



Not just seeing, but also feeling art: Mid-air haptic experiences integrated in a multisensory art exhibition



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ABSTRACT

The use of the senses of vision and audition as interactive means has dominated the field of Human-Computer Interaction (HCI) for decades, even though nature has provided us with many more senses for perceiving and interacting with the world around us. That said, it has become attractive for HCI researchers and designers to harness touch, taste, and smell in interactive tasks and experience design. In this paper, we present research and design insights gained throughout an interdisciplinary collaboration on a six-week multisensory display – Tate Sensorium – exhibited at the Tate Britain art gallery in London, UK. This is a unique and first time case study on how to design art experiences whilst considering all the senses (i.e., vision, sound, touch, smell, and taste), in particular touch, which we exploited by capitalizing on a novel haptic technology, namely, mid-air haptics. We first describe the overall set up of Tate Sensorium and then move on to describing in detail the design process of the mid-air haptic feedback and its integration with sound for the *Full Stop* painting by John Latham (1961). This was the first time that mid-air haptic technology was used in a museum context over a prolonged period of time and integrated with sound to enhance the experience of visual art. As part of an interdisciplinary team of curators, sensory designers, sound artists, we selected a total of three variations of the mid-air haptic experience (i.e., haptic patterns), which were alternated at dedicated times throughout the six-week exhibition. We collected questionnaire-based feedback from 2500 visitors and conducted 50 interviews to gain quantitative and qualitative insights on visitors' experiences and emotional reactions. Whilst the questionnaire results are generally very positive with only a small variation of the visitors' arousal ratings across the three tactile experiences designed for the *Full Stop* painting, the interview data shed light on the differences in the visitors' subjective experiences. Our findings suggest multisensory designers and art curators can ensure a balance between surprising experiences versus the possibility of free exploration for visitors. In addition, participants expressed that experiencing art with the combination of mid-air haptic and sound was immersive and provided an up-lifting experience of touching without touch. We are convinced that the insights gained from this large-scale and real-world field exploration of multisensory experience design exploiting a new and emerging technology provide a solid starting point for the HCI community, creative industries, and art curators to think beyond conventional art experiences. Specifically, our work demonstrates how novel mid-air technology can make art more emotionally engaging and stimulating, especially abstract art that is often open to interpretation.

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1. Introduction

Humans are equipped with multiple senses to perceive and interact with their environment. However, in HCI, vision and hearing have been the dominant senses, and our sense of touch, taste, and smell have often been described as secondary, as the lower senses (Spence, 2011). HCI researchers and practitioners are however increasingly fascinated by the opportunities that touch, smell, and taste can offer to enrich HCI. Re-

cent examples of such experiences include the novel olfactory display by Seah et al. (2014), taste-based gaming by Murer et al. (2013), olfactory in-car interaction by Dmitrenko et al. (2016), digital flavour experiences by Ranasinghe et al. (2014), and the added value of haptic feedback for audio-visual content by Maggioni et al. (2017). In particular, there has been a growing interest in uncovering the specificities of haptic experience design (Schneider et al., 2017) and the unique features of haptic

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stimulation that would allow the creation of emotionally engaging and meaningful experiences (Gatti et al., 2013; Seifi and MacLean, 2017).

With the advent of novel touchless technologies that enable the creation of tactile stimuli without physical contact (e.g., (Carter et al., 2013; Hamada et al., 2014; Hoshi et al., 2010; Long et al., 2014; Sodhi et al., 2013), a novel design space for tactile experiences has been opening up (Obrist et al., 2013). Most notably, it has been demonstrated that mid-air haptic stimulation can be used to convey emotions to the user (Obrist et al., 2015). This research has motivated further investigations of the design possibilities for creating novel mid-air haptics experiences (Ablart et al., 2017). Here we extend the use of mid-air haptics stimulation in the context of a museum, moving beyond a controlled laboratory environment to investigate the effect of multisensory stimulation on users' experience of art.

Museums and art galleries have always been in the forefront of integrating and stimulating multiple human senses, not only to explore new ways of representing arts, but also to increase the wider public interest in the artifacts being displayed. Harvey et al. (1998) showed that the use of touch specimens, sounds, and smells to complement the object along with interactive components (e.g., role playing induction device) and dynamic displays can have a strong influence on visitors' experiences, especially creating a strong sense of flow – being fully immersed and focused in a task (Csikszentmihalyi, 1997). Another intriguing work that relates to multisensory museum experiences is the Jorvik Viking Centre (Jorvik, 2017), where multisensory stimuli were used to enrich the experience of a tour concerning the Viking past of the city of York. This experience allowed visitors to touch historical objects (Viking Age artefacts), taste the unsalted, dried cod of the Viking diet, smell the aroma of the corresponding displayed objects, see the animals and inhabitants of the Viking city, and listen to the Viking sagas. More focused on the sense of touch, Loscos et al. (2004) presented how visitors could see and feel virtual 3D artworks (e.g., statues) using a haptic device that was connected to the user's right index finger to provide haptic feedback. This use of technology enabled users to touch and feel the contours and stiffness of the artwork.

Despite the increasing interest in the different senses as interaction modalities in HCI and related disciplines and professions (e.g., art curators, sensory designers), there is only a limited understanding of how to systematically design multisensory art experiences that are emotionally stimulating. Moreover, there also seems to be a lack of understanding on how to integrate different sensory stimuli in a meaningful way to enrich user experiences with technology (Velasco et al., 2016), including art pieces. Carbon (2017) replicated the work of Smith and Smith (2001) and pointed out the mismatches in the amount of time and space people spent in viewing artworks in a laboratory versus a museum context. Specifically, museum visitors had longer viewing time than was mostly realized in lab contexts, as well as longer viewing time when attending in groups of people. Additionally, this work uncovered a positive correlation between size of artwork and the viewing distance. These findings emphasize the fact that there is a need to carry out museum related investigations in the actual environment of a museum. Only through an in-situ approach, the intended users who have an intuitive interest and knowledge about art environments, are reached and can provide valuable feedback on the multisensory design and integration efforts.

Building on these prior works, in this paper, we present research and design efforts carried out as part of a six-week multisensory art display – Tate Sensorium – in an actual museum environment (i.e., Tate Britain art gallery). For the first time, mid-air haptic technology was used in a museum context to enhance the experience of a painting (i.e., the *Full Stop* by John Latham) through its integration with sound. The multisensory integration of touch and sound aimed to aid the communication of emotions and meaning hidden in the painting: *a large circular black spot in the approximate centre of an unprimed canvas* (see Fig. 2b).

In collaboration with a creative team of art curators and sensory designers, the specific experience for the *Full Stop* painting was created.

A total of three variations of the experience were created, keeping the sound the same but changing the mid-air haptic pattern to investigate the effect of the sense of touch on the visitors' art experience (see illustrated in Fig. 6 and described in Section 3.3). We hypothesized that museum visitors would enjoy more experience involving the pattern specifically designed for Tate Sensorium (Tate pattern, the most sophisticated and purposeful designed experience), followed by the experience involving the Circle pattern (congruent with the visual appearance of the painting) and finally the Line pattern (incongruent with the visual appearance of the painting). Visitors' experiences were assessed through a short questionnaire at the end of the Tate Sensorium experience and through interviews to deepen our understanding on the subjective differences of sensory enhanced art experiences.

In the following sections, we first provide a review of related work on multisensory research and design in museums, followed by a general overview on the multisensory art display – Tate Sensorium in the Tate Britain art gallery. We include the description of the exhibited art pieces and sensory design space. We then focus on the work around the *Full Stop* painting and the design and development of the mid-air haptic patterns as part of the specific touch-sound integration. We provide a detailed description of the data collection process and the insights from the analysis of 2500 questionnaires and 50 interviews. We conclude with a discussion of our findings with respect to the lessons learnt, limitations and future opportunities for designing multisensory experiences outside the boundary of a laboratory environment.

2. Related work

Museums are public places that contain a collection of artifacts that hold values in artistic, historical, and cultural contexts (Alexander et al., 2008). Importantly, museums offer “a multi-layered journey that is proprioceptive, sensory, intellectual, aesthetic and social” (Levent and Pascual-Leone, 2014). Given the experiential aspect of museums, they (and exhibitors) have always been looking for new ways to diversify and enrich the experiences that they deliver to the visitors. Therefore, there have been examples and efforts of enhancing art objects through sensory stimuli to engage visitors and convey meaning.

2.1. Multisensory interaction in the museum

Museums are a forerunner in harnessing new ways of interacting with public users. Therefore, they are recognized within the field of HCI as relevant places for designing interactive systems to reach out to the public. An example is *Transcending Boundaries* (PACE, 2017), an exhibition that explored the transcend between physical and conceptual boundaries (e.g., elements from one work can fluidly interact with and influence elements of the other works exhibited in the same space) via visual, auditory, and tactile interactions. In addition, there are various cases in which the integration of multiple senses has been explored in museums. For example, Lai (2015) explored the “Universal Scent Black-box”, an artwork composed of boxes emitting five smells: grass, baby powder, whiskey tobacco, dark chocolate, and leather. Visitors to the installation could trigger an odour emission in another area for other visitors and vice-versa. This olfactory interaction attracted much interest from the visitors and became an inspirational probe for exploring olfactory interfaces for communication. Based on those prior explorations, it has been suggested that multisensory design in a museum may enhance the richness, and even the memorability, of the visitor's experience (Eardley et al., 2016; Lehmann and Murray, 2005), due to the emphasis on the multisensory nature of our everyday life experiences. Work by Teramoto et al. (2012) has shown that auditory and visual modalities mutually influence each other during motion processing of external events so that the brain obtains the best estimates of such events (Teramoto et al., 2012). Within HCI, we can additionally observe various efforts of integrating interactive technologies (e.g., touch screens,

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