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# Embodied Tuning: Interfacing Danish Radio Heritage

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## Abstract

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*Most museum exhibitions favor vision, not hearing. When there is audio in exhibitions, it tends to take on a secondary role as a soundtrack or commentary. In some cases, however, audio should be the primary object of interest. Radio heritage is such a case. The traditional way of showcasing audio is through web-accessible archives or through listening kiosks in the exhibition. Neither one takes advantage of the unique affordances of the spatiality and physicality of an exhibition. We therefore propose an alternative way of exhibiting radio heritage in a listening exhibition where users move around and explore the physical gallery space.*

*We implemented a simple, low-cost prototype system called Exaudimus, allowing users to search for the audio streams using their own bodies as a metaphorical radio-tuning dial.*

*We tested the concept in a public exhibition at the Media Museum in Denmark. A small, qualitative user study conducted during the exhibition shows promise for this type of immersive experience. The users, however, tended to perceive it as a unique and finite experience, not motivating them to further explore radio heritage on their own afterwards.*

## Key Words

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*Audio Positioning, Exhibition Design, Mixed Reality, Radio Heritage, Visitor Studies*

park, full of experiences and information coming at you in many forms, some scripted some serendipitous [*italics in original*] [1].

## I. Introduction

The Web is a *wonderful* library, but a library nonetheless. On the other hand the new networked media – part instructional and part entertainment – are not archival but immersive. The image to hold in mind is an amusement

The advance in digital technologies has resulted in processes of digitization whereby radio heritage is becoming increasingly more accessible online. This is the case with the LARM Audio Research Archive ([www.LARM.fm](http://www.LARM.fm)) where analogue source material from the production archives of the Danish Broadcasting Corporation (DR) is *remediated* in digital form and then *repurposed* as cultural heritage.

The terms “remediation” and “repurposing,” developed by media theorists Jay D. Bolter and Richard Grusin [2], were introduced to the study of cultural memory by Astrid Erll and Ann Rigney [3], and we apply them here to highlight both the transformation of the form of the archival material, and the alteration of its meaning and purpose. From existing in the production archive only as a repository for reruns, the archive material is suddenly defined as cultural heritage and incorporated in a historical archive. Currently, LARM.fm is only accessible to researchers, but if the archive becomes accessible to the public, the audio artifacts could be further repurposed as a resource for e.g. remixing and education.

The web-accessed digital archive as a form is effective in giving access to huge amounts of material. However, to navigate freely and choose between thousands of digital artifacts can be an overwhelming experience for the layperson. Thus, the design of an inviting interface with curatorial elements (e.g. collection highlights or themed selections) to the archive becomes important if we want to engage the general public. Toward the end of the 90s in the heady days of unbridled Internet optimism, *Wired* magazine announced the imminent death of the browser, to be replaced by a form of immersive media, as stated in the opening quote [1]. Here we are, 16 years later, still using browsers to access digital archives, but much has changed: With e.g. current social media and games, the web has become a place to *be* rather than a library to use. This corresponds with *Wired* magazine’s vision of a transformation from the pull logic of the archive to the push logic of more salient and serendipitous experiences. Instead of users simply pulling information from the web, the web also pulls information from the users, and, from this information, both commercial and non-commercial content is pushed back toward the users [4]. Actually,

*Wired* still predicts that serendipity will be one of the trends of 2013. According to *Wired* [5], “technology is embracing the unexpected to recapture the art of surprise,” thus predicting the reincarnation of the “cyberflaneur” as a user seeking the discovery of new, surprising things through structured serendipity.

Our goal here is to explore a new serendipitous way of making radio heritage accessible to the public, where users neither feel that they have to pull audio artifacts from vast library-like archives, nor that they have no control over what is pushed upon them. We want users to explore and experience instead of taking the role of a busy librarian or a passive recipient of a broadcast.

Museums have traditionally showcased audio artifacts through web-accessible archives or through listening kiosks in the exhibition. Neither one takes advantage of the unique opportunities of the physicality of an exhibition. Instead, they often rely on users clicking through menus, playlists, and folders. We therefore propose an alternative way of exhibiting and interfacing radio heritage, where users move around and explore the physical exhibition space. We hypothesize that a mixed-reality exhibition has the potential for creating immersive experiences and enabling the engagement with radio heritage for museum visitors. Once established, engagement might form the basis for reflection, inspiration for further engagement, and learning. We added an explorative, location-based layer of sound to the physical exhibition using a mixed-reality approach [6], orienting the exhibition toward the analogy of “an amusement park, full of experiences and information coming at you in many forms, some scripted some serendipitous” [1]. In his analyses of libraries as information spaces, Björneborn has developed a holistic approach, integrating the multimodal affordances of the physical, digital, and social interfaces encountered by the users, which

we find adequate for conceptualizing an immersive information space. However, in a mixed-reality environment, the boundaries between the different information interfaces can become blurred and difficult to separate analytically. In this article, we present the implementation of an augmented reality audio system we call Exaudimus (Exhibiting Audio in Museums. Literal translation: “We are listening,” in Latin), as a platform for disseminating radio heritage, that is neither an archive, listening kiosk, nor a simple broadcast. The system was implemented in a listening exhibition at the Media Museum from October 2012 to January 2013.<sup>1</sup> We present selected findings from a small-scale, qualitative pilot study conducted in the exhibition concerning the occurrences of serendipity, and the affordance of reflection and inspiration for further exploration of radio heritage e.g. in digital archives such as LARM.fm.

The rest of the article is structured as follows: First, we give an account of the conceptual frame for the listening exhibition and the objectives it demanded of the Exaudimus system. This is followed by a section on Design, where we expound on the technological solution for Exaudimus. Before presenting our findings, we have a short section on our Method of Evaluation. Then we present and analyze the findings from our visitor study regarding engagement, serendipity, reflection, and inspiration, respectively. We end the Findings section with a part on Cultural Constraints. Finally, before the Conclusion, there is a Discussion, where the findings are placed in relation to broader themes, and where the perspectives resulting from the study will be elaborated.

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<sup>1</sup> [You are what you hear](#), at the Media Museum, Odense, Denmark.

## II. Concept of the Listening Exhibition

Museums form part of a visualist paradigm founded on a materialist epistemology focused on physical objects. Thus, the museum institution has difficulties in handling ephemeral objects of a digital or auditive nature [7] [8]. Consequently, the literature on sound in exhibitions is sparse outside the context of sound art. However, Marion Leonard has done some notable work on popular music in exhibitions, but her work is not informed by results from visitor studies [9] [10]. In exhibitions of cultural heritage, sound is seldom treated as an artifact, but as a secondary add-on, such as an audio guide providing a narrative commentary, or a soundscape providing atmosphere [11]. However, in this listening exhibition, we wanted to foreground the status of radio sounds as artifacts of cultural heritage; a status that they have gained upon being incorporated in the LARM radio archive. According to cultural memory researcher Jan Assmann:

Cultural memory exists in two modes: first in the mode of potentiality of the archive whose accumulated texts, images and rules of conduct act as a total horizon, and second in the mode of actuality, whereby each contemporary context puts the objectivized meaning into its own perspective, giving it its own relevance [12, p. 130].

In keeping with this distinction, we view the digital archive as the potential of radio heritage, which we actualize by presenting a curated selection of artifacts from the archive in the context of a museum exhibition. For fellow researcher of cultural memory Aleida Assmann, the museum exhibition is an institution of active memory that articulates *the past as present* by displaying artifacts from the archive, thereby *canonizing* these artifacts in relation to the remaining artifacts in the archive [13, pp. 98-100].

We will return to this point in the Discussion section of the article.

The intended objectives we had with the listening exhibition can be summarized in the following statements:

- 1). We intended to create engagement with radio heritage for ordinary museum visitors.
- 2). We intended the audio artifacts to be of primary importance in the exhibition.
- 3). We intended to make visitors aware of radio as their heritage.
- 4). We intended to make the visitors reflect on the interdependency of radio content and the listening situation.
- 5). We intended to inspire further engagement with radio heritage (e.g. in digital archives such as LARM.fm.).

Even though manual fine-tuning is no longer a necessity when listening to digital radio, we consider the process of “tuning in” to be one of the defining features of radio as a medium. We therefore chose “tuning in” as the conceptual metaphor for this exhibition on radio heritage. Exaudimus should enable the visitors to use their body as a tuning dial, tuning in to radio artifacts by moving about the exhibition space. Thus, on a practical level, the radio programs were “located” in the exhibition, forming a mixed reality together with physical objects in the room acting as props.

The theme of the exhibition was the interdependence between radio content and the listening situation (e.g. we listen to traffic radio while in the car). Due to a rather small gallery space of 90 m<sup>2</sup>, the exhibition was confined to seven different listening situations. Each listening situation consisted of four conceptual elements: an audio artifact, an interpretative text label, a few props, and, finally, an activity. The

activity element, where the visitor enacts the situation while simultaneously listening, was a strategy to strengthen the connection between the physical-material and the historical-immaterial dimensions of the exhibition. We believed that the visitor, through their bodily performance, would be more absorbed in the situation, and would therefore listen *differently* and perhaps reflect more on the relationship between the audio artifact and the situation.

Figure 1 (opposite page) gives an overview of the seven listening situations we tried to present in the exhibition. Due to copyright law, each audio artifact was confined to a length of two minutes and was played in a continuous loop. Even without this legal constraint, we believe that a two-minute duration for each audio artifact is the maximum demand on attention we can expect to place on visitors in general.

### III. Design of Exaudimus

The core function of the system was to deliver location-based audio to individual users. There are many ways of achieving this, including the use of hypersonic sound systems, listening kiosks, mobile devices, and more. However, there were some constraints related to the system:

- It had to be relatively inexpensive.
- It had to be flexible with regards to the location and size of the audio hotspots.
- It should be able to provide fluid transitions between radio static and the radio artifacts.
- To some extent, it had to exclude other sounds (from the room, from other hotspots, etc.).

Exaudimus is based on ceiling-mounted webcams tracking the visitors, who then receive audio in a wireless headset based on their positions relative to the predefined sound spots. The video tracking

Listening Situation		Audio Artifact	Props	Activity
1	Morning gymnastics	Captain Jespersen, 1952 (Exercise show)	Living-room carpet. Broomstick.	Gymnastics with broomstick
2	Evening entertainment	The Hansen Family, 1940–50s (Radio drama series)	Two easy chairs. Two pairs of slippers.	Relaxed listening
3	In the car	Denmark’s Car Radio, 1962 (Traffic radio)	Car seat. Steering wheel.	“Driving”
4	Sunday evening: Home alone	The Electrical Barometer, 1995 (Youth show)	Bed with teenage girl-style bedding. Bedside table with candles.	Lying in bed
5	On the bike	Third Ear, 2009 (Art montage podcast)	Bicycle mounted on “rollers.”	Biking
6	Journeyman early at work	The Morning Shepherds, 2006 (Morning show)	Stepladder. Transistor radio. Paint roller.	“Dry-painting” a wall
7	Listening to the BBC during the curfew	The Sabotage Bombing of the Always Factory, 1945 (Documentary)	Old radio set. Light bulb.	Listening in the darkness

Figure 1: Overview of sound spots in the exhibition

and audio generation is handled by the Exaudimus program. In our set-up, the system consisted of three USB 2.0 consumer webcams, an eight-channel audio interface, four wireless consumer headsets, and an office PC running custom software made with Max/MSP and Jitter.

During development, we experimented with different methods for video tracking individual users, including shape-based detection of polygons, and the detection of fiducial markers such as QR codes and amoeba tags.<sup>2</sup> Our idea was simply to put a unique visual marker on top of each wireless headset. Since

<sup>2</sup> We got inspiration for some of the tests from the [Blockwerk Orchestra project](#), used in the Long Gallery at Nottingham Castle

we used inexpensive USB 2.0 consumer webcams, it was difficult to obtain high frame rates, and this resulted in video blurriness during movement. Thus, for shape-based tracking to work in our set-up, the markers would have to be the size of a pizza box. Furthermore, the users would not have to look up or down too much for the ceiling-mounted cameras to be able to pick up the marker. We therefore settled on a color-based tracking method instead. One problem with color-based tracking is of course that users are able to bring clothing or objects of the target color into the exhibition, thereby introducing a false positive. Another problem is that the lighting conditions have to be relatively stable for the colors to be recognized. We therefore designed an LED-based solution, where we placed a small battery

pack with a differently colored LED on top of each wireless headset. The battery pack was attached with Velcro for quick removal and replacement. For the cameras to easily pick up the different colored dots, we placed the LEDs inside a ping-pong ball, emulating a soft light bulb. This made the dot larger and more evenly colored. Furthermore, we placed a small piece of sun-control window film on each webcam: The dark window film blocked out almost everything except for the colored LED dots. To enhance the visibility of the LEDs, we decided to keep the exhibition space as dark as possible, thus establishing a high contrast between darkness and light. Therefore, we used only a minimum number of spotlights to highlight the props for the listening situations and sealed off the exhibition space to daylight from the outside by covering the entrance with a black curtain.

Using the webcams, the system is able to distinguish between four colored headsets: green, blue, red, and yellow. Red and yellow are the least distinguishable colors, since a toned down yellow becomes reddish. This is most evident when the batteries run low. To ensure a relatively even color throughout the battery lifetime, we changed from alkaline batteries to lithium batteries. The flatter voltage curve of lithium batteries resulted in a much more even color. Still, the color tracking system is rather vulnerable to other changes in lighting conditions such as window shutters being opened or lamps being turned on. In our set-up, we had to monitor an L-shaped exhibition gallery, so we ended up using three cameras to cover the entire gallery. The color recognition for each color has to be calibrated for each camera individually, so we aimed at not changing the lighting too often.

Using simple trigonometry, the software constantly determines each user's position relative to the audio hotspots. If a user is not close to any audio hotspot, the system simply sends radio static to that

particular headset. When a user is approaching a hotspot, the static gradually disappears as the user is "tuning in" on the radio signal, and when the user reaches the hotspot itself, the signal is dry with no static at all. The sizes of the individual hotspots and the zones around hotspots, where static and the signal are crossfaded, are defined in the software, and in our case, the hotspot itself was roughly a one-meter diagonal. During development, we found that a linear transition from static to signal did not sound very good. Consequently, we ended up designing the growth of the signal as an exponential function.

The sound is delivered through a closed wireless headset. Most wireless consumer headsets use a carrier frequency of 2.4 GHz, which is the same as many other wireless consumer units, including routers, phones, Bluetooth units, and even microwave ovens. This may of course cause interference, and we did experience random connectivity problems between the headsets and the headset transmitters. In the museum building, as in many other museum buildings today, there are numerous units operating within the 2.4 GHz range, so this might become a problem.

All in all, the system ended up working satisfactory, but not perfectly smoothly. Mark Weiser, who is widely regarded as the godfather of ubiquitous computing, begins his most cited article by stating that "the most profound technologies are those that disappear" [14]. This thought is related to the notion of seamless design, meaning that designers should aim to integrate technology smoothly into the world, and that technology should disappear into the background. Obviously, this is more or less what we have tried to achieve in the listening exhibition. On closer inspection, however, there is more to it. Whenever technology fails, it simply cannot be invisible. Instead, it calls for attention. With a low-cost prototype system such as Exaudimus, things do

not always run smoothly. The tracking is sometimes slightly off because of calibration and lighting issues, and sometimes the wireless consumer headsets lose connection briefly. As the exhibition and Exaudimus were built around a radio metaphor, we were able to simply send static noise to any headset lost by Exaudimus' tracking module. It turned out that most users did not notice the occasional audio problems: A brief loss of signal or some unexpected static simply became part of the experience.

#### IV. Method of Evaluation

We decided against conducting a preliminary prototype test with users. We agree with Lehn et al. in that galleries and museums constitute a rich environment in which to study the conduct and interaction with and around artifacts [15]. Exhibitions offer an opportunity to explore the experiences that the artifact and exhibition design affords the visitor. A prototype test in a laboratory setting would generate data on the usability of the Exaudimus system, but not on the subjective experiences of actual visitors in the listening exhibition, which are influenced by their expectations of the museum visit. The actual location is critical for the experience, and a synergistic relationship exists between the place and the chosen media technology [16, p. 120]. To evaluate how visitors perceived the listening exhibition in relation to our objectives, we conducted a small-scale pilot study. The study consisted of 12 participant observations followed by an exit interview. The informants were sampled to obtain a roughly equal representation of both sexes and some age diversity. We ended up with seven female and five male informants between the ages of 15 and 64. Eight of the informants were under 30. In a Danish context, young adults are known to be less interested in cultural history and are the most difficult age group to attract for museums [17]. Thus, this particular group is especially important in relation

to new ways of engaging with cultural heritage. The interviews were structured and consisted of 17 open-ended questions. The authors designed the research questions and structure in cooperation with a private usability lab (SnitkerGroup), who then conducted the observations, interviews, and transcription services.

The transcribed data has been through consecutive processes of coding with regard to the occurrences of serendipity, reflection, and inspiration. For the sake of anonymity, the informants have been given pseudonyms.

#### V. Findings

##### A. Engagement and Experience

To foreground the audio artifacts (objective 2), we wanted to transform the traditionally visually oriented exhibition space into an auditorium (Latin: Listening space). Therefore, we tried to minimize the visual stimuli of the exhibition. We used only a few props for each listening situation instead of creating entire interiors. We kept most of the contextual and interpretative information in a catalogue, which the visitor could take with them afterwards to study at their leisure. This reduced the necessity of reading during the exhibition. However, we decided to keep labels for the audio artifacts, as these are a museological convention signifying "artifact" within an exhibition context [18].

For most informants, listening in an exhibition was a welcome change from the traditional visual museum experience. It seems that we succeeded in foregrounding the audio artifacts. According to David:

It was like entering a gallery, but every picture that you looked at was a sound clip! And I have never experienced that before! (David, 41)

However, some informants did not perceive the furniture in the exhibition as simply props. They perceived them as museum objects and therefore did not use them as intended (see the part on Cultural Constraints below.) Consequently, physical objects placed in an exhibition still retain a certain aura for some visitors, despite the foregrounding of sound.

Many of our informants reported the experience of immersion in the listening exhibition, as expressed generally by Karl:

It is a fun way in which you move around—and suddenly you are in another world. (Karl, 26)

It was the different aspects of the exhibition that enabled the experience of immersion for different visitors. Yet, for most of them, the physical props were important aspects of the experience. For others, it was the activity. However, the embodied performance did not seem to be of such importance for immersive experiences as we had at first anticipated. This could be due to the cultural constraints we discuss below.

### ***B. Serendipity***

As can be seen from the exhibition objectives, the intended outcome of the exhibition was not declarative knowledge regarding the acquisition of facts about radio heritage, but instead was centered on engagement, reflection, and inspiration. According to the well-known visitor studies' researcher Stephen Bitgood, learning associated with immersion is experience-driven rather than information-driven [19, p. 131]. Thus, we expected the learning outcome for an immersive exhibition such as this to include experiencing situations, feelings, and memories, rather than facts.

The exhibition contained a limited amount of information, and it was organized in a straightforward

way around seven clusters of props, each with an associated audio artifact. Consequently, there was no possibility of encountering other kinds of information in the exhibition space. Thus, we expected the occurrence of serendipity (defined as the occurrence of unexpected discoveries [20, p. 49]) to be in the triggering of memories in the visitors related to listening. This was also the case with most visitors, who were able to identify in some way or other with at least one of the audio artifacts. In particular, one visitor, Lisa, had a strong serendipitous experience. The realization that she had heard this radio segment before made her connect it to another memory of being in a similar situation:

When I stood and “painted,” I had to stop because I remembered this. I have heard this on the radio before. And now I had to listen carefully. [...] Thus, it made me laugh! I thought the part with Robbie Williams was brilliant. It is so funny because it made me think of a Rugsted and Kreutzfeld concert [...] And do you know the feeling that an actor or performer is looking right at you? [paraphrasing the audio artifact] I felt as if he looked only at me, when he sang [...] [laughing loudly]. (Lisa, 50)

A segment of mundane, morning-flow radio that Lisa had not paid particular attention to (which is the main point of this kind of radio show) suddenly took on a more profound meaning when it triggered another personal memory for her.

Another type of serendipitous experience that we did not expect to find was related to the form of the listening exhibition. The Media Museum is situated in a building that also has an art gallery and a museum of photography, so the visitors expected visual experiences and were pleasantly surprised when they had to listen instead, as expressed by Erica:

When I went behind the curtain [i.e. entering the exhibition] it was with a certain sense of wonder, I thought, what is this? So exciting. It was really exciting! It was fun that you were, like, active. I do not often visit museums and such, but when I do, you are usually just supposed to take it in, through the eyes. So, yes. It was a good experience. (Erica, 41)

### **C. Reflection**

We consider objective 1) and 2) as necessary conditions for realizing objectives 3), 4), and 5). Once we have established an engaging encounter between the visitor and the radio heritage, we might expect a deeper involvement with the material through reflection and inspiration. Regarding visitor reflection in objective 4), concerning the relationship between what you listen to on the radio and the situation you are in while listening (which was the main theme of the exhibition), half of the informants answered in the affirmative. When we further asked if they believed they would reflect on it while they listen to the radio in the future, only a few indicated that they would. It seems that we were able to convey the abstract exhibition theme to some visitors and make them reflect upon it. However, potential further reflection on the theme after the exhibition experience is limited.

There are different aspects to the relationship between radio content and the listening situation. One has to do with the “background nature” of radio as a medium. Several of our informants stated that a defining feature of listening to the radio is that you are able to do other activities while listening. This was also explicit in the exhibition design, where you were supposed to engage in an activity while listening to the audio artifact. Thus, the radio content is often of a lighter nature, which does not require your full listening attention in order to keep up. Another more subtle aspect is that the rhythm

and pace of the radio content changes throughout the day. Yet the exhibition was able to generate reflection on this more subtle point.

[...] it is of course because you are doing the same activities at the times when the shows are broadcast. Actually I think about how what they broadcast in the morning is no good broadcasting it at night. There is not the same rhythm in it. (Jenny, 25)

When asked if the exhibition had influenced their awareness of radio heritage (objective 3), most informants replied that the exhibition had raised their awareness. If the informant expressed any prior awareness of radio heritage, then it was just a matter of conforming or corroborating already held beliefs. However, the interesting aspect is those couple of informants that had no prior awareness of radio as heritage. Here, the listening exhibition was able to widen their cultural horizon to include radio as heritage. As Benjamin puts it:

Well, it has made me think. I have never regarded radio as heritage or something important to me, something you should cherish. Because I have never listened much to radio. But it was exciting to put it in perspective. (Benjamin, 21)

### **D. Inspiration**

The final objective 5) is concerned with the impact of the exhibition, and if the listening exhibition could function as an “appetizer” for further engagement with radio heritage. When asked if the exhibition had inspired them to find and listen to more historic radio heritage material, only three informants answered in the affirmative. Two of these expressed a prior interest in radio heritage before experiencing the exhibition. Thus, a positive engaging experience with radio heritage does not automatically inspire further engagement with radio

heritage. As Alexander states:

I would probably not seek it [i.e. radio heritage] out, but I think it [i.e. the exhibition] has opened my eyes—and ears—for its value, what I would recognize myself, not just war, but also contemporary stuff. In that way you sort of put it in perspective. (Alexander, 27)

However, the favorable attitudes of the informants to the listening exhibition as a whole show the potential for future exhibitions of radio heritage. Thus, the listening exhibition as an interface with radio heritage was successful in itself, but it was not able to inspire people to further engage with a digital archive.

Some visitors stated that they would not know where to find more radio heritage. This could have been made more explicit in the exhibition. We produced a catalogue from which the visitor could access different kinds of online material related to the exhibition via QR codes. However, observations showed that despite being free and prominently displayed at the entrance to the exhibition, almost no visitors noticed the catalogue, and thus did not get this opportunity.

### ***E. Confusion and Cultural Constraints***

As already mentioned, we thought the conceptual metaphor of the tuning dial was aptly chosen, especially because it enabled us to conceal any signal loss with static noise. Yet this metaphor was neither obvious nor apparent to the visitors. No informants reported that they “got it” and acted accordingly by fine-tuning with their body. Conversely, the static noise created confusion in some visitors. Some associated static noise with technical failure, thus assuming the headset was broken. The headset was, in fact, functioning well, and they should have just located the sound spots to get a clear signal, but it did

not occur to them because they did not understand the conceptual metaphor. Our youngest informant Heidi did not associate static with radio at all:

It doesn't seem like radio, when you listen to radio today, it does not seem like that at all. The way they talked, and I should concentrate on hearing what they said in some places because there was so much noise in the background. (Heidi, 15)

An experience such as Heidi's can go one of two ways: Either she will just reject the experience as being odd, or she will (e.g. through conversation with her parents) realize that she actually discovered something profound. Then she can turn it into a serendipitous experience resulting in a deeper understanding of “the way people talked” and “noise in the background.”

We intended the visitors to engage with the props in the exhibition, e.g. to sit on the bicycle, or lie down on the bed. However, this intention conflicted with a common visitor expectation: You are not allowed to touch objects in a museum. This is an example of what the well-known design researcher Donald Norman terms “cultural constraints.” The cultural conventions of the museum institution (Do not touch!) take precedence over the obvious affordances of the props (e.g. a chair affords sitting) [21, p. 8].

I have never tried something like this! [Laughing] And I am not sure if I did it right! I don't know if you were supposed to be part of...? So, I think I held myself back [...] You were probably supposed to lie down on the bed, but I found it was so transgressive to use things in a museum. [Emphasis in interview] (Gudrun, 22)

Many of the visitors who reported difficulties with getting a clear signal in the exhibition thus experienced the consequence of the cultural constraint that they abided by: They never placed themselves in the hotspot. In the design of Exaudimus, we even decided to use some gentle “nudging” as a way to get the visitors to engage with the props and not just stand looking at the labels. Therefore, we made the spheres of the hotspots rather small, and we placed them in exactly such a way that you had to sit on the chairs, lay on the bed, etc. to get a dry signal. Unfortunately, visitors who did not discover that they were both allowed and expected to touch the objects in this exhibition ended up having an impaired experience.

The cultural constraint of “Do not touch!” was so deeply engrained in some visitors that, despite noticing the direct invitation on the labels to engage with the props, they still had doubts about touching them:

I was not sure if I was allowed to sit on the bike [...] I was also in doubt about the paint roller, but then I just did it, because it said so clearly on it [i.e. the text label]: Grab the paint roller. Still I was not entirely sure if it was ok. (Lisa, 50)

On a positive note, Lisa did grab the paint roller, but we were surprised at learning just how hesitant some users were.

## VI. Discussion

Earlier we mentioned Mark Weiser’s notion of seamlessness in the design of technology. In his later years, Weiser refined his ideas about ubiquitous computing and began advocating seamful systems (as opposed to seamless systems). UbiComp researchers Chalmers and MacColl paraphrase some of Weiser’s talks where he suggested that “making

things seamless amounts to making everything the same” [22]. The idea behind seamfulness is to not try to hide away the seams between technology and the surroundings, but instead to make the seams beautiful in order to show the unique qualities of a system. When technology reveals itself in a beautiful, interesting, or even fun way, users are able to appropriate the technology and engage with it. In a radio sound experience, noise and brief losses of signal almost automatically become part of the experience. In other types of listening experiences, such problems might thwart the immersion. Thus, it needs to be considered during the design phase.

In the Exaudimus implementation, we had to make a simple headset with a light on top. We were afraid that users would find it goofy looking, but, in fact, this turned out to be a fun way of connecting with technology. Many visitors commented on the weird headsets, and as our informant Erica states:

First of all, I got to wear those funny hearing pieces, where initially I thought: No it cannot be right. We didn’t really dare to pick them up, my son and I. We thought: It’s a practical joke and someone will laugh at us, right? Ha, ha... (Erica, 41)

So even though (or because) the headsets were obviously a technological prototype, users found them novel and fun. The headsets were, at the same time, a toy to play around with, and a device to just wear and forget. In that sense, they provided a good seam.

In future listening exhibitions, we aim to make the seams between technology and the surroundings even more beautiful, interesting, or fun. Low-cost prototype systems such as Exaudimus will rarely work perfectly smoothly all the time, but that does not have to be a problem. The solution is not

to try and make a completely failsafe system. The solution is to try and make technology—including the occasional problems—part of the experience. We could imagine explorative audio systems where signal strength and connectivity is visualized with smiley faces or systems where users experiencing loss of connectivity have the option to instead connect to exhibits or even other users with a cable. We could even imagine simple systems where users have to adjust antennas themselves to get a clear audio signal. Troubleshooting can be fun if the technology reveals itself and provides possible solutions.

In a similar vein, we also want to explore more creative connections between sound and props. In the listening situations for this exhibition, the relationship between the artifact and props was straightforward. However, we can also imagine a more thought-provoking relationship between them, where instead of supporting each other, they act as a counterpoint e.g. listening to reports of casualties from a warzone while being on a children's merry go-around.

As pointed out by Aleida Assmann, the curation and presentation of artifacts in an exhibition constitute a canonization of these artifacts. It could be argued that by remediating and foregrounding segments of mundane radio shows in this way that they would receive an undue status and attention that they do not warrant, as they were intended to function as background entertainment e.g. while eating breakfast. According to the hierarchy of cultural artifacts coined by historian James Clifford, only one of our audio artifacts could be characterized as a *unique masterpiece* of radio heritage; namely, the clip with a live recording of a sabotage action during the German occupation of Denmark in 1945. The remaining audio artifacts are exemplars of the *mundane, mass-produced* category [23, p. 224]. The mundane artifacts are no less important, as they

show the everydayness and background character of the majority of radio heritage. However, the artifacts seem to have less emotional appeal, unless the visitor has a personal connection to them. As pointed out by Lisa, who even experienced a strong connection with one artifact she had heard before:

I find that the clips are perhaps not good enough. There was nothing special to them which made them super exciting or caught my attention other than the one with Robbie Williams [because she had heard it before]. (Lisa, 50)

It would be worth exploring if a differently curated listening exhibition with audio artifacts of a more unique kind could elicit a stronger emotional response from the visitors.

According to Bolter and Grusin, remediation is simultaneously a process of both *immediacy* and *hypermediacy* [2]. By repurposing the audio artifacts from the digital archive embedded within the tuning-dial metaphor, we are simultaneously attempting a more immediate listening experience than the one afforded by the archive, and, at the same time, we are directing attention at static noise and the process of tuning, thereby highlighting an aspect of radio listening that was removed when the audio artifacts were recorded and incorporated in the digital archive, where they are accessible without tuning. A further consequence of this remediation is that the more recent audio artifacts in listening situations 5 and 6 become associated with an analogue technology that they have no natural relation to, as they are *born digital* as podcast and digital radio. Even though the labels clearly stated that e.g. the sound clip was a podcast, critics may still bark at such an anachronistic remediation. However, we felt that a consistent conceptual metaphor was more important than avoiding such anachronism.

We mentioned the constraint of copyright law above. Thus, we were unable to use the entire radio shows as artifacts, and instead selected two-minute segments as metonyms for the shows. In this way, the listening exhibition is separated from the LARM radio archive. However, one could imagine a situation with no copyright constraints, where the listening exhibition could be an actual interface to the archive with direct links to the archived material. Such tangible interfacing of digital cultural heritage is also the purpose of the project meSch (Material Encounters with Digital Cultural Heritage) funded by the EU and running until 2017.<sup>3</sup> When designing mixed-reality interfaces for digital archives of cultural heritage we can take inspiration from the factors enabling serendipitous findings in a library context, identified by Björneborn [20], as we will need similar strategies for showcasing archived material.

## VII. Conclusion

Based on the results of our small-scale pilot study, we believe that the mixed-reality listening exhibition is a viable concept that can enable engagement with radio heritage for people that would probably not search for this material by themselves. The immersive nature of the listening exhibition fulfills many of the provisions envisioned by *Wired* magazine for the “informational amusement park of the future.” However, the listening exhibition did not function as an “appetizer” for the digital archive, as it did not inspire the visitors to further explore radio heritage on their own. This might become possible if there is a direct link between the exhibition and the archive, as discussed above.

The acquisition of declarative knowledge was not the objective of this listening exhibition. It enabled

reflection on an abstract theme—the relationship between radio content and a listening exhibition—and made visitors, who were not previously aware of the notion of radio as cultural heritage, aware of that connotation. However, given that all of the informants consistently read the labels in the exhibition, there might be a potential for the acquisition of declarative knowledge when the artifacts are invisible sounds. This remains to be tested in a visitor study that is more focused on learning.

The challenges of designing novel, immersive ways of disseminating cultural heritage in a museological context were also seen in this study, as the expectations of the visitors to the museum experience, some of which were deeply engrained, can run counter to the intentions of designers and curators. Some visitors will need to learn a new set of “exhibition competencies,” e.g. you are expected to touch and engage with the objects, if they are to profit in full from the immersive experiences of more engaging exhibitions. We think it is important that explorations and analyses of novel, immersive forms of exhibition design become informed by visitor studies, and that these studies are conducted in the actual exhibition setting with real visitors. That is the only way we can get an understanding of the complex affordances that an immersive exhibition environment offers the visitor, and the experiences elicited by this encounter.

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