Grasping Cultural Context through Multisensory Interactions

Jamie Kwan
Ryerson University
Toronto, ON, Canada
jamie.kwan@ryerson.ca

Jean Ho Chu
Georgia Tech
Atlanta, GA, USA
jchu35@gatech.edu

Daniel Harley
Ryerson University
Toronto, ON, Canada
dharley@ryerson.ca

Melanie McBride
York University
Toronto, ON, Canada
mcbride.melanie@gmail.com

Ali Mazalek
Ryerson University,
Toronto, ON, Canada
Georgia Tech
Atlanta, GA, USA
mazalek@ryerson.ca

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Abstract
This paper describes the research and design of three tangible and embodied prototypes that aim to enable users to meaningfully engage with an artifact's historical context and use. Together, these prototypes engage users in a cultural heritage experience that is sensorially embodied through a 'multimodal' ensemble of visual, aural, tactile, and olfactory interactions. A preliminary user test suggests that future work on multisensory interaction should focus on developing accessible design principles and considerations that support a sensorially embodied and tangible understanding of historical artifacts. We suggest that multisensory interactions present significant opportunities for interactive exhibits to expand our access to cultural history and its artifacts.

Author Keywords
Multisensory interaction; sensory; senses; smell; tangible and embodied interfaces; cultural artifacts; experience design; interactive museum.

ACM Classification Keywords
H.5.1. [Information Interfaces and Presentation]: Multimedia Information Systems – Animations; H.5.2 [Information Interfaces and Presentation (e.g., HCI)]: User Interfaces – Haptic i/o, Input Devices and Strategies; Interaction styles, theory and methods; K.3.0 [Computers and Education]: General.

Figure 1. The exterior (top) and the interior (bottom) of a 16th century prayer-nut (Image courtesy of the Metropolitan Museum of Art)

Introduction

This paper presents the first iteration of three multisensory prototypes centered on the history and use of Western European boxwood prayer-nuts, dating from the early 16th century (see Figure 1). Prayer-nuts feature many unique sensory properties that were integral to their meaning and use as a tangible and portable object. Unfortunately, like many other cultural history artifacts, these delicate objects require a glass case to ensure their conservation. Our goal is to enhance an artifact's presentation in museum spaces by meaningfully linking tangible and embodied interactions to the historical multisensory use of the artifact. We draw inspiration from historical texts, and invite visitors to use their sensory faculties to develop a personal connection with the artifact. Together, our interactions create an experience that is embodied, visual, aural, tactile, and olfactory, without compromising conservation efforts. We describe our design process, implementation, a preliminary user test, and future work.

Related Work

Sensory Interactions in Museums

Museums and public installations are increasingly incorporating digitally-enhanced interactive experiences that ostensibly provide visitors with a 'multimodal' [7] engagement with the past. We briefly review exhibits that incorporate similar sensory aspects to those that we include in our prototypes. However, in many cases these exhibits are not explicitly multisensory, but rather designed as mono- or duo-sensory experiences.

Augmented reality (AR) technologies, such as ScopifyROM at the Royal Ontario Museum [10] or Jurascope at the Natural History Museum in Berlin [2], use iPads or smartphones to overlay visual or textual content onto artifacts and museum collections to enhance visual engagement and provide additional historical and cultural information.

Permanent olfactory exhibits are uncommon in cultural history museums, with rare exceptions like the International Perfume Museum in Grasse [8]. Temporary olfactory exhibits typically present scent as a discrete sensory interaction, downplaying the other senses [e.g. 13]. Installations by scent artists such as Sissel Tolaas use scent as a means of challenging visitors' preconceived notions of smell, in some cases highlighting the subjectivity of visitor's olfactory perceptions [1].

Tangible interaction technologies have been developed in museums for a wide variety of subjects, particularly STEM. For example, the kinesthetic, tactile qualities of the digitally-enhanced puzzle blocks designed by Horn et al. for the Boston Museum of Science were said to help children understand programming concepts [6] through a multimodal design.

Technical Augmentation of Cultural Heritage

There is also a growing body of tangible interaction technologies that specifically engage with cultural practices. StoryBeads is a tangible record and playback device that aims to preserve the cultural heritage of the South African BaNtwane tribe through oral storytelling [9]. Because the traditional practice of using the beads as a means to share stories across generations is diminishing, the authors present a system that is simple to use and that can dynamically evolve over time.

Figure 2. "Visual Voyage" interactions (top) and the highlighted scenes (bottom)

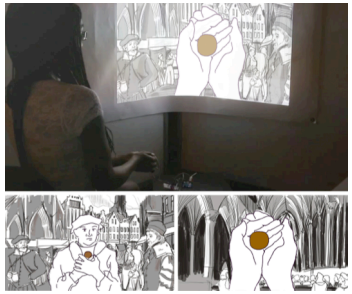

Figure 3. "Experiencing Spirituality" interaction (top) and projected animations (bottom)

In Mapping Place, museum visitors make and share stories of their family or neighborhood by using a multi-touch tabletop, connecting virtual story beads to tangible story shells [3]. The interactive experience aims to support an understanding of the mnemonic and symbolic meaning-making processes and mapping practices of the Lukasa, an artifact belonging to the Luba peoples of Central Africa.

Our Design

Project Goal

The goal of this preliminary phase of our project is to investigate multisensory interactions that are grounded meaningfully *vis-a-vis* historically and socioculturally 'situated' sensory properties of an artifact. We chose the prayer-nut for its rich multisensory dimensionality, with the goal of informing the design of similar cultural heritage experiences by the findings from this use case. Our approaches seek to: (1) situate the viewer within a first-person perspective; (2) link user actions to historical practices; (3) provide multiple sensory access points.

Interaction cues and feedback are provided to inform and clarify necessary actions.

Multisensory Prayer-nuts

Created in the Low Countries in the 16th century, prayer-nuts are intricately carved devotional objects that were symbols of wealth and piety [5, 11]. Falkenburg [5] describes this as a time in which laypeople developed personal religious experiences, which included a "dependence of spirituality on material objects."

We created three 3D-printed tangible objects similar in size to the original prayer-nuts, embedded with sensors to detect the visitor's interactions. The visitor uses their senses to interpret historical practices, guided by text, visual, and/or aural cues. The interactions are mapped meaningfully to the senses by situating sensory affordances in accordance with the artifact's history and cultural practices as a dynamic whole. Projections and speakers provide historical information as well as additional visual and audio content.

"Visual Voyage": This prototype (Figure 2) offers a tactile interaction to engage with the prayer-nuts. Opening and closing the prayer-nuts, or touching their outer and inner carvings were integral for achieving an intimate, and definitively, 'tangible' connection with the sacred. Scholten [5] writes, "the manual act of opening and closing that this meditative technique entails is reminiscent of the opening of a prayerbook, or even of the panels of a large altar."

This prototype is a 3D-printed tangible replica that enables visitors to explore the outer design and texture of the artifact. Users can open the tangible object to trigger a projection of an enlarged version of the biblical scene depicted inside the prayer-nut. Touching the scene inside the tangible object highlights the corresponding features in the projection, providing text that explains their context and importance.

"Experiencing Spirituality": This prototype (Figure 3) is inspired by the contemplative quality of 16th century religious practices. The prayer rituals were often private, personal experiences that took place outside the church. Falkenburg [5] suggests that the prayer-nuts "aided and directed the soul during prayer and

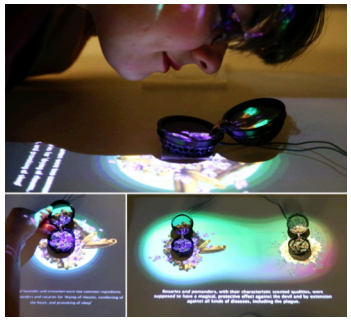

Figure 4. "Scents of Power" interaction (top) and animations (bottom)

meditation." The artifact represented a "complete meditative world, encompassing in itself the entire rosary prayer."

On approach, the visitor sees a projection depicting a historical layperson holding a prayer-nut in a marketplace, establishing the context and cosmopolitan setting of the Low Countries in the 16th century. When the tangible object is held, the image displayed on the wall transitions to a first-person point-of-view, showing hands holding the prayer-nut, as if viewed from the visitor's own perspective. Text and aural cues encourage visitors to relax their breathing while holding the tangible object. The interaction is completed when the scene of the marketplace transitions into a scene of a cathedral, providing text about the use of prayer-nuts in daily life. The ambient everyday sounds of the marketplace gently transition to sacred music written in the early 16th century.

"Scents of Power": This prototype (Figure 4) focuses on the scents of the prayer-nuts, which would have served various purposes. Some carried metaphorical meaning, linking the owner of the prayer-nut with the church and the biblical texts; others were believed to have apotropaic qualities, warding off evil or sickness [4, 5].

This prototype presents two tangible objects affixed to a table, with animations projected directly onto the tangibles and tabletop. Opening the objects displays images of the fragrant materials contained within, accompanied with text describing their historical context. If both objects are opened, an animation appears that connects the objects with a blending of the visuals, denoting the blending of aromas into a fragrant composition. Our custom scents for this interaction were created using spices, resins and essential oils inspired by preparations described in historical texts.

Technology and Implementation

Physical Design

Drawing on reference images from several available museum resources, we designed a 3D-printed tangible (Figure 5) using Rhinoceros, a computer-aided design software typically used in architectural and industrial design applications. The tangible object borrows the form and texture of the artifact to convey a tactile sense of scale and texture. As our goal was to create tools for experiencing the artifact, we did not create exact copies that might draw attention away from the intricacies of the original. The tangible objects were printed on a uPrint SE 3D printer in ABS plastic at 1:1 scale.

Input & Output

"Visual Voyage" uses a five-pin momentary capacitive sensor to provide tactile points of contact. "Scents of Power" uses a flex sensor affixed to a hinge to trigger projected animations. "Experiencing Spirituality" uses a capacitive sensor to register the user's touch and to initiate the beginning of the interaction sequence.

The Arduino program receives the sensing data as input and sends select information to a Processing sketch to display graphics, visuals and animations according to the user's interaction. Audio feedback was also provided in some interactions through the use of the Minim library.

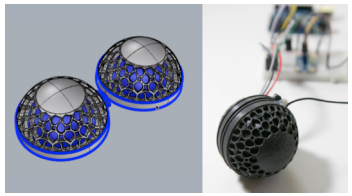

Figure 5. 3D model and the printed prayer nut

Figure 6. Sensors and Scents put into the "Scents of Power"

Scent Design

Historically, prayer-nuts contained a variety of "sweet-smelling ingredients" like lavender, rose leaves, saffron, and cinnamon [5; cf. 12]. Composed of essential oils, we created scents drawn from descriptions of historical preparations (Figure 6). From these, we chose two contrasting examples: a spiced scent and a floral scent. The first scent was composed of nutmeg, cinnamon, clove, frankincense and a touch of rose. The second emphasized lavender, with a touch of cinnamon. To simulate the missing aromas of the original prayer-nut's fragrant wood housing, each scent also included sandalwood and cedarwood essential oils.

Preliminary User Testing

In July of 2015, we showcased the first iteration of our three prototypes to eight of our fellow researchers and conducted an informal user test in our lab. Prior to interacting with the tangibles, we provided general context for each participant, briefly describing the history of the prayer-nuts, the purpose of the installation, and a key historical fact related to each prototype. The goal of our observations was to assess the use of the prototypes with regard to the following questions: (1) Interactions: Do the participants understand how to interact with the prototypes? (2) Experiences: Do the interactions allow participants to form a personal connection to the content?

Interactions: Without any initial guidance, many of the participants did not immediately understand what interactions were available with the tangibles. Some participants showed hesitation in handling the tangibles, which are light and looked somewhat fragile, especially as they were visibly wired to the Arduino. Similarly, when engaging with the interior of the object, participants were unsure of how many fingers they were meant to use to explore the tactile points. It was clear that textual, graphical and possibly tactile cues could easily have functioned as additional prompts to encourage the initial interactions.

Experiences: Overall, participants expressed that the use of multisensory and embodied experiences resulted in a more personal engagement with the activity. "Scents of Power" was particularly successful in this regard, as many participants were eager to describe how the scents reminded them of people and places for the floral scent, and foods and cultural traditions for the spiced scent. Further, one participant compared the tangible to personal religious practices that also involved rosary beads, handling the object in the same fashion.

Conclusion and Future Work

As a result of informal user testing, technical and design limitations indicated the next steps for the project. We learned that detailed instructions as well as visual and aural cues must explicitly communicate the required interactions and their purpose, freeing users to explore and form personal opinions. We also find possibilities for the functions of the three prototypes to be combined together, enabling a free exploratory interaction.

Future work includes improving the interactions to allow for increased robustness, accessibility and ease of use. We intend to develop additional methods of engaging the senses, experimenting with the texture, form and scale of new tangibles, taking into account how the user's interactions play out in the physical space. A more formal user test will be required to test

the novel interactions and the experiences, as well as to test implementation in a museum setting. Overall, design principles and considerations for multisensory interactions are needed, especially with regard to interactions that strive to respect the cultural and contextual aspects of historical artifacts as well as the diverse sociocultural identities and needs of users.

Providing multisensory entry points to experience cultural history can offer greater opportunities for visitors to meaningfully engage with cultural content. Although this project presented prototypes, it is a useful basis for exploring an evolving design space.

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