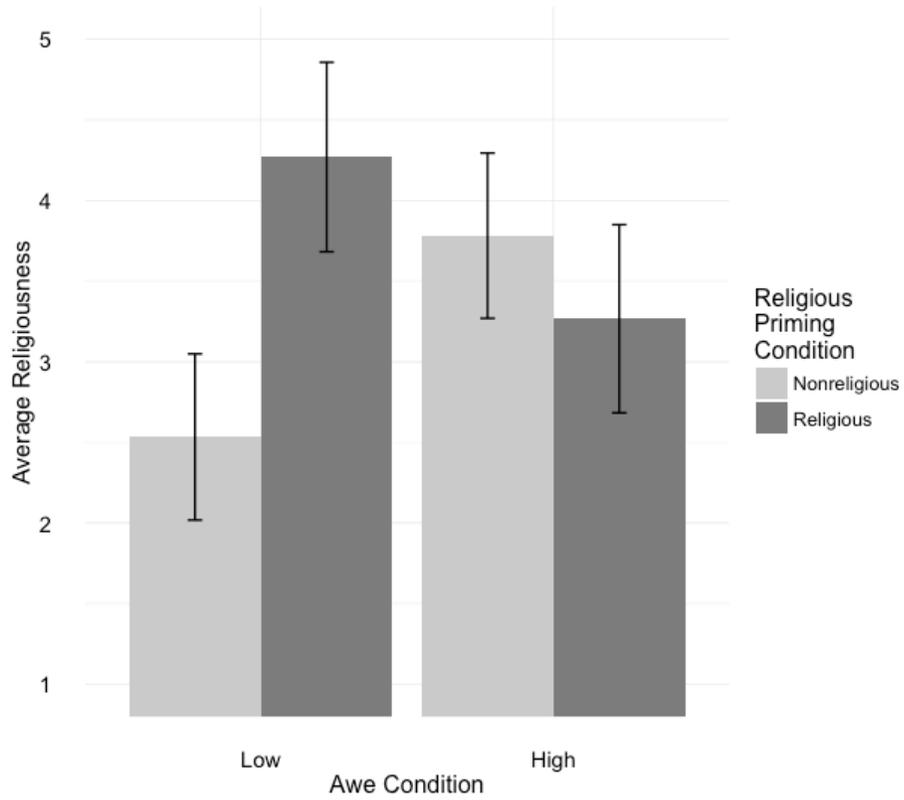


Figure 11. Average religiousness across religious priming and experimental awe conditions. A significant interaction between awe condition and religious priming condition was driven by higher ratings of religiousness among the low awe conditions by those in the religious priming condition than those in the nonreligious priming condition. Error bars represent +/- one standard error of the mean.

3.3 Discussion

Our first question was whether the experimental conditions were able to induce awe as predicted. Surprisingly, we found that this was not the case. In interpreting this finding, we recognize that our rating scale may not have included all possible architectural features that contribute to a sense of awe; the affective response to architecture may be explained by more than the architectural properties we selected in Experiment 1. Thus, we explain these findings by acknowledging that our rating scale developed in Experiment 1 did not capture enough of the factors that elicited awe in the first photo set used in Experiment 1.

In exploring emotions other than awe, we found that participants who felt awe were also more likely to feel afraid than participants who did not feel awe. In their 2003 paper, Keltner and Haidt explain the connection between awe and terror, hypothesizing that people may experience fear when they fail to understand or accommodate an awe-inducing experience (and likewise may experience enlightenment when they do succeed in fulfilling a need for accommodation).

We also found that across awe conditions, participants in the non-religious priming condition reported significantly higher levels of sadness than those in the religious priming condition, as well as that participants who felt awe reported higher levels of sadness than participants who did not feel awe across religious priming conditions. These findings suggest the presence of a relationship between awe and sadness; they may, for example, be co-occurring emotions. Because awe has only begun to be empirically studied from a psychological perspective in the past ten or so years, its relationship to other emotions is not greatly understood. Thus, the present findings suggest a relationship between awe and sadness, as well as confirm a relationship between awe and fear.

We found several differences across experimental conditions and felt awe in time estimation. Specifically, we found that during the photo stimuli phase of the time-estimation task, both those who were in the high-awe experimental condition and those who felt awe were more accurate in their estimation than those in the low-awe experimental condition and those who did not feel awe. As a further confirmation of this finding, we found that awe (but no other emotion) predicts accuracy during the photo stimuli phase of the task, such that higher felt awe predicts higher accuracy. In terms of the effects of felt awe, this unpredicted result is not readily explained. In terms of the effects of the experimental awe condition, it is possible that this effect is driven by the high ratings of architectural properties reflecting adornment, including images, column ornateness, ornament, and presence of sculptures and art objects. Because about a third of the participants estimated time by being cognizant of their eye movements during the photo presentation and replicating these movements during the time-estimation slide (as reported by participants after the experimental session), it is possible that the high level of decoration or detail in the high-awe condition photos facilitated this time-estimation process. Specifically, it may be the case that a high number of eye movements facilitates more precise time estimation than few eye movements, when this strategy is used.

We also found that those participants who felt awe were more likely to overestimate time than those who did not feel awe during the post-photo baseline phase of the task. Thus, our prediction that those in the high awe condition will experience the same amount of time as subjectively longer than those in the low awe condition was confirmed. The fact that we see an effect of awe during a baseline measure, as opposed to during the stimuli presentation, suggests to us that the effect of awe on time perception takes some time to develop, or perhaps that the

stimuli themselves masked this effect (for example, through high levels of adornment leading to increased time-estimation accuracy). Future research is needed to clarify these possibilities.

In exploring the effects of different affective states on the over- or under-estimation of time, we found that feeling happy is a significant predictor of time deviation during the photo stimuli phase of the experiment, indicating that happiness is a significant predictor of underestimating time. We found that during post-photo baseline phase, feeling awe or sadness is a significant predictor of overestimating time. These results suggest that happiness narrows one's sense of time, whereas awe and sadness expand it. Given that both awe and happiness are positive affective states, while sadness is a negative one, these findings paint an interesting and perhaps complex picture of the relationship between emotions and the experience of time.

In looking at participant religiousness and how it is affected by religious priming conditions, our results remain somewhat inconclusive. We found a significant interaction between awe condition and religious priming condition for participant religiousness, with the interaction driven by participants in the religious priming condition viewing the low-awe spaces reporting greater levels of religiousness than those in the non-religious priming condition viewing the low-awe spaces, although this difference was non-significant with a Bonferroni-corrected alpha level. No significant effects were found when looking at felt awe in place of awe condition on participant religiousness. Thus, our prediction that participants in the religious priming condition will feel more religious than participants in the non-religious priming condition was nearly confirmed, but only among the participants in the low-awe experimental condition.

We did not find that participants in the high awe condition felt more spiritual than those in the low awe condition, or that those who felt awe felt more spiritual than those who did not

feel awe; thus, our prediction that feeling awe would increase one's spirituality was not confirmed.

Because we split participants into high and low felt-awe groups, it is possible that some of the effects seen in the present experiment reflect individual personality differences. A replication of our current experiment including measurement of personality variables would help clarify this possibility.

One purpose of the present experiment was to replicate Van Cappellen et al.'s (2011) finding that religious priming predicts conformity among submissive individuals. We predicted that, as Van Cappellen et al. (2011) found, among people who are high in personal submissiveness, those in the religious priming condition would be more likely to conform to others' responses in a numerical estimation task than those in the non-religious priming condition. However, we found no significant interaction between religious priming condition and submissiveness.

In looking at differences across conditions in informational conformity, we found that neither experimental condition (awe condition and religious priming condition) nor felt awe had any effect on level of conformity. However, while we can conclude that neither feeling awe nor being primed with religious imagery has an effect on conformity, these results do not preclude the possibility of other social effects of awe or religious priming. Piff, Dietze, Feinberg, Stancato, and Keltner (2015) have found, for example, that feeling awe increases prosocial behaviors.

In summary, although many of the effects we predicted were not confirmed, we did see several interesting findings. We found that, as predicted, feeling awe is associated with an

overestimation of time in a time-estimation task. This result confirms earlier findings by Rudd et al. (2012) that feeling awe expands one's sense of time as measured through self-report surveys. In looking at how other emotional states affect time perception, we found that feeling sadness also leads to overestimation of time, and that feeling happiness is associated with an underestimation of time. We also found relationships emerging between awe and sadness, as well as awe and fear. These findings lend complexity to our current understanding of awe and its psychological effects.

Chapter 4: General Discussion

The purpose of the present research was to determine how, architecturally, interior spaces give rise to a feeling of awe (Experiment 1), as well as to investigate the behavioral effects of church interiors on informational conformity and the cognitive effects of awe-inducing architecture on religiousness, spirituality, and time perception (Experiment 2). In Experiment 1, we found that architectural properties reflecting immensity, adornment, natural light, and repeating elements strongly predict a feeling of awe. Moreover, we found that architectural properties encompassing immensity predict higher levels of excitement and lower levels of calmness; that properties encompassing adornment predict higher levels of surprise; and that properties encompassing natural light and repeating elements predict higher levels of happiness and calmness and lower levels of fear and disgust.

In Experiment 2, we found that, contrary to expectations, photographs of church interiors used as a religious prime did not increase informational conformity, as we predicted from Van Cappellen et al. (2012) and their findings on conformity using semantic religious primes. However, we did find that religious priming through photographs of church interiors rated low in properties of immensity and adornment did lead to an increase in religious feeling. Regarding awe-inducing architecture, while we did not find that our photographs of high-awe building interiors led to higher felt awe as predicted, we did find that awe may be related to both fear and sadness. We also found that higher felt awe increases time-estimation accuracy with stimulus presentation, eventually leading to time-overestimation; and that feeling joy will lead to an underestimation of time, while feeling sad will lead to an overestimation of time. In summary, our results from Experiments 1 and 2 contribute to a more precise and systematic understanding

of how, architecturally, interior spaces affect users' emotions, perception of time, and religious feeling.

Our findings from Experiment 1 present exciting possibilities for architectural design. Specifically, the systematic study of how architecture shapes users' emotional states may help create buildings that stimulate positive affect. The ability to empirically determine what affective states an architectural property may likely induce in a user, as we have demonstrated with the development of our rating scale, will be of special interest to architects and designers. Our rating scale may be a useful starting point for those working in evidence-based design who wish to incorporate more varied architectural properties or emotions into their study.

Likewise, built spaces that facilitate a feeling of awe may have more far-reaching positive effects, such as on health and prosocial behaviors. Stellar et al. (2015) recently found an association between awe and proinflammatory cytokines, which at a chronic level pose health risks such as cardiovascular disease and depression. It has also been recently found that awe increases prosocial behaviors through the diminishment of the self in the face of a vast or powerful stimulus (Piff et al., 2015). As we continue to understand awe from more perspectives in cognitive sciences and biology, it will be important to note what effects may have implications for architectural design.

As previously mentioned, both Experiments 1 and 2 were limited in their use of photographs as experimental stimuli. Architectural aesthetic experience arises from the movement through and interaction with a space; it is not limited to visual perception. Future research directions will include replication of the current work in both virtual reality and using real spaces to increase ecological validity and overcome this limitation.

The present work establishes an initial understanding of cognitive processes underlying affective and social responses to the environmental cues of church interiors, as well as presents compelling possibilities for our findings to be extended to evidence-based design.

References

- Baird, J. C., Cassidy, B., & Kurr, J. (1978). Room preference as a function of architectural features and user activities. *Journal of Applied Psychology, 63*(6), 719-727.
- Cicchetti, D. V. (1994). Guidelines, criteria, and rules of thumb for evaluating normed and standardized assessment instruments in psychology. *Psychological Assessment, 6*(4), 284-290.
- Gifford, R., Hine, D. H., Muller-Clemm, W., Reynolds, D. J., & Shaw, K.T. (2000). Decoding modern architecture: A lens model approach for understanding the aesthetic differences of architects and laypersons. *Environment and Behavior, 32*(2), 163-187.
- Hallgren, K. A. (2012). Computing inter-rater reliability for observational data: An overview and tutorial. *Tutorials in Quantitative Methods for Psychology, 8*(1), 23-34.
- Joye, Y., & Verpooten, J. (2013). An exploration of the functions of religious monumental architecture from a Darwinian perspective. *Review of General Psychology, 17*(1), 53-68.
- Kaiser, H. F. (1974). An index of factorial simplicity. *Psychometrika, 39*(1), 31-36
- Kaye, S. M., & Murray, M. A. (1982). Evaluations of an architectural space as a function of variations in furniture arrangement, furniture density, and windows. *Human Factors, 24*(5), 609-618.
- Keltner, D., & Haidt, J. (2003). Approaching awe, a moral, spiritual, and aesthetic emotion. *Cognition and Emotion, 17*(2), 297-314.
- Klapproth, F. (2007). Time perception, estimation paradigm, and temporal relevance. *Perceptual and Motor Skills, 104*, 749-757.

- Kline, R. B. (1998). *Principles and practice of structural equation modeling*. New York: Guilford Press.
- Lucey, P., Cohn, J. F., Kanade, T., Saragih, J., Ambadar, Z., & Matthews, I. (2010). The Extended Cohn-Kande Dataset (CK+): A complete facial expression dataset for action unit and emotion-specified expression. Third IEEE Workshop on CVPR for Human Communicative Behavior Analysis (CVPR4HB 2010).
- McGraw, K. O., & Wong, S. P. (1996). Forming inferences about some intraclass correlation coefficients. *Psychological Methods, 1*(1), 30-46.
- Nasar, J. L. (1983). Adult viewers' preferences in residential scenes: A study of the relationship of environmental attributes to preference. *Environment and Behavior, 15*(5), 589-614.
- Piedmont, R. (1999). Does spirituality represent the sixth factor of personality? Spiritual transcendence and the Five-Factor Model. *Journal of Personality, 67*(6), 985-1013.
- Piff, P. K., Dietze, P., Feinberg, M., Stancato, D. M., & Keltner, D. (2015). Awe, the small self, and prosocial behavior. *Journal of Personality and Social Psychology, 108*(6), 883-899.
- 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*(10), 1130-1136.
- Saroglou, V., Corneille, O., & Van Cappellen, P. (2009). "Speak, lord, your servant is listening": Religious priming activates submissive thoughts and behaviors. *The International Journal for the Psychology of Religion, 19*, 142-154.
- Stamps, A. E. (1991). Public preferences for high rise buildings: Stylistic and demographic. *Perceptual and Motor Skills, 72*(3), 839-844.
- Stamps, A. E. (1994). Formal and non-formal stimulus factors in environmental preference. *Perceptual and Motor Skills, 79*(1), 3-9.

- Stellar, J. E., John-Henderson, N., Anderson, C. L., Gordon, A. M., McNeil, G. D., & Keltner, D. (2015). Positive affect and markers of inflammation: Discrete positive emotions predict lower levels of inflammatory cytokines. *Emotion, 15*(2), 129-133.
- Valdesolo, P., & Graham, J. (2014). Awe, uncertainty, and agency detection. *Psychological Science, 25*(1), 170-178.
- Van Cappellen, P., Saroglou, V., Iweins, C., Piovesana, M., & Fredrickson, B. L. (2013). Self-transcendent positive emotions increase spirituality through basic world assumptions. *Cognition and emotion, 27*(8), 1378-1394.
- Van Cappellen, P., Corneille, O., Cols, S., & Saroglou, V. (2011). Beyond mere compliance to authoritative figures: Religious priming increases conformity to informational influence among submissive people. *The International Journal for the Psychology of Religion, 21*, 97-105.
- Van Cappellen, P., & Saroglou, V. (2012) Awe activates religious and spiritual feelings and behavioral intentions. *Psychology of Religion and Spirituality, 4*(3), 223-236.
- Vartanian, O., Navarrete, G., Chatterjee, A., Fich, L. B., Leder, H., Modroño, C., Nadal, M., Rostrup, N., & Skov, M. (2013). Impact of contour on aesthetic judgments and approach-avoidance decisions in architecture. *Proceedings of the National Academy of Sciences, U.S.A., 110*(Suppl. 2), 10446-10453.
- Wool, R. & Canter, D. (1970). The effect of the meaning of buildings on behaviour. *Applied Ergonomics, 1*(3), 144-150.

Appendix A

Architectural properties of building interiors: Rating scale

Ceiling height: distance from floor to highest part of ceiling

- 1 (9 feet or lower. Reference: standard ceiling height is about 8 or 9 feet)
- 2 (30 feet or lower. Reference: a typical school gym ceiling is 25-30 feet high)
- 3 (50 feet or lower. Reference: Vanderbilt Hall in Grand Central Station is 48 feet high)
- 4 (100 feet or lower. Reference: Notre Dame de Paris has a 125 foot high vaulted ceiling)
- 5 (200 feet or lower. Reference: US capitol rotunda is 180 feet high)
- 6 (400 feet or lower. Reference: the dome in the Florence cathedral is about 300 feet high)
- 7 (higher than 400 feet. Reference: the dome in St. Peter's Basilica is 448 feet high)

Ceiling shape: distance from highest part of wall to highest part of ceiling (does not apply to a tiered ceiling)

- 1 (flat)
- 4 (vaulted)
- 7 (high dome)

Ceiling tiering

- 1 (no tiers)
- 4 (distance from lowest tier to highest part of ceiling is more than 1 ft)
- 7 (distance from lowest tier to highest part of ceiling is more than 5 ft)

Ceiling pitch: degree to which ceiling slopes (does not apply to a domed or vaulted ceiling)

- 1 (level)
- 4 (slightly slanted; 20° or less)
- 7 (slanted; 45°)

Presence of images on ceiling or wall

- 1 (no images)
- 7 (most or all of the space is covered in images)

Symmetry of space

- 1 (no symmetry)
- 7 (space is perfectly symmetrical)

Size of space: approximate square footage

- 1 (under 100 square feet. Reference: a typical single-occupancy bathroom is 40 square feet)
- 2 (under 200 square feet. Reference: a typical bedroom is 150 square feet)
- 3 (under 500 square feet. Reference: a typical living room is 250 - 300 square feet)
- 4 (under 1000 square feet.)
- 5 (under 2000 square feet.)
- 6 (under 5000 square feet. Reference: a typical high school gymnasium is 4200 square feet)
- 7 (5000 or more square feet. Reference: football fields are 29,250 square feet)

Age of building: please indicate the approximate age of the building.

- 1 (brand new - 30 years old)
- 2 (50 years old)
- 3 (100 years old)
- 4 (200 years old)
- 5 (300 years old)
- 6 (400 years or older)
- 7 (500 years or older)

Windows

- 1 (no windows)
- 7 (all windows)

Column ornateness

- 1 (columns are basic and unadorned)
- 7 (columns are very ornate)

Arches

- 1 (no arches)
- 7 (all doorways and windows are arched)

Doorways/openings

- 1 (no doorways)
- 7 (space is open)

Presence of Water

- 1 (no water)
- 7 (space is filled with water/water is extremely prominent)

Religious symbology

- 1 (no religious symbology)
- 7 (religious symbology is extremely prominent)

Ornament: how much decoration or embellishment is in the space?

- 1 (no ornament; everything in the space is purely functional)
- 7 (space is covered in ornament)

Presence of sculpture/art object

- 1 (no sculptures or art objects)
- 7 (space is filled with sculptures and/or art objects)

Contour

- 1 (all edges of building are straight)
- 4 (edges of building are approximately half straight and half curved)
- 7 (all edges of building are curved)

Lighting; extent of natural light

1 (no natural light)

4 (space is partially lit with natural light)

7 (space is filled with natural light)

Repeating element (e.g., tiling or a patterned material)

1 (no repeating elements)

7 (repeating elements are extremely prominent)

Furniture/seating

1 (no furniture or seating)

7 (space is filled with furniture and/or seating)

Use of natural building materials: space is built with natural materials, i.e. wood, clay, stone, bamboo, straw, mud. Man-made materials include: brick, cement, concrete, glass, metal, plastic)

1 (space is made entirely from man-made materials)

4 (space is made from a mixture of man-made and natural materials)

7 (space is made entirely from natural materials)

Self-similarity: degree to which objects in the space are exactly or almost similar to a part of themselves

1 (no objects with self-similarity)

7 (most or all objects in the space possess self-similarity; self-similarity is very prominent)

Appendix B

Emotion Definitions

Afraid, *adjective*:

Filled with fear or apprehension

Anger, *noun*:

A strong feeling of being upset or annoyed because of something wrong or bad : the feeling that makes someone want to hurt other people, to shout, etc. : the feeling of being angry

Awe, *noun*:

An emotion variously combining dread, veneration, and wonder that is inspired by authority or by the sacred or sublime

Boredom, *noun*:

The state of being weary and restless through lack of interest

Calm, *adjective*:

Not angry, upset, excited, etc.

Disgust, *noun*:

Marked aversion aroused by something highly distasteful : repugnance

Excite, *transitive verb*:

To arouse (as a strong emotional response) by appropriate stimuli

Happy, *adjective*:

Enjoying or characterized by well-being and contentment

Sad, *adjective*:

Affected with or expressive of grief or unhappiness : **downcast**

Surprise, *transitive verb*:

To take unawares

All definitions retrieved from *Merriam-Webster online* at <http://www.merriam-webster.com/>

Appendix C

Spirituality Survey

Please rate the extent to which you agree with each statement below.

1. I feel that on a higher level all of us share a common bond

1 ----- 2 ----- 3 ----- 4 ----- 5 ----- 6 ----- 7
not at all *very much*

2. All life is interconnected

1 ----- 2 ----- 3 ----- 4 ----- 5 ----- 6 ----- 7
not at all *very much*

3. There is a higher plane of consciousness or spirituality that binds all people

1 ----- 2 ----- 3 ----- 4 ----- 5 ----- 6 ----- 7
not at all *very much*

4. Although individual people may be difficult, I feel an emotional bond with all of humanity

1 ----- 2 ----- 3 ----- 4 ----- 5 ----- 6 ----- 7
not at all *very much*

5. I believe that there is a larger meaning to life

1 ----- 2 ----- 3 ----- 4 ----- 5 ----- 6 ----- 7
not at all *very much*

6. I believe that death is a doorway to another plane of existence

1 ----- 2 ----- 3 ----- 4 ----- 5 ----- 6 ----- 7
not at all *very much*

7. I believe there is a larger plan to life

1 ----- 2 ----- 3 ----- 4 ----- 5 ----- 6 ----- 7
not at all *very much*

8. There is an order to the universe that transcends human thinking

1 ----- 2 ----- 3 ----- 4 ----- 5 ----- 6 ----- 7
not at all *very much*

9. I believe that on some level my life is intimately tied to all of humankind

1 ----- 2 ----- 3 ----- 4 ----- 5 ----- 6 ----- 7
not at all *very much*

10. Although dead, images of some of my relatives continue to influence my current life

1 ----- 2 ----- 3 ----- 4 ----- 5 ----- 6 ----- 7
not at all *very much*

11. It is important for me to give something back to my community

1 ----- 2 ----- 3 ----- 4 ----- 5 ----- 6 ----- 7
not at all *very much*

12. I am a link in the chain of my family's heritage, a bridge between past and future

1 - - - - - 2 - - - - - 3 - - - - - 4 - - - - - 5 - - - - - 6 - - - - - 7
not at all *very much*

13. I am concerned about those who will come after me in life

1 - - - - - 2 - - - - - 3 - - - - - 4 - - - - - 5 - - - - - 6 - - - - - 7
not at all *very much*

14. I still have strong emotional ties with someone who has died

1 - - - - - 2 - - - - - 3 - - - - - 4 - - - - - 5 - - - - - 6 - - - - - 7
not at all *very much*

15. Although there is good and bad in people, I believe that humanity as a whole is basically good

1 - - - - - 2 - - - - - 3 - - - - - 4 - - - - - 5 - - - - - 6 - - - - - 7
not at all *very much*