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The Emotional Impact of Cultural Heritage on the Public: Physiological and Psychological Effects of Multisensorial Experiences

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ABSTRACT

Non-visual and multisensorial cultural experiences are usually conceived to include the public with visual difficulties but can become an enriching and valuable way to engage all visitors. This study investigated the physiological and psychological responses to a non-visual multisensorial experience of the Chieri Baptistery, sited on the hills of Turin (Italy), through a 3D model of this architectural heritage. To this aim, a sample of 30 participants was blindfolded and randomly assigned to one of three possible cultural experiences involving different sensory modalities: one sense (hearing), two senses (hearing and touch), and three senses (hearing, touch and smell). A wearable wristband was used to collect physiological data, while online surveys were completed to collect responses related to emotional state, evaluation of the cultural experiences and information retention. Overall, multisensorial experiences were associated with a reduction in the arousal level linked with the relaxation state (higher HRV-HF parameter) but also with increased participants' engagement, appreciation of the cultural visit, and information retention. The impacts and results of this study can help improve cultural enjoyment in a plurality of publics and uncover new scenarios that could strengthen the encounter and the inner connection between Cultural Heritage and people.

Keywords: Accessibility, Multisensorial experience, Cultural heritage, Heart rate variability, Emotional state

INTRODUCTION

Accessibility and inclusion are nowadays consolidated concepts in Cultural Heritage management and enhancement. In this regard, attention has long been focused mainly on audiences with disabilities, translating into projects and actions dedicated to specific categories of visitors, rather than solutions that could "be usable by all people, to the greatest extent possible" (UN, 2006).

Today the public is very heterogeneous, and many cultural institutions are already working on finding new ways to engage and reach diverse audiences through more inclusive and integrated solutions. Thanks to a broader approach, designing cultural experiences considers each individual's specificities to create and improve the ways of experiencing cultural heritage and also reach the non-public[1]. Although attitudes that see accessibility as strictly correlated to disabilities are still popular, new approaches are evolving, opening up the possibility of creating quality cultural experiences for all audiences together. Moreover, since Cultural Heritage belongs to every individual (Council of Europe, 2005), it represents an opportunity to apply Design For All principles, considering the variety of publics and non-publics, each with different interests and needs.

To make Cultural Heritage accessible and inclusive, many barriers, not only physical ones, need to be considered. In fact, many people feel uncomfortable in museums and cultural places because they do not have the knowledge or instruments to experience them fully (Dal Pozzolo, 2021). Cultural contents are, indeed, still mainly experienced through a cognitive dimension, even if studies show that the emotional dimension can positively contribute to learning and cultural experiences (Eidelman et al. 2013). Furthermore, previous international studies have already enlightened physiological measures as a reliable indicator of the visitor's body reaction related to the emotional state of the experience (Higuera-Trujillo et al., 2021; Tschacher et al., 2012). Taking into account and studying the visitor's emotional state can contribute to creating new and different ways of enjoying and experiencing Cultural Heritage to ensure an individual and intimate appropriation (Benente et al., 2022).

Use of Senses in Cultural Heritage Experiences

Aware that vision is widely considered the primary sense in communication, the paper presents a study aimed at investigating the role of other senses in cultural experiences. Though non-visual and multisensorial tools, such as 3D tactile models, are usually conceived to include audiences with visual difficulties and children, they can become enriching and valuable ways of approaching Cultural Heritage for all visitors. Replicas and 3D models in cultural places are usually made to give people with visual difficulties an opportunity to access art and culture or to entertain kids during the visit. In the first case, specific routes tailored for blind and partially sighted people have often been created apart from traditional paths to offer 2D and 3D tactile representations[2]. Many curators and directors then realized that these 'special' spaces were not inclusive, since they forced blind people to be separated from their friends and family while visiting museums, while multisensorial approaches can support cultural experiences and make them more attractive to a wider range of visitors (Museo tattile statale Omero, 2006).

Museums are known to be places where touch is usually forbidden, mainly for conservation and safety reasons. However, inclusive design solutions have been increasingly used in museums in the last years to promote cultural access

[1]Terms such as 'non-publics' and 'disaffected public' refer to people who are not interested in and not used to experiencing cultural heritage for various reasons, someone who lives in marginalized conditions, and those who physically cannot reach cultural places.

[2]For example, the *Petite Galerie* at the Louvre Museum in Paris, opened in 2008 and then closed for renovation.

Figure 1: Multisensorial stations and 3D models integrated into museum exhibits to allow people to touch replicas (on the left) and to discover further information about the theme presented (on the right).

for all, through different senses (Figure 1). For example, Tactile Studio is an inclusive design agency that creates educational solutions for cultural places enhanced by sensory experiences such as touch, sound, and smell[3]. They promote new forms of engagement in arts and culture, with models and solutions made to be more integrated into the traditional routes and available and usable by everyone. Through multisensorial experiences, such as storytelling, tactile explorations, immersive visits, etc., people can discover new and different forms of encountering, enjoying, and appreciating Cultural Heritage. Furthermore, physiological and psychological studies can support in understanding and enhancing its emotional impact. In this regard, the study aims to investigate arousal changes related to the emotional activation of an adequate sample of participants during a cultural experience through different senses, except for vision.

METHOD

Participants

Authors recruited thirty healthy volunteers (17 females and 13 males; mean age 29, 77 $\pm$ 9, 55) to participate in the study. For each participant, demographic data were gathered. The experimental protocol was reviewed and approved by the Ethics Committees of the University of Turin (Italy). All participants signed the informed consent.

Experimental Conditions

Participants were randomly assigned to one of three experimental conditions (Figure 2): audio (A), audio-tactile (AT) and audio-tactile-olfactory (ATO) conditions. In all three conditions participants were blindfolded and wore noise-canceling headphones. In condition A, participants listened to an audioguide on the history and architecture of the Chieri Baptistery. In the AT and ATO conditions, information to guide the tactile exploration of the 3D model was added to the audioguide (for example, "Move your hands towards until you reach the stairs of the main entrance"). Furthermore, in the

[3] https://tactilestudio.co/

Figure 2: Experimental conditions: audio condition (A condition); audio-tactile condition (AT condition); audio-tactile-olfactory condition (ATO condition).

ATO condition, when the narrative voice mentioned the word "incense", an essence diffusion system was employed to dispense an incense fragrance for 30 seconds.

Physiological Parameters

Heart rate (HR) and heart rate variability (HRV), which are considered two of the most validated indicators for stress response, were measured continuously during the experimental procedure through an E4 Empatica wristband. Authors calculated frequency-domain HRV indicators: high frequency (HF) and low frequency (LF). HF was used as an index of the parasympathetic nervous system (PNS) activity, while LF as an index of sympathetic nervous system (SNS) activity.

Emotional State

To assess the participants' emotional state before and after the experimental condition, eight items of the circumplex model of affect were used. This model includes different emotional states ranging from positive to negative, and from high arousal to low arousal emotions. In the survey, participants had to answer questions like "To what extent do you feel this way right now, that is, at the present moment?" using a 5-point Likert scale ranging from "1 (not at all)" to "5 (extremely).

Experience Evaluation

Similarly, four adjectives were used for the experience evaluation section of the survey (engaging, boring, pleasant, exhausting), always using a 5-point Likert scale from "1 (not at all)" to "5 (extremely)". In addition, a question about the pleasantness of the incense fragrance was added only to the online survey administered after the ATO condition.

Information Retention

To comprehend the impact of the three experimental conditions (A, AT, ATO) on the retention of information provided during narration, participants answered three questions about some architectural features of Chieri Baptistery (floorplan typology, its position relative to the Cathedral, *tiburium* shape) and a question about the use of incense.

Experimental Procedure

At the beginning of the experiment, participants were introduced to the experimental procedure and asked to read and sign the informed consent. After completing the first online survey, they wore the E4 Empatica wristband to collect physiological parameters and were asked to put on a blindfold and headphones. Then, they took a 5-min rest during which their baseline physiological status was recorded. Afterward, participants were randomly assigned to one of the previously described experimental conditions.

In the end, they removed the blindfold and headphones and completed the last (second) survey. The experiment lasted approximately 30 minutes. (See Figure 3 for the timeline).

Statistical Analyses

Statistical analyses were performed with the software SPSS (IBM, version 26.0). For physiological measures (HR and HRV), a Python code was programmed to calculate for both rest and experimental conditions the mean HR and the HRV frequency domain parameters (LF; HF), also using the *pyhrv* Python package (Gomes et al., 2019). Furthermore, to compare physiological data across experimental conditions, the differences between experimental and rest conditions for all parameters were used as outcome measures. The same approach was also applied for emotional state responses resulting from surveys, with the difference in scores between the second and the first survey used as outcome measure.

At first, two participants from HR analysis (one from AT and one from ATO conditions), and three more participants from HRV analysis (one from each condition) were excluded from the analyses due to Z-point scores that exceeded 2.8 standard deviations. On the contrary, no outliers were found in the survey scores.

In the second place, to analyze the difference between the three conditions in physiological and psychological data the non-parametric Kruskal-Wallis H test was used followed by pairwise comparisons. Lastly, Bonferroni correction was applied as post-hoc analysis.

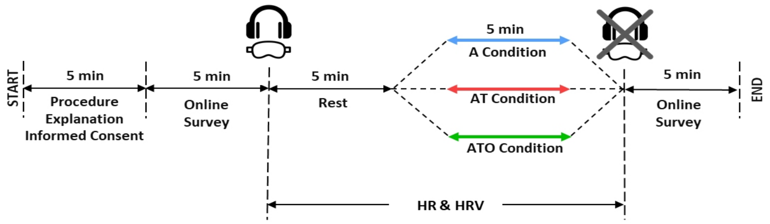

Figure 3: Timeline of the experimental procedure. Notes: A condition: audio condition; AT condition: audio-tactile condition; ATO condition: audio-tactile-olfactory condition; HR: heart rate; HRV: heart rate variability.

RESULTS

Physiological Measures

Regarding HR and HRV-LF measures, the Kruskal Wallis (H) test did not reveal significant differences between conditions, while a significant difference between conditions was found in HRV-HF parameter ($p = 0.001$). Pairwise comparisons indicated that HF was significantly higher in AT and ATO conditions in comparison with A condition ($p < 0.001$ and $p = 0.022$ respectively), while no effects were found when comparing AT with ATO ($p = 0.221$). Post-hoc test using the Bonferroni correction confirmed the significant difference only for A-AT comparison ($p = 0.001$) as shown in Figure 4 and Table 1.

Emotional State

Concerning emotional state, the Kruskal Wallis (H) test revealed significant differences between conditions in the "agitated" ($p = 0.02$) and "dull"

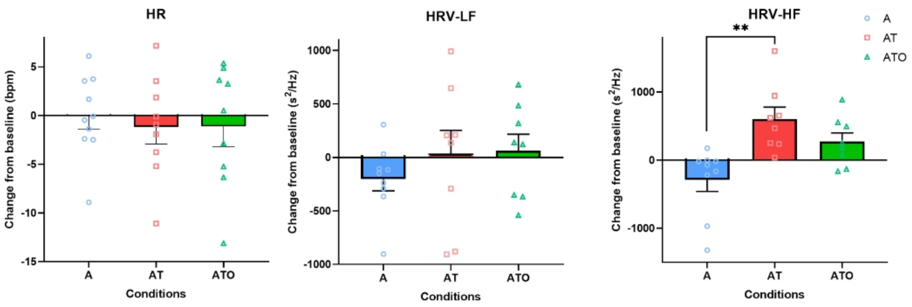

Figure 4: Physiological data analysis. Notes: A: audio; AT: audio-tactile; ATO: audio-tactile-olfactory; HR: heart rate; HRV: heart rate variability; LF: low frequency; HF: high frequency. ** = $p < 0.01$, generated by Bonferroni correction. Error bars depict the standard error of the mean (SEM).

Table 1. P-values resulting from statistical analyses conducted on the physiological data.

	PHYSIOLOGICAL DATA		
Conditions	HR	HRV-HF	HRV-LF
		H Kruskal-Wallis (p)	
A-AT-ATO	0.566	**0.001**	0.493
		Pairwise comparison (p)	
A-AT	-	**0**	-
AT-ATO	-	0.221	-
A-ATO	-	**0.022**	-
		Bonferroni correction (p)	
A-AT	-	**0.001**	-
AT-ATO	-	0.664	-
A-ATO	-	0.067	-

(p = 0.021) adjectives. Pairwise comparisons indicated that AT condition generated significantly less dullness (p = 0.046), while ATO condition generated significantly less agitation and dullness (p = 0.005 and p = 0.007 respectively) compared to A condition. Both adjectives were still significantly different in the ATO condition in respect to the A condition after Bonferroni correction as post-hoc analysis (p = 0.015 and p = 0.022 respectively), as shown in Figure 5 and Table 2.

Experience Evaluation

Regarding experience evaluation, the Kruskal Wallis (H) test found significant differences between conditions in “enjoyable”, “engaging”, and “boring” adjectives (p = 0.03, p = 0.004, and p = 0.015 respectively), while no differences were found in the “exhausting” adjective (p = 0.612). Pairwise comparisons indicated that AT condition was considered significantly more enjoyable (p = 0.01), while both AT and ATO conditions were considered significantly more engaging (p = 0.002 and p = 0.016 respectively) and significantly less boring (p = 0.006 and p = 0.028 respectively) than A condition. All comparisons were still significantly different after Bonferroni correction as post-hoc analysis, with the exception of the adjective “boring” in the A-ATO comparison (see Table 3 and Figure 6A).

Information Retention

Regarding information retention data, Authors calculated the percentage of right answers to the four questions about the architecture of Chieri Baptistery and the use of incense. Results showed that participants assigned to all conditions answered correctly when asked about the floorplan typology of the

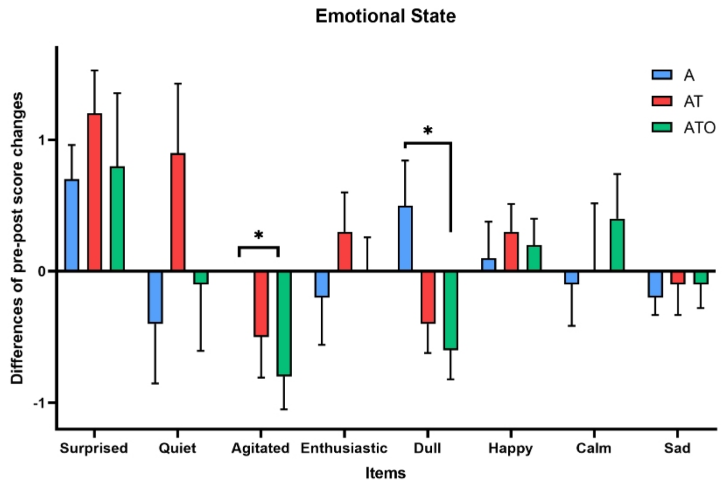

Figure 5: Emotional state data analysis. Notes: A: audio; AT: audio-tactile; ATO: audio-tactile-olfactory. * = p < 0.05, generated by Bonferroni correction. Error bars depict the standard error of the mean (SEM).

Table 2. P-values resulting from statistical analyses conducted on the emotional state data.

	EMOTIONAL STATE DATA			
Conditions	Enthusiastic	Calm	Happy	Sad
	H Kruskal-Wallis (p)			
A-AT-ATO	0.673	0.674	0.893	0.722
	Pairwise comparison (p)			
A-AT	-	-	-	-
AT-ATO	-	-	-	-
A-ATO	-	-	-	-
	Bonferroni correction (p)			
A-AT	-	-	-	-
AT-ATO	-	-	-	-
A-ATO	-	-	-	-
	Surprised	Quiet	Agitated	Dull
	H Kruskal-Wallis (p)			
A-AT-ATO	0.528	0.304	**0.02**	**0.021**
	Pairwise comparison (p)			
A-AT	-	-	0.147	**0.046**
AT-ATO	-	-	0.175	0.497
A-ATO	-	-	**0.005**	**0.007**
	Bonferroni correction (p)			
A-AT	-	-	0.441	0.138
AT-ATO	-	-	0.526	1
A-ATO	-	-	**0.015**	**0.022**

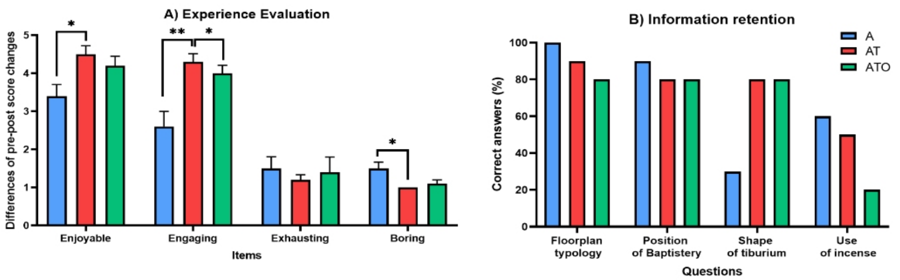

Figure 6: A) Experience evaluation data analysis. * = p < 0.05, ** = p < 0.01, generated by Bonferroni correction. Error bars depict the standard error of the mean (SEM). B) Information retention data analysis. Notes: A: audio; AT: audio-tactile; ATO: audio-tactile-olfactory.

Baptistery and its position relative to the Cathedral. Interestingly, participants assigned to the conditions involving tactile exploration (AT or ATO) greatly improved in the number of correct answers related to the *tiburium* shape in relation to those that underwent the audio-only condition. On the contrary, the question about the use of incense showed an inverse trend with ATO condition participants, reporting a greater number of wrong answers compared to both A and AT conditions participants (see Figure 6B).

Table 3. P-values resulting from statistical analyses conducted on the experience evaluation data.

	EXPERIENCE EVALUATION DATA			
Conditions	Enjoyable	Engaging	Exhausting	Boring
		H Kruskal-Wallis (p)		
A-AT-ATO	**0.03**	**0.004**	0.612	**0.015**
		Pairwise comparison (p)		
A-AT	**0.01**	**0.002**	-	**0.006**
AT-ATO	0.443	0.457	-	0.583
A-ATO	0.069	**0.016**	-	**0.028**
		Bonferroni correction (p)		
A-AT	**0.029**	**0.005**	-	**0.018**
AT-ATO	1	1	-	1
A-ATO	0.208	**0.047**	-	0.084

DISCUSSION AND CONCLUSION

The study investigated the physiological and emotional responses of 30 healthy participants to a non-visual multisensorial experience of a 3D replica of the Chieri Baptistery.

Data analysis revealed significant differences only between participants in A-AT and A-ATO comparisons, indicating the positive impact of multisensorial experiences on both physiological and psychological levels.

In particular, our results show that implementing tactile exploration of a 3D model while listening to an audioguide resulted in higher PNS activity (connected with relaxation), but also higher engagement, enjoyment, and lower boredom.

On the other hand, adding an odor essence during a multisensorial experience did not influence the physiological level. However, the trisensory condition positively affected participants' psychological responses, with reports of less agitation and dullness, and higher engagement. Indeed, previous studies have already demonstrated that multisensorial experiences are associated with positive physiological and psychological effects (Schebella et al., 2020).

Regarding information retention, it seems that adding a tactile exploration congruent to auditory information is useful in enhancing the retention of that information. This result is in line with studies that observe not only that hearing perception is also modulated by somatosensation (Wu et al., 2015), but also that different sensory modalities (auditory, kinaesthetic) play a role in the storage of tactile information (Gallace & Spence, 2009). On the contrary, adding an essence that is congruent to the actual topic of the narration leads to worse information retention. This result contrasts with other studies that implemented odors in multisensorial experiences. Indeed, they found that the presence of constant odors in the environment is not detrimental for engagement and involvement (Ranasinghe et al., 2020), and furthermore increases both concentration and learning performances (Bordegoni et al., 2017). Authors speculate that presenting an odor essence in the middle of an experience could have been a source of distraction due to the novelty of the stimulus.

In general, results seem to confirm the first hypothesis: multisensorial experiences can lead to reduced arousal level, higher engagement, appreciation of the visit, and information retention. The role of different senses should be recognized and included in the design project of cultural experiences. Simply adding multisensorial devices along the visit path is insufficient. It is crucial to integrate them into the museum or cultural space's proposed narrative, in order to achieve an emotional and intimate appreciation of Cultural Heritage, enriching one's perception, knowledge and memory.

Limitations and Future Directions

This study has limitations that must be considered, such as the small sample size of all three conditions and the noise made by the essence diffuser during its activation. To further substantiate the multisensorial experience effect, future research should replicate this study using different odors, for different time periods or as a constant environmental fragrance. It would also be interesting to replicate the same experiment with participants with visual difficulties to investigate differences between sighted and blind people in the physiological and psychological responses to multisensorial experiences.

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