Virtual-Reality Music-Based Elicitation of Awe: When Silence Is Better Than Thousands Sounds

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Abstract. Several researches have revealed the potential of awe, a complex emotion arising from vast stimuli able to prompt for a restructuration of people' mental schema, on wellbeing and health. Despite a lot has been revealed about awe, researchers still face the challenge of eliciting intense instances of awe in a controlled way. A combination of two or more emotion-induction techniques can enhance the intensity of the resulting emotion. VR has resulted as one of the best techniques to elicit awe, but it has never been tested in combination with other effective awe-inducing methods, such as music. Here, we tested the combined effect of VR and music on the resulting awe's intensity. We randomly assigned 76 healthy participants to one of these four conditions: (i) VR with background sounds (ii) VR and Music, (iii) only Music; (iv) VR without sounds. VR environments and music have been validated in previous studies on awe. Before the exposure to each stimulus, we asked participants to rate the extent to which they *felt* (i.e., experienced) seven emotions. After the exposure, we measured also how much participants *perceived* (i.e., they "read" it into the emotional material) each of the seven emotions, as well as their general affect (Positive and Negative Affective Schedule), their sense of presence (i.e., how much participants felt to be "*present*" within a scene) (ITC-SOPI Inventory), the sense of perceived vastness and need for accommodation associated to the stimulus material (Brief Awe-Scale). We also assessed also participants' disposition to live seven discrete positive emotions (Dispositional Positive Emotions Scale) and musical preferences (STOMP). "VR with Music" condition elicited a higher (even not significant) sense of ecological validity compared to Music condition. All conditions elicited significantly higher sense of felt awe, joy, and fear compared to the baseline and a significantly lower anger after each condition. Participants in the Music condition felt a lowest sense of amusement after the exposure. We found no effect of condition on felt awe. Conversely, perceived awe was significantly higher in the "VR and Music" condition compared to the Music condition. "VR without sounds" condition elicited significantly higher sense of fear compared to Music condition, and significantly lower sense of pride and sadness compared to Music condition. We found no significant effect for any covariate variable. These results have relevant implications for fundamental research on awe and to design awe-based training enhancing wellbeing health, or targeting severe emotional disorders, such as Depression.

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1 Introduction

Emotions are pervasive phenomena shaping most aspects of people life [1–8]. Since William James' seminal work [9], several researchers have dedicated an entire life to define what emotions are and how they are made [10], to understand and predict their impact on our life. At the heart of this question dwells another issue, that is, how to study emotions in a controlled way [11–15]. A wide array of emotion-induction techniques has been developed to address this issue [13–17] and several meta-analytical works [18–20] have been carried out to find out the best technique to use, in order to obtain the most intense emotional impact. However, one aspect emerged. Not all techniques are equally effective in inducing a target mood, affect or emotion [21]. Thus, most research focused on identifying the best technique for a target emotion (e.g., [12]). Far more recent is the research on the best emotion-induction techniques for complex emotions, such as awe [1, 22–27]. Despite awe has been mostly labelled as a "positive" emotion (e.g., [28–30]), recent studies demonstrated that this phenomenon is closer to a mixed, ambiguous state [25–27, 31]. Thus, awe results as an unusual emotion [23]. The uniqueness of awe is reflected also in the way it shapes our life. Awe might be conceived as a sort of "interference" into the quiet flow of life since it can deeply and enduringly change people' perspective towards life, themselves and other people [23, 32, 33]. Awe emerges when we face something much bigger than us (conceptually or visually) that can question us and our accustomed way to process stimuli, or to make predictions [34]. This emotion can expand our perception of time available to live [35], thus decreasing also our level of distress, when we are repeatedly exposed to it [36], and enhancing the satisfaction with our life [37]. Awe makes us more generous [29], prone to help other people [38, 39], less aggressive [40]. Finally, a key point on awe is the effect on the self. Awe leads to a self-diminishment (less attention/importance towards the self), which has been found beneficial for several reasons, above all, recently, for ameliorating depressive symptoms. Tarani [41] showed that awe could decrease the degree of ruminative thoughts on the self and the contingent feeling of hopelessness.

Given all this complexity associated to awe, researchers still struggle to reproduce intense experiences of awe in a controlled setting [22]. Several awe-eliciting techniques have been developed to address these issue but Virtual Reality (VR) resulted among the most effective ones [1, 22, 26, 27]. Virtual Reality can be defined as a 3-D computer generated environment users can also interact with [22]. One key asset provided by VR is resembling even complex phenomena in a controlled setting, thus placing VR nearer reality. Recently, it has been demonstrated that VR and an equivalent scenario in real life do no significantly differ in terms of resulting affective intensity, including awe [42]. However, even in real life, highly intense experiences of awe are extremely rare. Therefore, the question becomes how to enhance the intensity of awe using VR. One solution is provided by the literature on emotion-induction [43]. Combining techniques, which have already resulted effective in eliciting a target emotion, can enhance the intensity of the resulting affect [18, 43]. With this regard, another understudied

awe-inspiring technique is music, which has been tested only in few studies to date [44, 45]. The aim of this study was to test the combined effect of VR and Music for the elicitation of highly intense instances of awe in the lab. We disambiguated the effect of Music and VR alone (without background sounds), as well as VR with music or with background sounds, using pre-validated stimuli. We chose only one excerpt of awe-inspiring music taken from Silvia [44], and a awe-inducing VR environment that has been tested by the Authors in a previous study [27].

Moreover, since the effect of awe-inspiring music resulted mediated by Openness to Experience personality trait [44] as well as by musical preferences [45], we considered also musical preferences [46], Big Five personality traits [47], and the disposition to live positive emotions (Positive Emotion Dispositions) [48], including awe, Finally, the emotion-music link is often questioned since it has been frequently suggested that music can only "mimic" emotions and not make people feel authentic emotional states [49]. Therefore, also in this study, we disentangled this aspect by distinguishing between emotions perceived by participants into the musical material and really felt.

2 Methodology

2.1 Sample and Procedure

The study sample comprised 76 adults (42 women) volunteers from Italy. Their mean age was 23.14 (S.D. = 4.01). We chose a between-design in which each participant was randomly assigned either to one of these conditions: (i) VR with background sounds (ii) VR and Music, (iii) only Music; (iv) VR without sounds.

Upon arrival to the lab, participants signed formed consent, the VR and musical equipment was settled. Each emotional induction lasted 5 min. Before each session, participants were required to rate the extent to which they felt (i.e., really experienced) seven emotions (joy, anger, pride, disgust, sadness, amusement and awe) on a 7-point likert scale (1 = not at all; 7 = extremely). Only after the exposure, we measured also their general contingent Affect (Positive and Negative Affective Schedule, PANAS [50]), how much they perceived (i.e., they "read" this emotion into the emotional material) each of the seven emotions (joy, content, pride, love, amusement, compassion and awe), their sense of presence (i.e., how much participants felt to be "present" within the scene depicted in VR or through music) (ITC-SOPI Inventory [51]), as well as the sense of perceived vastness and need for accommodation associated to the stimulus material (Brief Awe-Scale [26]). Finally, since awe elicitation has resulted modulated by trait variables and music effectiveness depends also on people musical preferences, we assessed also participants disposition to live seven discrete positive emotions (Dispositional Positive Emotions Scale [48]) and musical preferences (STOMP [46]). Participants in the VRE conditions received the same instructions provided by [27] (Fig. 1).

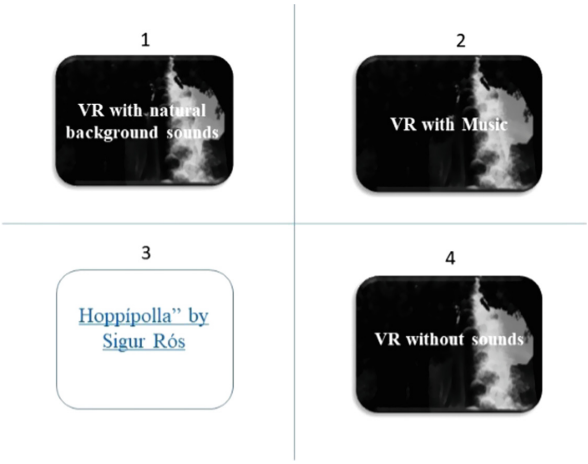

Fig. 1. Research matrix representing the four experimental conditions: 1. VR with natural background sounds; 2. VR with Music; 3. only Music; 4. VR without sounds.

2.2 Measures and Instruments

Self-reported state measures: we measured three main categories of state variables:

(i) Discrete emotions: we assessed the extent to which participants *felt* (i.e., really experienced) vs. *experienced* (i.e., only perceive it into the emotional stimuli) seven distinct emotions (joy, anger, pride, disgust, sadness, amusement and awe) on a 7-point likert scale (1 = not at all; 7 = extremely), as We did in [27].

(ii) General Affect: we adopted the Italian PANAS version [50] that encloses the two main categories of the affective experience. This self-reported instrument is composed of 20 adjectives measuring the positive (PA) (10 adjectives) and the negative (NA) (10 adjectives) dimension of affective experience.

(iii) Sense of presence: we chose the Italian version of the ITC-SOPI Sense of Presence Inventory to rate the extent to which each participant experiences a sense of being "really" present within the emotional stimulus on four dimensions (Engagement, Physical Presence, Ecological Validity, Negative Effects). This self-reported scale is composed of 36-item on a 5-point likert scale (1 = strongly disagree to 5 = strongly disagree).

(vi) Awe sub-dimensions: we assessed awe-related sub-components with a scale that we validated in a previous study, which is called "Brief Awe-scale" [26]. This self-reported instrument is composed of seven items rating the two main dimensions of awe on a 7 point likert scale (1 = not at all; 7 = extremely): perceived vastness (4 items) and need for accommodation (3 items).

Self-reported Dispositional Measures. Besides state measure of affect, emotion and sense of presence, we also assessed:

(i) Disposition to live Positive Emotions: this scale has been developed by Shiota et al. [48] and it is a 38-item instrument on a 7point likert scale (1 = strongly disagree; 7 = strongly agree) to measure the intensity of seven different discrete positive emotions (joy, contentment, pride, love, compassion, amusement), including awe.
(ii) Musical Preferences: this self-reported instrument is a widely used 14-item scale measuring people' preferences for musical genres. It is composed of four scales referring to four general music-preference components: (i) Reflective & Complex; (ii) Intense & Rebellious; (iii) Upbeat & Conventional; (iv) Energetic & Rhythmic.

Stimuli. The selected music was ("Hoppípolla" by Sigur Rós), which has already validated by Silvia [44] and selected in order not to be familiar to our participants.

The VR environment was taken from [27] as the most awe-inspiring scenario.

3 Data Analysis

We carried out nine separated mixed ANOVAs 4 (between condition: VR with natural background sounds; VR with music; Music; VR with no sounds) x 2 (time: pre vs. post exposure) for each of the state discrete *felt* emotions (joy, anger, pride, disgust, sadness, amusement and awe) and affect variables (positive and negative affect). Moreover, we carried out eleven between ANOVAs (between condition: VR with natural background sounds; VR with music; Music; VR with no sounds) for each of the state discrete *perceived* emotions (joy, anger, pride, disgust, sadness, amusement and awe) and dimensions of presence (Engagement, Physical Presence, Ecological Validity, Negative Effects).

4 Results

Results showed no significant differences for positive or negative affect across conditions. We found only a significant effect of time (pre-post exposure) for *felt* anger [$F(1,68) = 9.852$; $p = .003$; $\eta^2_{partial} = .127$], fear [$F(1,68) = 4.223$; $p = .044$; $\eta_{partial}{}^2 = .058$], joy [$F(1,68) = 100.380$; $p < .0001$; $\eta^2_{partial} = .251$ awe [$F(1,68) = 100.380$; $p < .0001$; $\eta^2_{partial} = .596$], which were all significantly increased after the exposure to each condition. We did not find a significant effect of condition on felt awe. Finally, we found a significant interaction effect between time and condition for amusement [$F(3,68) = 3.64$; $p = .017$; $\eta^2_{partial} = .138$]: participants in the Music condition felt a lower sense of amusement (even if not significantly) after the exposure compared to other conditions.

Regarding *perceived* awe, Bonferroni post hoc comparisons showed that only "VR with music" condition [$F(3,68) = 3.129$; $p < .0001$; $\eta^2_{partial} = .121$] induced a significantly higher level of awe compared to the "Music" condition. Moreover, data revealed a significant effect of condition on perceived pride [$F(3,68) = 5.593$; $p < .05$; $\eta^2_{partial} = .198$] (Post hoc with Bonferroni showed that "Music" elicited a significantly higher pride than "VR without sounds" condition), perceived sadness [$F(3,68) = 4.904$; $p < .05$; $\eta^2_{partial} = .178$] (post hoc with Bonferroni showed that "Music" elicited the

Table 1. Descriptive statistics for each state variable in the four conditions before and after emotion induction (M = mean; SD = Standard Deviation)

	Pre-experimental								Post-experimental							
	VR with natural background sounds		VR with music		Music		VR with no sounds		VR with natural background sounds		VR with music		Music		VR with no sounds	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Felt_Anger	2.45	1.572	1.78	1.060	2.22	1.437	1.93	1.385	1.91	1.221	1.61	1.461	1.17	.383	1.29	.469
Felt fear	2.45	1.036	2.11	1.278	2.67	1.572	2.86	1.834	3.18	1.537	2.83	1.505	2.17	1.724	3.71	1.729
Felt joy	3.55	0.522	3.56	1.617	3.61	1.614	3.57	1.651	5.00	1.000	4.72	1.674	5.17	1.689	4.36	1.692
Felt sadness	2.36	1.859	2.17	1.425	2.56	1.886	2.00	0.961	2.27	1.737	2.06	1.731	2.89	1.811	1.79	1.369
felt Pride	3.73	1.348	3.78	1.927	3.67	1.749	3.36	1.447	3.82	1.471	3.61	1.819	4.50	1.790	3.00	1.797
Felt amusement	4.64	1.206	4.00	1.495	4.28	1.274	3.36	1.336	4.18	2.089	4.50	1.823	3.56	1.723	4.79	1.626
Felt awe	3.73	1.421	2.83	1.855	2.67	1.283	3.14	1.460	5.45	1.508	5.56	1.653	4.61	1.819	5.64	1.865
Perceived Anger									2.09	1.640	1.06	.236	1.39	.979	1.14	.363
Perceived fear									4.00	1.342	3.06	1.514	2.17	1.383	3.57	1.869
Perceived joy									4.64	.924	4.67	1.372	5.17	1.383	3.14	1.791
Perceived sadness									2.36	1.206	1.89	1.079	3.56	1.653	1.86	1.406
Perceived pride									3.45	1.508	3.06	1.765	4.28	1.602	1.86	1.610
Perceived amusement									4.18	1.834	4.61	1.754	3.78	1.396	3.43	1.950
Perceived awe									5.91	1.446	5.89	1.811	4.44	1.790	5.43	1.742
Positive affect									2.61	0.32193	2.74	.51930	2.85	.45794	2.81	.43828
Negative affect									2.46	.26934	2.45	.42179	2.60	.38267	2.60	.38122
Physical presence									58.64	6.577	56.94	12.698	57.61	8.311	60.64	13.821
Engagement									48.55	6.251	49.44	8.618	47.00	7.436	50.86	6.993
Ecological validity									17.00	2.530	19.06	3.638	15.50	4.475	18.93	5.903
Negative effect									13.64	4.675	11.94	4.425	10.00	5.099	12.43	4.433
Vastness									17.18	3.99545	19.89	5.37849	16.67	4.08728	19.28	5.97982
Need for accommodation									8.18	2.96034	7.67	3.88057	8.44	3.61731	9.14	5.41873

significantly lowest sadness) and perceived fear [F (3,68) = 2.762; $p < .05$; $\eta^2_{partial} = .109$] (Bonferroni's post hoc revealed no significant differences), and joy [F(3,68) =5.405; p = .002; $\eta^2_{partial} = .193$] (post hoc revealed that "VR without sounds" elicited a significantly lower perceived joy compared to "VR with sounds" and "Music" condition). Pride and Sadness were significantly lower in the "VR without sounds" condition compared to the Musical one, while fear was significantly higher in the "VR without sounds" condition compared to the Music condition.

We did not find any significant differences across condition for the dimension of perceived vastness and need for accommodation, awe sub-components. However, "VR with music" conditions showed the highest level of perceived vastness compared to other conditions, while "VR without sounds" elicited the higher need for accommodation compared to the remaining conditions.

With regard to the sense of presence, we found only an almost significant difference between Music and "VR with Music" in terms of Ecological Validity [F (3) = 2.613; p = .058; $\eta^2_{partial} = .103$] ("VR and Music" condition elicited a higher, but not significant, sense of ecological validity compared to "Music" condition).

To deepen the analysis of perceived and felt awe across conditions, we conducted twenty-one mixed ANCOVAs 4 (between condition: VR with natural background sounds; VR with music; Music; VR with no sounds) x 2 (time: pre vs. post exposure) on *felt* awe, and twenty-one one-way between-measures ANCOVAs 4 (between condition: VR with natural background sounds; VR with music; Music; VR with no sounds) on *perceived* awe. We entered each trait variable as a covariate separately in each model. None of these models resulted significant. For descriptive statistic, please, see Table 1.

Finally, we carried out not parametrical Pearson's correlations between the disposition to live awe and each dimension of musical preferences for each condition separately. We fund only a significant positive correlation between disposition to live awe and preference for "Reflective and complex" dimension of musical preferences (r = .479; p = .033).

5 Discussion and Conclusion

Emotion-induction studies can provide two main guidelines for researchers interested in intensifying specific emotions or affect in the lab: (i) To choose emotion-elicitation techniques that have already proved as effective for the target emotion; (ii) To test a combination or two or more of these techniques to increase the intensity of the resulting emotion. In this study, we advanced this field in two ways. First, we tested these guidelines on a complex ambiguous emotion, that is, awe. Secondly, we provided the first empirical evidence of a joint induction through Virtual Reality and Music in the lab. Our results showed that for complex emotions such as awe, the combination of two or more emotion-elicitation techniques shaped the resulting emotional experience differently in the case of a perceived vs. felt emotion. Specifically, we showed that while inducing higher intensity perceived awe in the lab was a function of a combination between VR and music, this did not occur for felt awe. Curiously, felt awe was not differently affected by none of our variables (both condition and trait variables

considered as covariates). These results are only partially in line with previous findings from [44, 45]. Specifically, Pilgrim et al. [45] showed that preferences for several musical genres interacted with stable personality and cognitive dispositions (e.g., need for cognition) include the subsequent awe experience, for instance, country music was positively and significantly correlated with cognitive closure, which is associated with discomfort with ambiguity and difficulty to adapt to the environment, thus should be negatively related to awe. However, Pilgrim et al. [45] focused on dispositional awe, while, in this study, we initially concentrated on a combination of state and trait awe. therefore, we also carried out several correlations between disposition to live awe and each dimension of musical preferences. Interestingly, we found only a positive linear link with "Reflective and complex" dimension of musical preferences, which includes blues, jazz, classical, and folk music. Also, Pilgrim et al. found that reflective and complex music was associated with greater experienced awe if controlled for need for cognition. Therefore, in future studies, we should also consider the role of personality and cognitive stable factors to explain differences across conditions. Moreover, as suggested by Pilgrim et al., since people experience awe in relation of their preferred music (e.g., [52, 53]), maybe, our selected music did not meet the preferences of participants. Another possible explanation could be that awe can act differently from a "conventional" emotion, thus requiring a higher degree of perceived salience and relevance of music to be elicited. Future studies should manipulate or disambiguate the role of perceived relevance of music in inducing awe. Curiously, while the preference for country music enhanced the resulting perceived awe after the "VR and music" more than the "Music" condition, it was the condition without sounds that was affected more by this musical preference compared to the Musical one. *Sometimes, silence wins against visual and vestibular stimulation* (VR) for eliciting intense awe.

A possible future step to deepen the differences between perceived and felt emotions, could be to use psychophysiological measures during the ongoing emotional experience [54]. Indeed, felt and perceived awe acted differently in this study, showing diverse pattern of results concerning the induction of this emotion in the lab.

All these findings help gain new knowledge about the elicitation of ambiguous emotions, such as awe, in a controlled setting, which is a suitable procedure for designing valid and effective evidence-based trainings or treatment based on these emotions. A crucial implication concerns the use of VR and musical stimuli for the treatment of severe disorders, such as Major Depression, or simply, for the promotion of wellbeing and health of a wide population.

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