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# A Comparison of Audio-Tactile Exploration Methods to Discover the Tapestry of the Apocalypse

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**Abstract.** Artwork accessibility is a major issue for blind and partially blind museum visitors. To that extent, tactile graphic techniques and supports have been developed to allow haptic exploration of bi-dimensional artworks which is not always available in museums. This study aims to compare different technologies with a focus on the Tapestry of the Apocalypse, located in the Castle of Angers, France. To evaluate their impact on the museum visitors' experience, we seek to establish the benefits and drawbacks and look for further improvements. Several tactile supports have been used in this experiment: a tactile book with embossed paper, a swell paper representation, a 3D printed puzzle, and a haptic device, named F2T (Force-Feedback Tablet). Blind, partially blind, and sighted participants were tasked to explore these supports accompanied by audio descriptions. Participants were presented with several Likert scale and open-ended questions to rate their general feeling. Overall, all the conditions received good ratings from the participants. However, more nuanced comments were gathered on each condition. New ways to improve the technologies have been proposed through users' feedback.

**Keywords:** artwork accessibility · multisensory exploration.

## 1 Introduction

The Tapestry of the Apocalypse is a unique artwork of the fourteenth century. Recognized as the world's largest collection of medieval tapestries, this document is a 104m long and 450cm height medieval set of tapestries. Throughout 84 scenes, mythology and middle age reality are mixed. To facilitate the accessibility of this artwork to all, the Castle of Angers offers special guided visits to blind and partially blind (BPB) people. However, those visits are limited and must be scheduled with a minimum of five persons. Independence of navigation and art appreciation have been demonstrated to improve satisfaction and increase the motivation to discover art [2].

In this paper, we will focus on art appreciation. We attempt to find different audio-tactile systems adapted to the BPB audience. A tactile book of the castle and its tapestry is already available in the museum shop [3]. Yet, this tactile board is not in open access inside the castle. Furthermore, to our knowledge, no study has been published on tests made with BPB people on this tactile book. Moreover, this book has not been designed to be used with complete autonomy, with some advice being given inside for helpers.

To reduce the cognitive overload generated by the large-scale integration of tactile information through touch we propose alternative methods of tactile exploration. These new audio-tactile exploration methods are composed of swell paper representations, 3D prints, and a force-feedback haptic device. Our three new experimental systems aim to be inclusive and in the end, to be used with complete autonomy. By comparing all of those methods we attempt to find the advantages and drawbacks of each method with the aim of improving them in order to get the most adapted system.

In the first part of this paper, we describe all of the systems and the experienced method. Then we compare the participants' feelings and comments for each system. A conclusion on those tactile systems follows, along with a discussion on the possible ways to improve them.

## 2 State of the Art

In the literature, the representation of 2D artworks like tapestries or paintings is mostly transcribed to 2.5D presentation [14]. Edman [5] listed a multitude of materials to support tactile graphics (e.g. swell paper, vacuum-forming). These supports are still used by experts specializing in the transcription of images for BPB people through simplification. To create these representations, guidelines have been established to achieve better haptic perception by the Braille Associations [1]. Those techniques and guidelines are used to create the swell paper representations presented in this paper.

However, it has been shown that the tactile sense is not enough to promote independent exploration, especially for 2D artworks. It is recommended to complement the experience by presenting auditory information, such as audio-description [4, 13]. To make visual presentation accessible to BPB people, most researchers will look into cross-modal concepts through visual-to-tactile or visual-to-auditory cues. As such, all of our tactile experiences will be supported by audio descriptions (AD). Though there is no consensus known on how to design artwork representations for BPB people, most researchers in this domain will look into an iterative approach involving the targeted population. Kobayashi *et al.* [8] proposed an iterative approach involving BPB people to create a representation with progressive details of the "Storm below Mount Fuji" by Hokusai on swell paper. Raynal *et al.* [11] proposed the use of tangible graphics and an interactive interface in an educational setting in the form of a board game for the BPB. They showed that this type of device improves collaboration between people with different levels of visual acuity, thus promoting an inclusive design.

Our work is in the same vein and intends to use this experience to improve our tactile models based on the feedback we receive. However, it is difficult to evaluate if the created devices will be effectively used in the museum context. Our goal is to not isolate BPB museum visitors from other visitors. This is why it is important to involve people with different visual abilities to approach an inclusive design [9], which we will apply for our experiment. According to our knowledge, no research has been conducted to compare multiple audio-tactile devices in an inclusive setting. To that extent, this article has the objective of looking into the relevance of art representation methods and their impact on the museum experience for an inclusive audience. The next section will focus on describing the methodology for the techniques used.

### 3 Methodology

#### 3.1 Experimental Conditions

For the experiment conducted here, several types of presentations, illustrated in Figure 1, have been chosen to be compared, with two presentations based on a tactile book provided by the staff of the Castle of Angers, and each accompanied by an AD to assist the exploration. For each condition, free exploration was not temporally restricted. An estimated time of 15 min was intended by the supervisors, however, participants took more time to explore. Thus not all participants were able to test every experimental condition in one day.

**Condition A.** The tactile book uses an embossing technique via Pachica paper to represent elements from scenes of the artwork. An AD extracted from the CD, delivered with the tactile book, is provided to accompany the exploration. However, it has been specified that a helper is required to use this tactile book, thus not allowing independent exploration from blind users.

**Condition B.** The same tactile book and AD are used accompanied by a swell paper representation of one or several elements of the scene designed by experts from “Centre Normandie Lorraine”. The particularity of the swell paper representation is the simplification of the element of a scene through contour presentation from the tactile book. It introduces “blank space” textures for better tactile perception and high contrast colors.

**Condition C.** A 3D printed puzzle was designed to make detachable pieces from scenes using the pipeline of Redon *et al.* [12]. Each scene element has been segmented using the Segment Anything Model (SAM, [7]), while their height value was manually attributed. An adapted AD from the tactile book’s CD has been used to accompany users’ exploration. The ADs are divided into several sections. In this way, free exploration time is possible for each described object.

**Condition D.** The F2T (Force Feedback Tablet) is a 2-DOF haptic device that allows haptic exploration via a flat joystick [6]. The presentation of a scene is made by deploying three exploration modes composed of: a global and a detailed guidance; and an exploration without guidance [10]. This method uses annotated paths and virtual images with haptic effects and audio feedback areas.

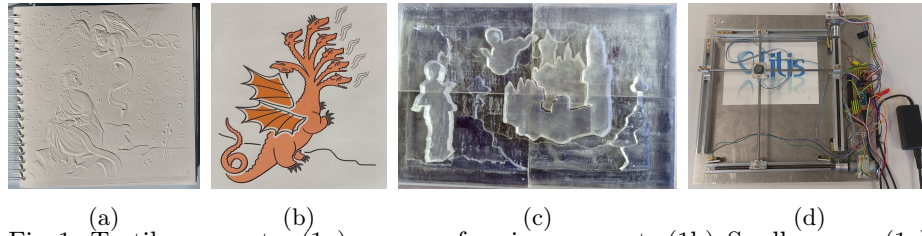


Fig. 1: Tactile supports. (1a) vacuum-forming support. (1b) Swell paper. (1c) 3-D puzzle. (1d) The F2T prototype.

Conditions A, B, and C were conducted in the gallery of the Tapestry of the Apocalypse, while condition D was tested in one of the buildings of Castle of Angers, to limit noise in the gallery. To avoid learning bias, each condition represented distinct scenes of the tapestry with a minimum of shared information.

### 3.2 Participants' Profile

A total of 13 participants aged between 41 and 77 years old have been recruited, with nine BPB people. Among them, seven had already used ADs and six had already visited the Tapestry of the Apocalypse. Before undertaking the investigations, ethical clearance was obtained from the ethical committee. The participants number varies from one condition to another: nine for condition A; eight for condition B; ten for condition D; and eleven for condition C.

## 4 Results

Following each experience, a questionnaire was completed by the participants and transcribed by helpers. It is composed of a Likert scale, with ratings ranging from 1 ("not at all") to 5 ("a lot"), and open-ended questions. The results have been analyzed by using the median, the lowest, and the highest values. Conditions B, C, and D are still in an experimental phase, while condition A is tested to have a base for comparison.

### 4.1 Likert-Scale Results

We observe in Table 1 that all tactile supports were highly appreciated, but not at the same level. If we focus our attention on the highest and lowest value condition B is the most satisfying system, with less variability in answers. For the detail level in the ADs, the tactile systems, and the experiment's length no preference can be identified, see Tables 2 and 3. However, if we look at the comments real differences appeared. This will be discussed further below.

### 4.2 Participants' Comments

During the questioning phase, participants' suggestions were noted by the supervisor. This allows more nuanced appreciation. Globally, participants found that all the systems and supports lacked of guidance.

Table 1: General ratings about experiences. Five answers were possible and transcribed as numbers, 1 meaning “not at all” and 5 “a lot”. Here are represented the median, the lowest, and the highest marks.

	Did you enjoy the experience?	Did you find the experience interesting?	Was the experiment understandable?	Has the experience improved your feelings about the Tapestry of the Apocalypse?	Are you satisfied with the amount of information provided by the represented scene?
Condition A	5 [2; 5]	4 [2; 5]	4 [2; 5]	5 [2; 5]	4 [2; 5]
Condition B	5 [4; 5]	5 [4; 5]	5 [4; 5]	5 [1; 5]	4 [3; 5]
Condition C	4 [2; 5]	4 [2; 5]	5 [1; 5]	4 [1; 5]	4 [4; 5]
Condition D	4 [1; 5]	4 [1; 5]	4 [1; 5]	4 [1; 5]	4 [1; 5]

Table 2: Experiences details rating, 1 meaning “not enough” and 5 “too much”.

	What do you think of the detail level in the audio description?	What do you think of the tactile detail level ?
Condition A	3 [3; 4]	3 [3; 5]
Condition B	3 [1; 3]	Tactile book: Swell paper: 3 [3; 4]      3 [1; 3]
Condition C	3 [2; 5]	3 [1; 5]
Condition D	3 [1; 5]	

Table 3: Experiences length rating, 1 meaning “too short” and 5 “too long”.

	What do you think of the experiment’s length?
Condition A	3 [1; 3]
Condition B	3 [1; 3]
Condition C	3 [2; 4]
Condition D	3 [3; 4]

Some participants found condition A instructive and liked its esthetics: participant 10 said “I liked it, it was a good discovery and instructive”. Some comments highlighted the sensation of frustration, sometimes due to the complexity of the tactile support or due to the presence of element descriptions that are not tacitly represented. Participant 2 commented “It is stressful and frustrating not being able to tactilely identify what’s on the audio”. Another issue was the height of the reliefs which did not allow enough sensation, and the speed of the AD, which did not leave time to find elements according to the participants: P3 said “Audio flow should be slowed down and relief heights increased”. To that extent, some participants wished to control ADs, P2 said: “I would prefer to manage the audio flow myself and have more guidance”.

For condition B the speed was also a problem, which makes sense because we used the same type of audio support: P1 said “The AD is too fast, when I touch I need to really explore”. The other point was about the level of detail when the tactile book was found overloaded with details, and the swell paper representation was under-loaded, representing only certain elements of the scene. Moreover, some elements considered important were missing. As we prepared the swell paper as a complement for some details: P2 said “Two pages were necessary to explain the scene, here, it’s reductive. Missing elements are essential to give the meaning or content of the image”. The principle of two supports with different levels of difficulty was highly appreciated: P6 said “I like the different treatment of the two supports”.

For condition C, ADs were partitioned. Some participants appreciated it: P2 said “It’s good that the ADs of each item are detached”. It was also a new approach so it was disturbing for people, making it too complicated to grasp: P6 said “The change of dimension between objects is disturbing”; P9 found that it was not easy to understand with touch and the guidance with audio was not clear enough. Moreover, it was complicated for BPB to reassemble the puzzle once it was unraveled: P9 said “It’s complicated to replace the removable elements”; P2 explained “When it’s all off, you don’t know which piece you’re holding”. However, participants found the idea innovative and with great potential: P1 said “The idea is brilliant”; P10 commented “I’ve never seen this type of device”; P4 opined “It was a good idea, but you would have to be used to the object to be able to put it back on the support”. During the experience, participants offered us new perspectives. For example, P9 suggested adding a marker to start with and to move around. P12 suggested other perspectives: adding a magnetic side like on children’s puzzles, cutting into 6 side-by-side frames to help find the objects, and creating a new system consisting of a flat surface with shapes that rise with the AD. P2 suggested adding a plate with boxes and numbers for easier storage and retrieval of objects.

Regarding condition D, participants generally appreciated how the content of the tapestry was presented to them through complementary exploration modes (global and detailed guidance). Some of them were surprised, by the fine details of the contours provided by the detailed guidance mode. However, as it is a novel technology, people needed a learning phase to enjoy this new tactile support as commented by P6: “It would be great to have a learning phase”. They also suggested the inclusion of sound signals to accompany guided exploration: P2 said “There is no signal to distinguish between elements (for the detailed guidance mode)” and P5 noted “Silent areas should be explained”. Other participants noted that certain haptic effects hinder further exploration. The motor noise disturbed some participants, even while wearing headphones, and some effects were found to be hard to understand.

## 5 Conclusion and Perspectives

In this article, we compared several tactile supports intending to make the Tapestry of the Apocalypse accessible to BPB persons. We first described these supports, then we showed that all of them have been appreciated. However, some improvements must be made whether in terms of speech speed or complexity of information, tactile, and audio. The addition of swell paper representation support is intended to represent the elements of a scene in a simplified way. It complements the tactile book use, which alone is difficult to grasp. It contains interesting details that are pleasant to touch, but difficult to interpret by touch only.

The 3D print is a new interactive way to discover art, allowing interesting interactions. However, it was disturbed by its presentation method and object shapes. It needed to be simplified and clarified in the tactile information and the orientation. For future 3D puzzles, we will add some physical landmarks to guide during the exploration. Moreover, a magnetic part will be put on the support and removable objects to make the puzzle reassembling effortless. Another major modification will be to create a storage plate to easily retrieve objects.

The F2T is a modular support that allows one to explore a scene. Global guidance mode was found to be a good way to locate elements from a scene, and overall all exploration methods complement each other. Nevertheless, in addition to a learning phase that needs to be reviewed to make it easier to use. Each presented exploration mode will be improved, notably by looking into how multiple haptic effects can be integrated for better perception of a scene. Improvements will enable better interpretation during the exploration without guidance. These modes would be more understandable by adding sound signals to indicate changes between elements. Regarding system design, a new prototype is under construction to lessen motors' noise.

For future works, it could be interesting to combine these different methods according to the participants' feedback. The fine relief of the book could be combined with the interactivity of the 3D print. The F2T global guidance mode could reinforce the 3D print exploration. We will continue to improve our prototypes by further involving participants in the design and evaluation.

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