A Process for Selecting and Validating Awe-Inducing Audio-Visual Stimuli

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Abstract. Awe is a complex emotion that influences positively individuals' wellbeing both at a physical and at a psychological level. Eliciting awe in a lab setting is a delicate task, and several effective techniques have been developed to pursue this goal, such as audio-video stimuli. Nevertheless, a standardized procedure to select these audio-video awe-inducing stimuli is still needed. Therefore, we validated a methodology to select and discriminate among awe-inducing stimuli. The novelty of the methodology is two-fold: (i) it allows testing whether each content elicited the target emotion, and (ii) it allows to identify the most awe-conductive videos, using both classical statistics and Bayesian analyses. Four videos displaying awe, amusement and neutral contents were shown to participants in a counterbalanced order. This procedure allowed for identifying and validating awe-inducing stimuli that can be pliably used to improve individual's wellbeing and mental health in different contexts.

Keywords: Awe · Wellbeing · Mood-induction · Emotions · Bayesian

1 Introduction

Awe is generally considered as an emotion dwelling on the extremes of fear and pleasure [1]. Therefore, recently, it received the label of "complex", due also the fact that it encompasses opposite trends both in terms of valence and appraisal. In particular, according to Keltner and Haidt [1] feeling of awe can be flavoured both by positive and negative themes (i.e., beauty, virtue, power, threat, uncanny), and it arises from two distinct patterns of appraisal, namely "perceived vastness" and "need for accommodation". In other words, two requirements need to be simultaneously satisfied for a stimulus in order to elicit awe. First, stimuli need to be perceived as vast, both at a physical (e.g., high mountains) and at a conceptual level (e.g., complex mathematical theories). Further, awe elicitors question individual's mental frames, in order to induce a need to accommodate these previous schemas in accordance to new information.

In the psychological field, awe is regarded as one of the main drivers in individuals' life, changing profoundly people's perspective towards world and themselves [2]. More

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pragmatically, this emotion leads to medium and long-time consequences on people' psychological [3, 4] and physical wellbeing [5].

Considering the scientific and practical relevance of this emotion, how to induce awe into experimental setting, is a significant methodological challenge. Most of the available experimental studies agree on using awe-inducing videos based on different kinds of natural phenomena. Nevertheless, two needs emerged from this field. First, the identification of clearer and unambiguous awe-inducing stimuli. Further, a standardized procedure is needed to validate these stimuli, in order to classify them as awe elicitors.

In details, to date, researchers have applied a "discriminant" methodology to select awe inducting stimuli (e.g., [4]). In other words, they asked participants to what extent they felt several discrete emotions including awe, basing only on differences among these emotions (i.e., they carried out simple One-Way ANOVAR or Within ANOVA). Thus, they did not deepen the analysis of the impact of other potential intervenient emotions elicited by the same content. According to literature [6, 7], since awe is a complex emotion encompassing both positive and negative valence, there are some emotions that can be secondary elicited by awe-inducing stimuli, but other that should not be induced by such stimuli. In this regard, multiple comparisons among emotions cannot be enough to identify a pure awe-inducing stimuli, but it is also necessary to consider similarities with emotions elicited by other control conditions, such as neutral stimuli. To address this issue, we introduced a mood induction procedure designed for eliciting awe, or other complex emotions. To reach a higher sense of immersion and isolation, even in a controlled setting, we used a VR device. The main novelty of our contribution is three-fold: (i) the encoding of a standardized mood induction procedure to elicit awe and other complex emotions; (ii) the identification of two new awe-inducing stimuli; (iii) the induction of awe by means of a VR device.

To date, awe has been measured only with respect to other emotions, therefore we included a further emotional content (i.e., "amusement"; intended to elicit an emotion that was commonly used to contrast the effect of awe [6, 8, 9]), and a control condition (i.e., an emotional neutral content was selected to control for effect of other potentially intervenient emotions [6, 10]).

The validity of the proposed methodology was tested according to the following hypotheses/criteria:

1. Stimuli selected to induce awe elicit significant higher level of awe compared to amusement and neutral stimuli.
2. Stimuli selected to induce awe are statistically similar regarding the elicitation of awe.
3. Stimuli selected to induce amusement elicit significant higher level of amusement compared to awe and neutral stimuli.
4. Stimuli selected to induce awe and neutral stimuli elicit a statistically similar level of amusement.
5. Stimuli selected to induce awe and amusement stimuli elicit significantly higher levels of the target emotions compared to other emotions.

2 Methodology

2.1 Sample and Procedure

The study sample comprised 36 adults (18 men and 18 women) volunteers living in the Piedmont and Lombardy regions of Italy. Their mean age was 25,5 (S.D. = 4,1). We chose a within-design in which each participant watched each video once using a head-mounted device. The order of video presentation was counterbalanced for each subject. Participants stood up in an isolated room wearing a Samsung Gear VR, in which each video content was displayed. Each video session was followed by a rest phase, in which participants were invited to fill out a questionnaire concerning several different emotions they could have experienced during video exposure.

2.2 Measures and Instruments

Self-report. The extent to which participants experience several different emotions was assessed using a questionnaire composed of 8 items. In details, participants were required to report the extent (from 1 = not at all; to 7 = extremely) to which they felt each of these emotions: Anger; Awe; Disgust; Fear; Pride; Sadness, Amusement and Joy. This instrument was commonly used to assess awe compared to other emotions [6, 11, 12].

Video. According to guidelines provided by literature [3, 4, 6–9, 11, 13–16], we created ad hoc emotive contents (2 awe-inducing stimuli; 1 amusement-inducing stimulus; 1 neutral stimulus) by using Shotcut video editing tool. Literature suggests that awe elicitors are mainly natural (i.e. usually do not include humans [11]), and they should entail a need to accommodate as well as a perception of vastness. Moreover, awe elicitors encompass both a positive and a negative valence, that is, they can convey both pleasant and unpleasant feelings. In details, since we considered discrete emotions and not general affects, fear and joy (see "self-report" section) can be interpreted as two awe sub-components, reflecting its two poles of valence. In light of these premises, we selected the two awe inducing stimuli. The first awe inducing video (A1) showed scenes of tall trees in a forest. The latter awe-inducing video (A2) was taken from the Nebelhorn Mountain ("Drohnen Flug Übers Nebelhorn"). For each awe-inspiring video we chose the nonvocal "Deep Space Awe Inspiring Music" as a background music. Amusement video (AM) is a combination of different YouTube clip-videos about jokes, and the opening theme of *Benny Hill* Show (namely, the *Yakety Sax* composed by Boots Randolph and James Q. Rich). Finally, neutral video (N) concerned a scene of hens wandering across grass. Video are displayed on a Samsun Galaxy Note 4, using Samsung Gear VR. Each video lasted 2 min.

3 Data Analysis

Kolomogorov-Smirnov test of normality showed that all measures were not normally distributed. Consequently, a Wilcoxon-Signed Rank test was carried out to test for significant differences among conditions. We used the Bonferroni correction for multi-comparison in paired groups, to correct p-value (i.e., p-value should be less than 0.01 to indicate a statistically significantly difference).

Moreover, to statistically grasp awe complexity, we chose to improve the stimuli validation procedure by deepening the analysis of the relationships occurring among awe, its sub-components (i.e., joy and fear as discrete emotions related to awe), and other discrete emotions that should be not related to awe (i.e., disgust, anger, pride; sadness and amusement) across the four conditions (A1, A2; AM; N). We hypothesized that awe inducing stimuli were able to induce a statistically similar level of awe (awe 1 = awe 2 regarding the level of elicited awe), and that awe stimuli and neutral stimuli elicit a statistically similar level of amusement. Moreover, we hypothesized that other emotions, which do not pertain to awe, were significantly similar across the conditions, while other emotions related to awe were not. To test this hypothesis, we carried out the paired sample T-Test Bayes Factor (BF), namely a ratio between the likelihood of the data given null-hypothesis and the one given the alternative one [17–20]. We carried out all analyses using JASP. In this study we chose BF to compare repeated measurements under the hypothesis of similarity among them. The use of BF allowed us to states if a model in which similarity is considered can be better than a model where differences are taken in to account. BF, provided the likelihood ratio of this comparison.

4 Results

Result were presented in relation to the experimental hypotheses.

H1: Awe inducing stimuli induce a significant higher level of awe compared to amusement and neutral stimuli.

A Wilcoxon-Signed Rank test indicated that A1 and A2 induced the highest levels of awe compared to AM (A1 vs. AM: $Z = -4.100$; $p < 0.001$; A2 vs. AM: $Z = -3.999$; $p < 0.001$) and N conditions (A1 vs. N: $Z = -4.840$; $p < 0.001$; A2 vs. N: $Z = -4.861$; $p < 0.001$) (see Table 1 for descriptive statistics). At the same time, AM and N did not induce a significantly different level of awe ($Z = -2.337$; $p = 0.02$). Finally, the Wilcoxon-Signed Rank test indicated also that A1 video did not induce a statistically significantly different level of awe compared to A2 video. We deepened this result by carrying out the paired sample T-Test Bayes Factor (BF).

H2: Awe inducing stimuli are statistically similar regarding the elicitation of awe.

Table 1. The table shows the correspondence between each video content and the respective label employed in this study.

Stimuli	Label	Content
Awe inducing stimulus	A1	Mountain
Awe inducing stimulus	A2	Tall trees
Amusement inducing stimulus	AM	Collection of sketches
Neutral inducing stimulus	N	Hens wandering

To test that both A1 and A2 video elicited a statistically similar level of awe, we computed Bayes Factors to show an evidence for similar levels of awe across the two Awe conditions over the alternative model of differences in these repeated measures. Results showed a substantial effect[1] for the two conditions A1 and A2 ($BF01 = 4.345$; err. $= 1.410e{-8}$). In other words, A1 and A2 elicited statistically significantly similar levels of awe. H0 was not rejected (Fig. 1).

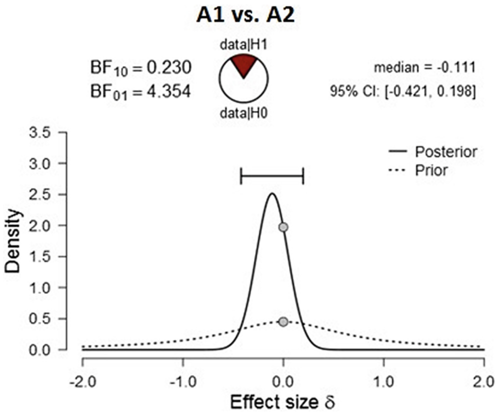

Fig. 1. Bayesian graph of A1 vs. A2 conditions with respect to awe measure.

H3: Amusement stimulus elicited a significant higher level of amusement compared to awe and neutral stimuli.

Wilcoxon-Signed Rank test showed that AM induced the highest level of amusement compared to the A1 video ($Z = -4.879$; $p < 0.001$), to A2 ($Z = -4.914$; $p < 0.001$), and to the Neutral condition ($Z = -5.193$; $p < 0.001$) (see Table 2. for descriptive statistics). AM was statistically significantly higher in AM condition relative to the Neutral ($Z = -3.463$; $p = 0.001$). A1 ($Z = -3.463$; $p = 0.01$) and A2 ($Z = -1.906$; $p = 0.057$) did not induce statistically significantly higher levels of amusement relative to the Neutral condition. As above, this last result was deepened computing the paired sample T-Test Bayes Factor (BF) (Table 3).

H4: Awe stimuli and neutral stimuli elicited a statistically similar level of amusement. In order to test that A1, A2 and Neutral stimuli elicited statistically similar levels of amusement, we calculated Bayes Factors, as we did for testing H2. Again, results showed a substantial effect for the condition A2 ($BF01 = 3.447$; err $= 8.406e{-9}$), but an anecdotal effect for A1 ($BF01 = 1.473$; err. $= 3.288e{-9}$). In other words, A2 did not significantly differ from Neutral regarding the level of

[1] Evidence in favor of the model of interest (similarity of measures) is considered anecdotal (1 < BF < 2.5) or substantial (2.5 < BF < 10). Comparing the relative predictive success of one model on another, if the BF was substantial the two measures were statistically similar relative to the hypothesis that are different. If BF < 1, it can be considered as an evidence supporting the differences instead of similarities.

Table 2. Descriptive statistics. Conditions are ranked according to their mean level of awe.

	A1	A2	AM	N
Valid	36	36	36	36
Missing	0	0	0	0
Mean	4.03	4.25	2.25	1.61
Std. Error of Mean	0.22	0.29	0.26	0.15
Std. Deviation	1.32	1.73	1.56	0.90

Table 3. Descriptive statistics. Conditions are ranked according to their mean level of amusement.

	A1	A2	AM	N
Valid	36	36	36	36
Missing	0	0	0	0
Mean	2.56	2.22	5.22	2.08
Std. Error of Mean	0.24	0.26	0.21	0.23
Std. Deviation	1.42	1.55	1.25	1.40

amusement, whereas A1 did. Indeed, A2 elicited lower levels of amusement compared to the A1 condition (A1 mean = 2.556; S.D. = 1.423; A2 mean = 2.222; S.D. = 1.551) but significantly more similar to the Neutral condition (Fig. 2).

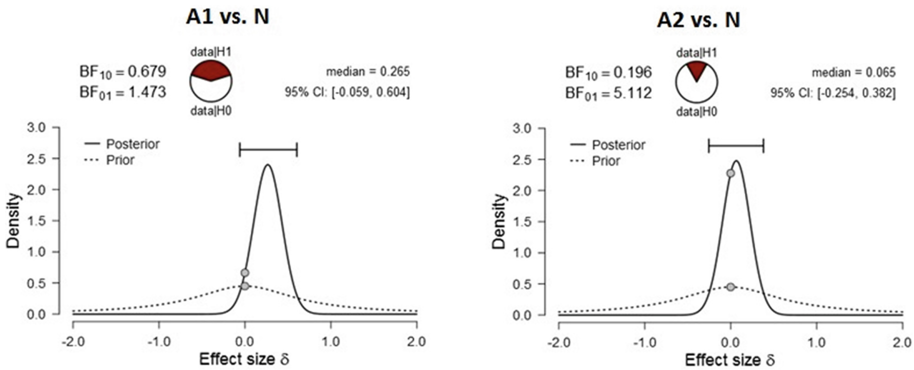

Fig. 2. Bayesian graph of A1 and A2 vs. N conditions considering amusement measure.

H5: Awe and amusement stimuli elicited significantly higher levels of the target emotions compared to other emotions. A Friedman test indicated that there were no differences in anger, pride, or sadness across conditions. Moreover, participants perceived a significantly higher level of disgust only in the Neutral condition compared to the A1 ($Z = -2.648$; $p = 0.008$). A1 and A2 elicited significantly similar levels of fear (BF01 = 4.966; err. = 1.824e−8). Further, A1 and A2 elicited the highest level of fear compared to other conditions. In details, A2 elicited a statistically significantly higher level of fear with respect to AM condition ($Z = -2.626$; $p = 0.009$). Finally, A1 and A2 elicited a significantly similar level of joy (BF01 = 5.294; err. = 2.052e−8). Further, compared to the Neutral stimulus, A1 ($Z = -4.356$; $p < 0.001$), A2 ($Z = -4.116$; $p < 0.001$) and AM elicited a significantly higher level of joy ($Z = -3.492$; $p < 0.001$). However, the levels of these secondary emotions were lower than target emotions for A1, A2 and AM.

5 Discussion and Conclusion

Results showed that the videos selected to induce awe and displayed by means of a VR device elicited significantly higher levels of awe compared to amusement and neutral ones. The same happened for amusement. AM video elicited the highest levels of amusement with respect to the A1, A2 video, and to the Neutral one. More interestingly, videos elicited also other secondary emotions that, however, were pertinent to the essence of awe. For example, fear belongs to the domain of awe, therefore, the fact that A1 and A2 elicited significantly similar high levels of fear is in line with literature. Nevertheless, only A2 video, which depicted scenes of tall trees, induced a level of fear significantly higher compared to AM contrast condition. At the same time, A2 elicited also a significantly higher level of Joy compared to the Neutral control condition. This suggested that A2 video resulted as a perfect interplay between positive (i.e., joy) and negative (i.e., fear) valences. In other words, since awe is a complex emotion encompassing both positive and negative valence, both A1 and A2 stimuli emerged as the closest to this definition, even A2 emerged as slightly better. Other emotions, which were unrelated to awe or amusement, did not significantly vary across conditions. Bayesian analyses combined with classic statistics help us control for every intervenient effect of other emotions, in order to clearly control for each secondary emotion potentially elicited by awe stimuli, and to identify the most awe-conductive stimulus (see Fig. 3 below for a summary of this validation procedure).

In other words, these preliminary data provided a support for the use of this new mood validation procedure, and allowed to identify two new awe-conductive stimuli. Further it provided a preliminary support for the use of video displayed on a VR device to induce awe. Finally, this procedure showed also which of these videos emerged as the most awe-conductive one (i.e., A2 video). This procedure can be implemented in different ways. First, it can be easily reproduced and applied to identify a suitable set of awe-inducing stimuli for several different contexts. This is relevant not only for research purposes, but also in clinical field, for improving individuals' wellbeing, and also for prevention. Indeed, it has been demonstrated that dispositional awe was associated with lower levels of proinflammatory cytokines, involved in the onset and development of several chronic diseases. In details, as regard to the heath context, our procedure allows for structuring ad hoc awe-training to improve physical and mental health, using not invasive, low cost standardized validated stimuli. Moreover, this procedure can be extended also to other complex emotions, such as nostalgia, maybe testing whether it is more effective than traditional mood induction techniques. For example, a 2D videos

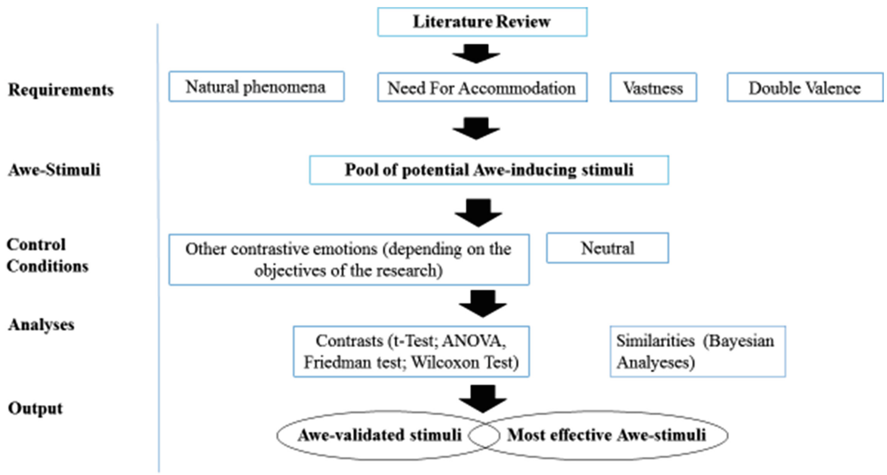

Fig. 3. A diagram illustrating the phases to implement this new methodology for eliciting awe using videos.

showing an awe content on a laptop monitor can be compared to the same video displayed on a head-mounted immersive display. Moreover, it could be useful in deepening the analysis of the relationship between complex emotions and health, by understanding the underlying mechanisms. Indeed, according to Riva [21], new technologies can be involved also in a process of individuals' transformation, mainly in a rehabilitative context, and this study can result as the first step to address this issue empirically. This validation procedure allows to identify suitable stimuli to elicit positive complex emotions able to trigger a transformative change process [2, 22]. For example, these stimuli can support a patient in the entire process of rehabilitation, by promoting an incisive change in his/her lifestyle. Further, this procedure could be implemented by using Virtual Reality, which has already resulted as a suitable and successful methodology of mood induction [23, 24]. Finally, some limitations concern the small sample, thus it could be useful to further analyze these data separately, according to each subgroup. Finally, a possibility to improve this research could be introducing measures of psychological wellbeing [25], and coping strategies [26], as well as assessing the ongoing awe experience, through psychophysiological measures.

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