

Unpacking the Audio Game Experience: Lessons Learned from Game Veterans

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ABSTRACT

People with or without visual impairments play and enjoy audio games. While this genre of computer games has attracted a strong fan base and some attention in HCI, little research has been dedicated to the people who actually play audio games in their daily life. There is a pressing need to capture the viewpoints of authentic or expert players, designers and developers to advance audio game design. Thus, we give voice to seven game veterans of sound-based gaming, i.e., people who each have more than a decade of profound experience in playing or designing audio games. We conducted a total of 14 interviews and employed grounded theory methods to unpack their experiences. We found that audio games enriched their life through *creativity*, *play*, and *social exchange*. Those core concepts were influenced by peripheral concepts like, *inter alia*, *aesthetics & enjoyability*, *accessibility*, or the *availability* of audio games. We show how they relate to each other and discuss design implications.

CCS Concepts

•Applied computing → Computer games; •Human-centered computing → HCI theory, concepts and models;

Author Keywords

Audio Games; Expert Interviews; Grounded Theory.

INTRODUCTION

Audio games are fascinating technological artifacts. They can be played and enjoyed by sighted people and by people with visual impairments alike. They are particularly appealing to the blind, of course, given that this user group most of the times cannot turn to mainstream computer games when in the mood for gaming. Thus, audio games have attracted a strong fan base (on the Internet) that plays, enjoys, and discusses audio games. We cite the biggest audio games online platform audiogames.net [4] to find a definition for the genre of audio games for this paper:

“Audio Games, as opposed to video games are computer games who’s [sic] main output is sound rather than graphics. Using sound, games can have dimensions of atmosphere, and possibilities for gameplay that don’t exist with visuals alone, as well as providing games far more accessible to people with all levels of sight.”

From a design and development perspective, audio games clearly lack sophistication compared to conventional video games¹, which turned into a billion dollar industry. For this reason, audiogames.net also serves as a meeting point for gamers, amateur developers, and (semi-)professionals, who are not just interested in playing, but also in advancing audio games as a genre to catch up with video games. Hence, they use the platform to criticize existing audio games, to discuss current developments, and to team up or recruit people for designing new audio games. To the best of our knowledge, audiogames.net is the only community of its kind – both in terms of size and of its members’ sophisticated interests – and therefore provides a unique opportunity to learn from the lived and engaged expertise of audio game veterans.

Besides this attention from gamers and (semi-)professionals, audio games have also attracted researchers in Human-Computer Interaction (HCI). A number of studies have been conducted during about the last twenty years that investigated audio games from a scientific perspective. When looking at this literature, it soon becomes evident that most studies that collected empirical data involved sighted or visually impaired people to evaluate novel prototypes and audio games. That is, after the HCI researchers have proposed a new concept or application, people with often no prior experience in audio games were asked for their feedback.

The present paper, in contrast, makes two adjustments to this common and respectable approach. For one thing, we engaged with participants prior to product design and development. For another, we recruited very experienced audio gamers and audio game designers to learn from them, instead of asking people, who are *new* to audio games to test a prototype game.

Hence, the objective of this research is to *add the perspectives of experienced audio gamers to the audio games literature*. We recruited a mix between practiced audio game developers, that is, people who actually do the coding, and audio games designers, in a broader sense – people who thought a lot about

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¹The audio games community often refers to video games as mainstream games.

audio games, the underlying development and design process, and who collaborated intensely with developers, for example, by writing game plots, doing voice acting or extensive bug (beta) testing. They were all active members of audiogames.net, the biggest audio games online community. In this way, we seek to make this relevant and knowledgeable group of users heard.

We chose grounded theory methods to unpack and conceptualize their experiences in a structured way. This approach gave emergence to an analytic framework, which captures the core of the audio game experience (*play, creativity, social exchange*), direct influencing variables (*accessibility, metatools, aesthetics & enjoyability*), and peripheral influencing factors that had an impact on the overall system of audio game experiences (*availability, innovation, mainstream industry, broad appeal*). We offer those different categories as design lenses to be applied when designing new audio games, tools to support their development, or when conducting further investigations into how people play and design audio games.

RELATED WORK

Audio games as tools: One of the first papers on audio games dates back to 1999. Sánchez et al. [25] investigated the potential of audio games for supporting learning and mental map generation in blind school children. This work and related follow-up research [24, 18, 7] focused on *learning processes* mediated by audio games. Hence, the games *per se* and the underlying design processes were delineated as black boxes, and there were no audio gamers involved in the studies.

Audio games in focus: Other researchers have directed their focus towards audio games themselves rather than using them as a tool. This includes work of German researchers Röber and Masuch [21, 22], Nordic researchers Liljedahl [17], Friberg [11], Gärdenfors [13] and Targett [31] or Rovithis et al. [23].

Röber and Masuch [21, 22] wrote about the composition of audible sequences, which they grouped into “speech, music, and natural or artificial sounds” [21, p. 2], sonification techniques and strategies as well as interaction techniques. Furthermore, they created prototypes to explore 3D audio, however, they did not include any audio gamers in their studies.

Targett and Fernström [31] illustrated several design ideas in two audio games they created for therapeutic training such as concentration exercises. For example, they experimented with *auditory icons* for communicating information. Liljedahl et al. also dealt with communication and investigated “how a radical shift from eye to ear influences the experience of playing a simple arcade style computer game” [17, p.200]. They highlighted principles of sound design and the *scary shadow syndrome*. Friberg and Gärdenfors [11] proposed a categorization system for sounds in audio games including recommendations for theorizing when developing audio games. Rovithis et al. [23] proposed the design principles “organizing the sonic content”, “navigation & feedback sounds”, and “narrative content: two parallel directions” [23] for audio games in educational contexts.

In a review paper, Yuan et al. [39] collated strategies for *game accessibility* that covered several impairments. In the context

of low vision, their proposed strategies were to “replace visuals with audio” (among more fine grained recommendations), to “replace visuals with haptics” and to “enhance visuals”. Furthermore, Garcia and Neris [12] derived audio game guidelines from the literature, from playing audio games themselves, and from an observational user study with two participants. To some extent, we [33] took an opposite approach to the above described work around (positively framed) design recommendation. Based on an analysis of audio games made by sighted students in an interaction design class, we derived (negatively framed) design *anti* rules, that is, synthesized design concepts, which are likely to lead to bad audio games (e.g., “Use Excruciatingly Painful Sounds” or “Do Not Use Sound Fitting the Ingame Context!” [33]).

Tools for creating audio games: There are also research projects that described tools for designing audio games. For example, a software editor for creating node-based audio games [28] and a concept for a map-based editor implemented as a web application [35] have been published recently. *TAGDK*, on the contrary, was a proof of concept for a *tangible* audio game editor [34], that is, the designers could manipulate physical bricks for creating games. Older tools, like the Blastbay Game Toolkit (BGT) [30] provided audio game developers with little experience in programming a tool for creating games. Unfortunately, developers’ support has stopped and the software is outdated (we’ll pick this up later in the interviews).

Even though much of the work described above is considered with *designing* audio games, there is – to the best of our knowledge – (almost) no documentation or reflection of the processes, that researchers engaged in when designing their games. The only information that we found stemmed from a developer’s blog, outside of academia. Here, the developers of Papa Sangre I and II [9, 10] captured key events during the design of their price-winning and widely acknowledged audio games (e.g., 2nd best iOS game in 2013 [19]).

Moreover, to some surprise, none of the papers includes audio gamers as either advisors or participants. In addition, not every study included visually impaired people. With the present contribution, we make one step towards closing this important gap. As we will show in our interviews with visually impaired audio gamers, affected people perceive games differently from sighted gamers.

METHODS

Since the goal of our study was to gain an *in-depth understanding of the audio game experience* and challenges in the design of such games, we participated in in-depth and iterated interviews with audio gamers and designers with profound expert knowledge, stemming from many years of engagement. Thus, we labelled our participants as *veterans*.

Research Paradigm and Research Questions

From an epistemological perspective, we followed a constructivist grounded theory approach to understand how expert users experience and design audio games. Such a research philosophy “[...] acknowledges that the resulting theory is an interpretation [...] The theory depends on the researcher’s view; it does not and cannot stand outside of it” [6, p. 130].

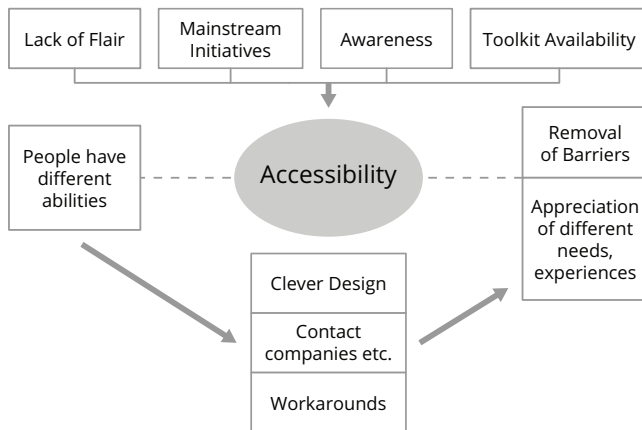


Figure 1. Axial coding for the major category *accessibility*, following a coding paradigm by Strauss and Corbin [29].

In detail, we aimed at examining

- why the participants cared (so much) about audio games.
- what the participants thought important about audio games.
- what the participants thought were good/bad audio games.
- how they designed or developed their own audio games.

We drew on the participants’ responses to our questions to construct a theory. To cite Strauss and Corbin, by theory we denote “[...] a set of well-developed categories (e.g., themes, concepts) that are systematically interrelated through statements of relationship to form a theoretical framework that explains some relevant [...] phenomenon.” [29, p.22].

Data Analysis and Data Collection

Grounded Theory

Grounded theory methods have evolved over the years departing from the classic publication by Glaser and Strauss [14] with its positivist focus on discovering patterns as embodied by the data to more constructivist interpretations of the methodology [6, 2]. We adhered to the latter and more recent developments and adapted a coding scheme as proposed by Charmaz [6]. In detail, we employed *initial coding* as soon as the first interviews were conducted. We then initiated *focused coding* and grouped “[...] the most significant or frequent initial codes to sort, synthesize, integrate, and organize large amounts of data” [6, p.46]. During that later phase, we also engaged in an adaptation of *axial coding* [29]. We found it was a valuable device to help us contextualize phenomena entailed in our data. As an example, Figure 1 shows how we arranged one of the major categories *accessibility* along an axis with sub-categories *people have different abilities* (condition) and *removal of barriers / appreciation of different needs and experiences* (consequences). Those categories are framed by context conditions (top row) and strategies or actions (column at the bottom). We will look into this in more detail in the *findings* section.

Throughout the process, we also employed the constant comparative method [14, 6] between data, codes, memos, and

Participant	Exp.G.	Exp.D.	Dur.1	Dur.2
1. Christian	12 yr	10 yr	87 min	25 min
2. Simon	13 yr	5 yr	55 min	33 min
3. Andy	26 yr	8 yr	91 min	24 min
4. Daniel	14 yr	10 yr	106 min	23 min
5. Jason	14 yr	9 yr	83 min	20 min
6. Justin	15 yr	7 yr	83 min	24 min
7. Dwayne	17 yr	6 yr	135 min	42 min

Table 1. Overview of participants. *Exp.G.*: years of audio games experience. *Exp.D.*: years of experiences in audio games design/development. *Dur.1* and *Dur.2*: duration of first and second interview.

participants. Such comparisons were the backbone to theory development grounded in the data, and they provided contrasts necessary for allowing the categories to emerge.

Preliminary Analysis: The Community

audiogames.net is the biggest audio game online community on the Internet. It has about 150.000² registered members and hosts hundreds of thousands of posts in its archive. According to its mission statement, “[t]his site exists as a community portal for all things to do with audio games. Here you will find news, articles, an active community forum and our database of over 500 titles on platforms from Microsoft Windows to iOS” [4]. We therefore expected to find experienced audio gamers as well as audio game designers at this virtual place.

Interviews: Participants & Procedure

Our participants, as displayed in Table 1, were recruited from audiogames.net. Before we started our recruitment, we got in touch with its administrators. One of the portal’s admins and main figures, Daniel (we changed the names of all participants for preserving anonymity), eventually also participated in the study.

In more detail, the recruitment procedure was the following. First, we contacted Daniel and asked for permission to post on the forum, explaining and advertising the planned interview study. As a response to this post, we received messages from 14 community members, who were willing to talk to us about audio games. Assisted by Daniel, who has functioned as the ‘head’ of the portal for over a decade and who knew most of the active members, we finally selected seven participants, as displayed in Table 1, based on their prior experience of audio games and game design, respectively. Daniel helped us with this selection and ensured that we would only talk to people with competence in audio games development. Hence, in this way, we were introduced to expert members, who we eventually interviewed twice on the phone or via Skype. The study was conducted in accordance to our university’s ethical guidelines and obtained approval. The participants were informed about the purpose of our study prior to the phone/Skype calls and consented to the study via email. Each of them had the option to name an audio game they wanted to receive (for \$20 max) as a small token of appreciation. In sum, we conducted 14 interviews, each lasting between about

²Accessed on 29th July, 2019.

20 to 135 minutes and transcribed the corresponding audio recordings.

We talked to each participant twice (see Table 1). The goal for the first round of interviews was to let the participants speak freely without interrupting them. We let them control the conversation and decide what they wanted to tell us about audio games. For this reason, we asked very open questions. For example, we asked each participant where they usually sat down to play games and in what situations. After we had talked to each participant, we scheduled a second round of interviews, allowing us to explore areas that attracted our attention during the initial coding of the first-round data. Moreover, we used this opportunity to discuss some tentative conclusions we made during the ongoing analysis (i.e., we implemented some kind of member checking). We stayed in touch with one of the participants (Dwayne) on Skype, and we had several chat conversations about audio games with him after the interviews.

The characteristics of the interviewed audio game veterans were very diverse regarding their knowledge and design experience. All of the participants had visual impairments (most of them were legally blind), which we found interesting and we will come back to this in the *discussion* section of this paper. Depending on when in life they (partially) lost their vision, they had collected more or less experience with computer graphics and (mainstream) computer games which they brought to their audio game experience. Some of them started playing games early in their youth, others later in their lives. They were either introduced by someone else (friends, parents or teacher) to audio games, or discovered this genre by themselves. Some participants still play (mainstream) non-accessible computer games, with either external help or accessibility workarounds (we will discuss these in the accessibility section). The recruited participants live in six different countries on three continents, with different levels of education (ranging up to an audio gamer with a PhD) and job situations. The participants were between 22 and 36 years old.

Their experience in designing audio games also differed from participant to participant, which allows different perspectives on different levels of expertise. They range from expertise in music, sound or voice acting, to expertise in software development and coding, to the expertise of game design.

However, in conclusion, all of the participants engaged in playing audio games with passion and wanted to bring the field of audio games and audio game design forward. Nevertheless, they were critical about the current state and the community, as we will elaborate in the upcoming findings section.

FINDINGS - UNPACKING THE AUDIO GAME EXPERIENCE

The analysis of this data gave rise to a number of concepts or categories, which together capture our theory of how the veterans of audio games experienced this genre. It became apparent that they received great joy from playing and designing audio games through creative engagement, playful activities, and social exchange. This theory is illustrated in Figure 2. We located the audio games experience (*AG XP*³) at the core of the theory, which basically meant joy by *creativity, play*, and by

³“XP” for experience, as common among gamers.

social exchange to our participants. In this context, they often encountered software products and ideas that were tailored to the abilities of sighted people, and so *accessibility* emerged as a salient category. This, again, had a direct influence on the tools or *metatools* they used for communication purposes and audio game development, and it also strongly impacted the *aesthetics & enjoyability* of interactions. The outer shell of our model comprises concepts that all influenced *AG XP* to some extent, if only peripherally. The impact of the *mainstream industry* (located at the outer edge) was omnipresent. It drove technological *innovation* in conventional games and thereby influenced the design of audio games. More *innovation* led to a higher *availability* of audio games, and this again, fostered *innovation*. Eventually, our participants hoped that more and better audio games will increase their *broad appeal* and attract broader audiences, advancing audio games from a niche genre to becoming recognized by the *mainstream industry*.

As evident from, for example, Figure 1 that *zooms* into major category *accessibility*, the categories and sub-categories that we have found were arranged in a complex network of interrelationships. Given the richness of the feedback that we have received, we could also have focused on one of these sub-networks in order to write up a dedicated paper, e.g., about how the participants worked toward their goal of *accessibility* or about the workarounds they have created in pursuit of accessibility. In the present work, however, **we concentrate on the overall system** that accounted for the participants’ experience of audio games (*AG XP*, Figure 2), since, to the best of our knowledge, nobody has investigated before what audio games mean to the people, who made them part of their life.

Therefore, in the remainder of this findings section, we will look into each core category as displayed in Figure 2. Before we go on, we will also briefly report one further category that we named *the current state of audio games*, because this category should serve as a proper introduction to the domain, and more importantly, our participants cared a lot about it.

The Current State of Audio Games: “Hunting Eggs”

As a general observation, we were impressed how attentively and closely the participants monitored (international) developments in the audio game scene. For example, they monitored the Japanese audio games market. Even though they had difficulties in understanding the Japanese-English (auto)translations, they still appreciated those games for their high degree in innovation with regard to gameplay. As we will see later, *innovation* in audio games was an important topic to our participants. In their opinion, audio games still lag behind mainstream video games in large parts due to the disinterest of larger companies in developing audio games: “*Market technology is not being used for creating audio games. So we are basically stuck on the eighty’s and ninety’s.*” (Andy).

Accordingly, in our participants’ estimation, audio games have only a small market with a relatively small and special audience compared to the giant video games industry. To little surprise, this is connected to a general lack in resources such as money and available toolkits (cf. *metatools*), and led to a relatively small number of available audio games (cf. *availability*), which are often also rather simple. For example,

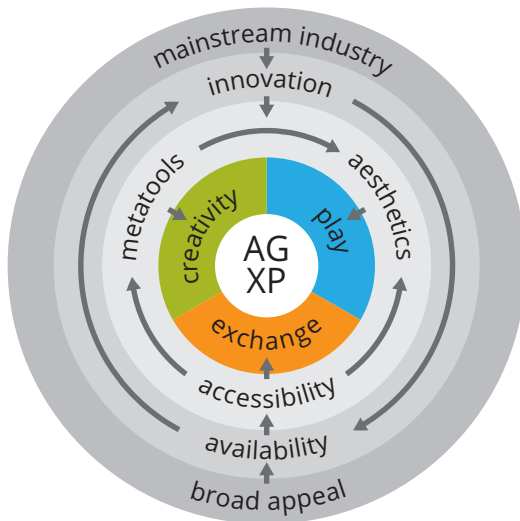


Figure 2. Audio Games as experienced by the veterans of sound-based gaming – relationship of main categories.

the complete database⁴ of audiogames.net features a total of 715 games, ranging from freeware developed by one hobby-developer only to commercial audio games, and spanning 28 different genres (e.g., *Arcade Games*, *First Person Shooters*, *Racing Games*, *Simulation Games*, *MMORPGs*, and so on).

Andy also observed that people are not prepared to pay a lot of money on audio games, and that the community or market is characterized by an independent hobby-developer culture, with many titles being developed at low cost and shared for free. Simon critically reflected that “*the problem is, they [the audio gamers] are easily satisfied with existing audio games, because they have no choice ... there aren't that much titles available, and many of them never experienced real mainstream gaming.*” Dwayne⁵ ironically commented on the same issue: “*I've seen people here in the forum writing that 'Super Egg Hunt' was one of the best audio games ever made. Not that there's not quality in this game, but ... seriously ... we're talking about a game where the goal is to collect eggs without getting caught by a chicken! [GRINNING EMOTICON ADDED]*”.

Besides this criticism, which was shared among all participants, they nevertheless spoke with great passion of audio games and spent a significant amount of time on advancing the genre by developing their own games. Indeed, as we will discuss in *innovation*, the shortcomings of the current state of audio games was among their core motivations for engaging with it proactively. We go on to unpack how the audio games experience positively shaped their life.

⁴ Accessed on 29th July, 2019.

⁵ Cited from personal communication on Skype chat.

The Inner Core of the Audio Game Experience

Play: “Gamers at Heart”

Playing games is a fundamental human desire, as prominently argued by Huizinga [15]. To our participants, too, playing games was an important activity from which they gained joy, a feeling of social contentedness (see *social exchange*), and also self efficacy. To quote Jason:

“Well, I play audio games because I enjoy the active gaming. I enjoy kind of immersing myself in a story of some kind [...] I like story. I like being involved in a world I can get kind of lost in. And I can't really do that in a mainstream console anymore like a lot of the games now you just can't play if you're visually impaired. [...] So, the short answer as to why I play audio games is, because I can't play mainstream games and I am kind of a gamer at heart.” (Jason)

This quote is representative for our participants' longing to engage in playing computer games. Audio games enabled them to take a break and dive into worlds of fantasy, action or relaxation. Furthermore, they challenge them in a positive way, providing rewards on successful completion. Jason went on:

“You know, I really enjoy the process, I really enjoy you know getting lost in a world playing a story and figuring things out. Puzzles, I like puzzles, whether they're actual like number puzzles or whether it's like – OK, hit that switch over, push that statue four squares to the left and whatever. You know, complex puzzles, I love boss strategy like finding out a strategy that works to kill creature in role playing game [...] And, as I say, the only real options available to me are audio games. I don't have anyone to sit here and read the *Final Fantasy* script to me and do all the button inputs so.” (Jason)

This latter issue in Jason's quote points at the importance of *accessibility* in the context of audio games. Obviously, in order to receive joy from gaming, one has to be physically able to play and interact with the games. We will elaborate on this issue later in the dedicated *accessibility* section.

Social Exchange: Shared Moments

Many conventional video games can be played in multiplayer mode, so that friends can share some quality time together. We found the same longing for shared leisure time in our participants' account of their use of audio games. Social exchange was an important motivation for both playing audio games and engaging in collaborative development efforts. Justin described some fond memories for us:

“I have played a few games, console games with friends. I remember for, when I finished university, a similar experience comes to mind. We went to a friend's house, and the whole plan was to just play FIFA. They handed me a controller and they described the moves and they told me what to press. And it was really nice because it was really exciting, like, I was like: 'I'm gonna make a goal'. And then they were cheering, and my friends were like: 'It's better if we let Justin play, and we tell him what to do. It's like more exciting than playing myself.'” (Justin).

Gaming and developing or designing can bring people with various backgrounds together, if the software is accessible or when the people/friends can support each others and remove barriers, as described by Justin. This social component was especially important to our blind participants, because their disability makes it harder to travel and meet with people who share same interests in person, compared to sighted people. Audio games, the online community audiogames.net (e.g., Christian alone created more than 7000 posts on the forum), and joint development projects were therefore a valued means to exchange with like-minded people.

Creativity: Quality of Life Through Creative Engagement

The core of the audio games experience, as displayed in Figure 2, is completed by the joy the participants received through *creativity*, next to *play* and *social exchange*. This had mostly to do with our participants' activities as audio game designers and developers. For example, they enjoyed writing plots for audio games (Jason, Andy), coding (Christian, Simon), voice acting (Andy), or advancing concepts for accessibility (Daniel). Hence, they chose to become active creators rather than just passive consumers. Andy explained his motivation as follows: "I'm an actor and a writer and I'm dealing with plot all the time. I wish to see plots in the games I play." (Andy). Furthermore, they were also engaged in creating additional software that extended existing audio games or made them more customizable, for example, Christian made a map editor for Swamp [3].

We go on to detail peripheral categories that had a direct influence on how the participants experienced audio games and their design. Hence, we describe qualities or tools in the context of audio games, which had an effect on how *creativity*, *play*, and *social exchange* could unfold.

Qualities/Tools Influencing the Audio Game Experience

Accessibility: Video Games as a Point of Reference

To little surprise, *accessibility* emerged as a salient category during the interviews due to the participants' visual impairments. In line with the participants, we think that *different people bring along different abilities* and those have an influence on how people can experience audio games (and conventional video games). This condition and additional themes or sub-categories are captured by Figure 1, which illustrates the axial coding for *accessibility*. In this diagram, we can also see how, for example, *clever design* and *workarounds* were employed as strategies to *remove barriers* and to make video games accessible or to design audio games without those barriers. Another strategy to support *accessibility* was to contact the (big) gaming companies (Daniel) in order to create *awareness* for blind people's needs, establish *mainstream initiatives for improving design*, and to eventually *appreciate that different people have different requirements*. *Awareness* and *mainstream initiatives* represent *context conditions* in the terminology of axial coding, next to *lack of flair* and *toolkit availability* (see *metatools* section). They all had an impact on the *accessibility* of mainstream video games and on the design strategies for audio games. We go on to provide some exemplary details.

Interestingly, many observations that we made about *accessibility*, related to experiences made by our participants when playing mainstream computer games despite their visual impairment:

"I was first introduced to mainstream games due to my friends and my sisters. We always had a console. My first one was the Master System and there we started to play Sonic The Hedgehog, Alex Kidd and stuff like that. [...] We sort of developed some workarounds like the rhythm of the music could be used to know exactly the time for jumping and stuff like that so I managed to beat the first stage of both games in Alex Kidd." (Andy)

Hence, from Andy's report, we learn that blind gamers also play conventional video games by employing certain *workarounds*. How well these work depends on the characteristic of the video game, as evident from Christian's and Daniel's statements:

"I never had perfect vision. It was good enough that I could play 2D games like Super Mario Brothers or Sonic the Hedgehog or Mega Man. But the 3D games [PAUSES]. Once we got a Playstation with more complex graphics and that those were a lot harder for the vision that I had and then that went away so." (Christian)

"And then suddenly: mid ninety's bang – everything went 3D, and both my spatial abilities with being able to see what's on the screen and the complexity of the images themselves got to be way too much for my level of sight to cope with." (Daniel)

As evident from those two quotes, new developments in mainstream video gaming around more complex graphics make it harder or impossible to play those games for people with visual impairments. This is the reason why audio gamers and developers like Daniel tried to reach out to game studios in order to create an awareness for special needs and to remove barriers.

While removing such obstacles in conventional games and supporting accessibility were certainly appreciated by our participants, there was also a downside to these efforts when undertaken with a *lack of flair*. In short, it was a frequent worry to be reduced to being blind. In this regard, Daniel stated that

"[...] a lot of audio games go from the perspective of 'let's make a blind protagonist'. You know, [...] I and lots of other blind people get sick of everybody being blind. You know, can we just have a game with somebody who happens to be blind who does something else? Again, I ... I'm quite happy with there being blind characters in games ... but I'm afraid I prefer a blind character where the most important thing about them wasn't that they were blind." (Daniel)

Apparently, playing and developing audio games is often concerned with being blind. The challenge for developers of audio games (but also of video games that aspire accessibility) is to support special needs without being paternalizing and without destroying the enjoyability of the game.

Aesthetics & Enjoyability: Towards “Developing an Own Style”

This category collates feedback about what makes playing audio games pleasurable from a perspective of aesthetics. It comprises aspects relating to the felt beauty when gaming as well as features that make playing fun in a broader sense (or spoiling fun in the worst case). Surprisingly, five participants (Justin, Jason, Simon, Andy, Dwayne) stated that ‘old school’ console games had a direct influence on how they experienced the *aesthetics & enjoyability* of audio games and how they designed for audio games. As described above, some of them were able to play simple video games. This experience created certain mental models or expectations of how computer games can or should be designed. For example, Daniel observed that audio games made by designers that were born blind lacked certain qualities regarding game physics:

“Some people, who are making audio games, haven’t had the experience of very basic elements of physics in a mainstream game. I mean things like Super Mario. Mario’s walking speed is not constant. So the difficulty in Super Mario is getting Mario to move to the right with rather complex timing challenges.” (Daniel)

On the contrary, audio games that have been created by sighted designers are also subject to shortcomings, which limit the quality and complexity of gameplay: *“The audio game was something planned by sighted developers at first [...] And they didn’t know what was and what wasn’t our abilities when it comes to playing video games in general. So most audio games are quite simplistic like center the sound and press a key” (Andy)*. Still, our participants as well as the community in general were surprisingly tolerant (cf. Section The Current State of Audio Games: “Hunting Eggs”) towards certain aspects in audio games that had a clear effect on their game aesthetics. For them it was totally fine, if text within games was read out by their built-in screen readers instead of using voice actors. Indeed, despite this robotic voice, they actually often preferred the screen reader, because of convenience and practicality (information processing speed). As another example, in many audio games interactables and items (e.g., a treasure chest) were repetitively emitting sounds, so that the player could find them. This often led to a crowded soundscape of noise, which was however fine for our participants:

“I really know this is not the ideal. But I’ve been part of some teams of testers. And we went through a long process of finding out which would work better. I really don’t know, honestly, if we could find a better solution for that. But at the same time we agree that a lot of beeps and bleeps cut a large part of the immersion.” (Andy)

Immersion, as mentioned above by Andy, was an important concept in audio games. Jason differentiated between environment immersion and story immersion:

“So environment immersion is basically what I get when I am deeply attached to the soundscape, when I basically feel like I’m actually part of the game [...]. An example of what might break it, if there’s terrible voice acting or terrible sound design that will break environmental immersion. Story immersion is what I feel when I feel

like I’m with the characters [...] I actually feel like I’m part of the character [...] like story immersion is what I give a damn about what happens.” (Jason)

Christian even saw an advantage for audio over conventional video games with regard to immersion, because *“[...] you usually going to have like headphones on so you’re usually just kind of in it so you already have like an advantage there.”*

In summary, the experiences of *aesthetics & enjoyability* were impacted by issues of *accessibility* in at least two ways. On the one hand, game quality lagged behind, because blind developers haven’t been ‘educated’ by conventional video games. On the other hand, certain features of games with graphics had to be substituted, for example, the visual renderings were sonified to make them perceptible via sound. The challenge is to advance the *aesthetics & enjoyability* of audio games by drawing on auditory abilities and avoid substituting or copying from conventional video games. Or to put it in Christian’s words, *“audio games must develop their own style.”* We will take a look at an example where this has already been accomplished.

Metatools: “Not to Reinvent the Wheel”

Since all of the participants were actively involved in the development of audio games, they regularly mentioned (higher level) tools to aid design. These comprised existing tools, but they also had demands that haven’t been addressed by technological solutions yet. One developmental toolkit that was regularly mentioned (by Simon, Christian, Daniel, Justin, Dwayne) was BGT [30]. The BGT had a big impact on the community, because many dozens of titles were implemented using it. Unfortunately, this software hasn’t received any updates in years and is therefore dated. For this reason and due to technological limitations, many games built using BGT look quite similar from today’s perspective (Simon) (cf. next section). Furthermore, an increasing number of games made with BGT now get flagged by anti virus software. Hence, there is a demand for modern and accessible software development kits to aid design:

“None of the major game companies have produced an audio game, but another [...] problem is that the game development tools to create audio games are not the same as that are available for developers with the same amount of resources to create graphical games.” (Daniel)

Regarding supported functions, Unity [32] was reported to be very promising (by Christian, Daniel, and Andy), however, it couldn’t support *accessibility* to the necessary degree.

In essence, the category of *metatools* was about “not having to re-invent the wheel” (Christian). Therefore, the participants advocated the use of toolkits like BGT or Unity. Moreover, they informed us that many games “reuse the same sounds” (Simon) and low quality sounds due to financial reasons. Therefore, there was a need for shared libraries of high quality sounds. Finally, there was demand for the creation or collating of proven *design patterns/recommendation* for audio games as some reoccurring design challenges have already been successfully addressed. As an example, Daniel mentioned a clever design element or proven pattern, which might help audio games in defining their own style. He reported about games

that incorporated text messages and email as part of the game story. Whenever the protagonists received such a text message, the game engine used the player's standard text reader for displaying this information (in contrast to text-to-speech or voice acting). In this way, this part of the game felt very authentic and real to the user, because this is how they actually experienced real email.

Peripheral, But Global Influencing Factors

Innovation: "Many Games Feel the Same"

As mentioned above, our participants felt that audio games lagged behind video games. For this reason, they talked about *innovation* frequently, for example: "I've gotten used to there not really being all that much innovation going on." (Christian) or "the last 30 games that I've played feel all pretty much the same. There is nothing new to them." (Simon). These statements applied both to game concepts/mechanics as well as to game content/elements such as sound files. As mentioned in *metatools*, many semi-professional audio games consisted of the same sound snippets, which of course contributed to the felt lack of innovation. While this was a rather negative observation, it also strongly motivated our participants in creating their own games and improving the *current state of audio games* (cf. corresponding above section).

Availability: "Our Choices are Limited"

While the participants were happy that the audio game genre was diverse with many categories of games, they also regretted restrictions in the availability of audio games. Similar to conventional video games, older titles often didn't work on current computing technology. As there are by far fewer audio games available than video games, the impact of problems in portability is much stronger here.

Dwayne gave an example when he was describing the importance of *replayability* of audio games:

"[...] in the audio games scene we have so few things to pick from in each genre that you play a game sometimes even if it really doesn't have any replayability just because you need to scratch that itch." (Dwayne)

One workaround for facing software decay was either using old soft- and hardware ("Yeah I mean it's [a game] so priceless you have to get like an iPhone 4 cause you can't get it on the newest iOS. You should still be able to download it then." (Dwayne)) or a virtual machine. This however comes with its own problems:

"[...] virtual machines don't work well with audio games. They have lag between the sound and the key presses so a lot of people used [emulator software] Wine instead, because they don't want to do [Windows on macOS] Bootcamp. And well, screen readers don't work in Wine so you can only use TTS [Text-To-Speech]. So that's why people offer TTS generally, because of Wine." (Dwayne)

In summary, since the number of audio games is limited in comparison to video games, the impact of software decay hits a small community more heavily than it would hit a large community. Strategies to overcome technological constraints produce either new issues or force them to use old soft- and

hardware with all typical security-related consequences, which old soft- and hardware setups can bring along.

Broad Appeal: "Attracting Multiple Audiences"

The participants observed an increase in interest in audio games due to more demands for radio dramas and interactive audio books, which have been pushed by the recent introduction of Amazon Echos and similar products: "Usually when you get sighted people who come to audio games, they tend to have come the route of audio dramas rather than gamers." (Daniel). Regardless of why those newbies started audio games, these new players were happy to recognize this new attention and wanted to utilize this momentum in order to advance the design of audio games and innovate. However, they also were aware that there was still much hard work to be done (for them), because they found that new sighted audio gamers relatively soon lost their interest. They explained this by a novelty effect: "[Audio games are] not perceived as 'Hey, I can play this game. This is really interesting!' It's perceived as 'WOW I don't have any graphics!'" (Daniel). Still, this effect wouldn't last for long and interest in audio games in general soon faded. People quickly turned back to the "hyper-complex 3D graphics that they were used to" (Daniel). As a counter strategy, the community was experimenting with audio games that featured complementary graphics modes in order to attract broad user groups. However, the outcome of their explorations was only very preliminary and with mixed results. In addition, they also considered crafting intelligent stories as a strategy for catching the interest of more people and concealing the limitations of audio games (note, this also relates to sub-category of accessibility *clever design* as displayed in Figure 1):

"It tries to attract both audiences. [...] You're playing a dog. And the dogs they can't see very well compared to how they can hear. This is an intelligent way to put a game to the mainstream market without appealing something like 'I'm doing a game for the blind, please help me buying this thing.' No. You are controlling a dog and a dog can't see very well. So you're relying on sound. So good luck, this is my game." (Andy)

Interestingly, Dwayne observed an opposite approach in the design of the popular audio game Manamon [36], which features many repetitive loops of sound effects: "It's kind of an audio game for blind people that was never really trying to appeal to sighted people, right."

Mainstream Industry: Shadowy Existence and "Trickle Down"

The participants expressed their hope that by progress in the *mainstream industry*, audio games would also benefit and be advanced through a "trickle down effect" (Dwayne). By this, they referred to, e.g. the publication of novel video game development kits (that can also be used for creating audio games) or hardware improvements that provide a better platform for playing games (e.g., mobile phones and app-stores).

At the same time, however, the participants also argued that audio games should be treated as a special genre in its own right and thought that audio games deserved to step out of the shadow of the mainstream:

“I don’t know ... it’s really hard to compare audio games to anything because they can only really be compared to themselves and even comparing them to early mainstream games is hard because it’s kind of a different ballpark [...]” (Dwayne)

DISCUSSION

The feedback of the participants was very rich in many regards, because they both told us on a personal level why audio games enriched their life, and also they reflected about the audio games community from a more global perspective. As a consequence, it is possible to look at this data from many different angles, foregrounding different aspects. We chose to place the audio games experience (*AG XP*) at the center and provided a general account of what our participants got out of audio games by playing and designing them. We now return to specific aspects that we find relevant for further discussions.

Prevalence of Visual Impairments in the Community

When we designed this study and went into the community, we were not explicitly recruiting audio gamers with visual impairments. Instead, we were looking for motivated audio gamers (independent from their vision) who wanted to talk to us about how they experienced audio games. In the end, all of the participants had severe visual impairments. This is an interesting fact, but it was not part of our recruitment strategy.

It is however clear that many audio gamers have visual impairments, and this has implications for audio game design. For example, when designing audio games, one must take into account that blind people are not used to the computer mouse – a classic device for *graphical* user interfaces. Instead, they prefer keyboards or special (game) controllers. A mouse might be appropriate for sighted people and for visually impaired people with some remaining vision as the main input for the next audio game shooter, but it will probably be useless for fully blind people, who are not used to working with a mouse.

Video Game Culture and Audio Games

Sighted gamers can play audio games, of course, but they usually strongly prefer video games or quickly lose interest in audio games. This has become especially apparent when our veterans talked about sighted gamers in audio games. Unsurprisingly, video games are heavily rooted in today’s culture, since they are “*the product of larger cultural contexts*” [27, p.8]. Without going into too much detail about video game culture⁶, we want to point out that the cultural expectations of digital games are heavily linked to video games, which produces a mental image of ‘what games should look like’. Audio games apparently do not fit this cultural mental model, as the findings especially about *broad appeal* or *mainstream industry*, show.

One should not ignore one crucial fact why video games have a better status in comparison to audio games. Video game productions usually have a higher budget, and therefore (usually) higher quality and more options for marketing. To cite Shaw: “*The complex interweaving of social networks, mainstream*

⁶We point the interested reader to an article by Shaw [27] as a valuable starting point.

and video game press coverage, marketing, economics, and so on, all go into what makes a game popular.” [27, p.8]. Thus, (sighted) video gamers who are ‘not restricted’ to audio games have more options to choose from to satisfy their gaming needs; and there they tend to choose a high quality video game over a niche audio game for blind people.

Audiogames.net as Community of Practice

The first finding that surprised us (at least to some extent) was the importance of the *community*. While our research was actually geared towards investigating the audio games *experience*, it soon became evident that *social exchange* was a crucial component next to joy through *play* and *creativity*. The audio games community clearly reflects properties of Wenger’s concept of Communities of Practice (CoP) [37]. In Wenger’s sense, a community can be seen as a CoP if it fulfills three characteristics: (1) *The members of a CoP share a domain of interest, that forms their identity*; (2) *The members of a CoP build strong relationships that allows them to learn from each other*; and (3) *The members of a CoP are practitioners, who have a shared repertoire of resources*.

The shared domain of interest of the people in audiogames.net is explicitly centered around audio games; as gamers, designers, and developers. This characteristic is clearly found throughout the data and findings, especially when looking at the passion our participants showed throughout the interviews for audio games. According to our participants, there are strong bonds, i.e. audio game-centered relationships, between members of the community. They discuss audio games as a group, they support each other in creating audio games, and they help each other if they aren’t able to access or install an outdated game; and therefore they learn from each other. This trait is reflected in *social exchange*, as presented above. Wenger lists several examples as part of a repertoire of resources; namely experiences and stories, tools and the addressing of recurring problems, which makes them practitioners. We found this characteristic in several of our findings, including *metatools* or *aesthetics*.

However, this has to be interpreted with some limitations. Not every member of the audiogames.net community is a practitioner, some have just registered for the sake of audio gaming. A CoP in a traditional sense – and how Wenger postulated this concept – mainly consists of experts; membership in the CoP requires *commitment* to the domain of interest [37]. While we recruited participants with extended expertise in specific areas (e.g., voice acting, teaching music, game development), the community also consists of laypeople who just want to get the newest information about audio games without further participation in a CoP’s sense.

Furthermore, members of the community offered their talents (e.g., voice acting or coding) to other designers for free. We were reminded about the structures of *mod communities* in video games [26]. Typically, interested people stick together to create new mods (modifications) for their favorite game in order to improve it and to gain publicity in the community. In contrast to the audio game community, mod communities usually focus on one particular game, while the audio game community has a whole genre as its focus.

The Community's Call for more Inclusive Video Games

When we were talking to the audio game veterans, they often referred to mainstream games and the absence of accessibility functionalities in today's video games (see e.g. the quote of Jason in *play*, or the *accessibility* section). This accessibility problem in video games is a well known issue. International Special Interest Groups (SIG), e.g. IGDA Game Access SIG [16], promote game accessibility at game conferences and on the web to create awareness among decision makers, in particular, game companies and game developers. Apparently and with no surprise, the audiogames.net community too calls for more accessibility in mainstream games.

Involving the Target Group in Audio Games Design

Accessible games state on their website: “*The best way to get players with disabilities playing your game is to get them to help you make it...*” [1]. We fully support this statement. One of our driving motivations for this study was to involve participants who clearly belong to the core target group. In this way, we gained a better understanding of the people who play audio games and their experience in doing so. Hence, the present study about genuine gamers complements prior work that examined audio games without involving audio gamers as participants, for example, [20, 12, 28].

The Audio Game Experience and Design

In comparison to prior work cited above – without the involvement of genuine audio gamers – the grounded theory as elaborated in this paper can help us gain insights into audio games, in particular, regarding three aspects: (1) to understand the audio games community, (2) to understand the culture in which existing audio games were conceived, (3) to guide the design of future audio games. Aspects (1) and (2) were covered thoroughly in this paper. We go on to discuss the latter aspect, namely how our findings can be used as ‘design guidelines’.

When employing the elaborated grounded theory as an audio game design ‘guideline’, a game designer or developer can use the several sub-theories (categories) as elements to consider when designing or creating a new audio game. We will list some examples, however, they should be considered as non-binding examples or suggestions, as it is our conviction that prescriptive guidelines based on ethnographic work are to be used with caution. Dourish [8] prominently pointed to such issues from a general HCI perspective and we [33] did it more recently in an audio games context. However, in our estimation, the listed considerations are valuable and valid (since they are derived from the categories and are therefore from our audio game veterans).

When creating new audio games, designers may consider the social aspect (as shown in *social exchange*) when designing their new game. Members of the community are interested in playing with friends, sharing experiences, despite of any visual impairments. On the one hand, this calls for audio games that have (local) multiplayer support, and on the other hand, additional support for gamers who are not used to audio games or who need additional means to enjoy them (e.g., visuals). This would also increase the *broad appeal* of audio games.

Another ‘guideline’ which a designer may consider is the option that community members can create things for the game too; either as creators or modders (see *creativity*). Further design recommendations could suggest including different levels of *accessibility* support, to create an ability-based [38] audio game. An example could be to provide different modes for people who already have 3D gaming experience from before they lost vision.

Still, in some instances, we see value in collating proven audio game design patterns, i.e., descriptive guidelines about patterns that worked well across a number of audio game design situations. One for example could be, when to best use text-to-speech, screen readers or voice actors for conveying verbal information (similar but more general work in accessibility can be found at [5]).

Furthermore, there is a strong demand for higher-level development toolkits, since popular solutions like the BGT [30] are outdated and 3D game engines are not accessible. There are toolkits in the making [28, 34, 35], however, audio gamers should be and hopefully will be included during the development of those toolkits.

Limitations

We chose a qualitative approach to theorizing about why people get involved in audio games, and we were not interested in generating findings that generalize beyond this local setting.

We were intrigued by the fact that so few women seem to be interested in audio games. Of course, we aimed at a gender balanced recruitment, but this was not possible despite all efforts. There was one woman among the respondents, but she started playing audio games only very recently and also she had no experience in audio game design. This was also the case for six other male people, who we excluded from the study in order to comply with the research objectives. It seems relevant to investigate the reasons for this imbalance and its implications in future work.

CONCLUSION

We offered a unique perspective on audio games from the lived experience of seven expert users with visual impairments. To the best of our knowledge, there is no comparable study that has captured the needs and opinions of experienced audio gamers or designers before. Instead, studies in audio games usually invite participants to test a new audio game idea and then to provide their feedback based on this short-term and ‘artificial’ (de-contextualized) experience. Hence, the present work gives voice to people who deeply care for audio games and highlights their genuine concerns in a structured way using grounded theory methods. We suggest that the resulting theory shall be useful to inspire and sensitize good design when creating future audio games. Moreover, it adds to the scientific literature and empirical data about the relatively under-researched domain of audio games and their design.

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REFERENCES

- [1] Inc. AbleGamers Foundation. 2019. Accessible.Games powered by: AbleGamers Charity. (2019). <https://accessible.games/>.
- [2] Tavis Apramian, Sayra Cristancho, Chris Watling, and Lorelei Lingard. 2017. (Re)Grounding grounded theory: a close reading of theory in four schools. *Qualitative Research* 17, 4 (2017), 359–376. DOI: <http://dx.doi.org/10.1177/1468794116672914>
- [3] Aprone. 2018. *Swamp*. Game [Windows]. (8 August 2018). Aprone, Unknown.
- [4] AudioGames.net. 2019. Community Portal Welcome Message. (2019). <https://www.audiogames.net/>.
- [5] AbleGamers Charity. 2018. The APX Design Patterns. Website. (2018). Accessed 29th July, 2019 from <https://accessible.games/accessible-player-experiences/>.
- [6] Kathy Charmaz. 2006. *Constructing grounded theory: a practical guide through qualitative analysis*. Sage Publications, London.
- [7] Erin Connors, Elizabeth Chrastil, Jaimie Sánchez, and Lotfi B Merabet. 2014. Action video game play and transfer of navigation and spatial cognition skills in adolescents who are blind. *Frontiers in human neuroscience* 8 (2014), 133. DOI: <http://dx.doi.org/10.3389/fnhum.2014.00133>
- [8] Paul Dourish. 2006. Implications for Design. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '06)*. ACM, New York, NY, USA, 541–550. DOI: <http://dx.doi.org/10.1145/1124772.1124855>
- [9] Somethin' Else. 2010. *Papa Sangre*. Game [iPhone]. (December 2010). Somethin' Else, London, UK.
- [10] Somethin' Else. 2013. *Papa Sangre II*. Game [iPhone]. (October 2013). Somethin' Else, London, UK.
- [11] Johnny Friberg and Dan Gärdenfors. 2004. Audio Games: New Perspectives on Game Audio. In *Proceedings of the 2004 ACM SIGCHI International Conference on Advances in Computer Entertainment Technology (ACE '04)*. ACM, New York, NY, USA, 148–154. DOI: <http://dx.doi.org/10.1145/1067343.1067361>
- [12] Franco Eusébio Garcia and Vânia Paula de Almeida Neris. 2013. Design Guidelines for Audio Games. In *Human-Computer Interaction. Applications and Services*, Masaaki Kurosu (Ed.). Springer Berlin Heidelberg, Berlin, Heidelberg, 229–238. DOI: http://dx.doi.org/10.1007/978-3-642-39262-7_26
- [13] Dan Gärdenfors. 2003. Designing sound-based computer games. *Digital Creativity* 14, 2 (2003), 111–114. DOI: <http://dx.doi.org/10.1076/digc.14.2.111.27863>
- [14] Barney G. Glaser and Anselm L. Strauss. 1967. *The discovery of grounded theory: strategies for qualitative research*. Aldine Publishing, Chicago.
- [15] Johan Huizinga. 1971. *Homo Ludens. A Study of the Play Element in Culture*. Paladin, UK.
- [16] IGDA. 2019. IGDA Game Access SIG. (2019). <https://igda-gasig.org/>.
- [17] Mats Liljedahl, Nigel Papworth, and Stefan Lindberg. 2007. Beowulf: An Audio Mostly Game. In *Proceedings of the International Conference on Advances in Computer Entertainment Technology (ACE '07)*. ACM, New York, NY, USA, 200–203. DOI: <http://dx.doi.org/10.1145/1255047.1255088>
- [18] Lotfi B. Merabet and Jaime Sanchez. 2009. Audio-Based Navigation Using Virtual Environments: Combining Technology and Neuroscience. *AER Journal: Research and Practice in Visual Impairment and Blindness* 2, 3 (2009), 128–137.
- [19] Metacritic. 2013. *Papa Sangre II*. Website. (31 October 2013). Accessed 29th July, 2019 from <https://www.metacritic.com/game/ios/papa-sangre-ii>.
- [20] Michael A. Oren. 2007. Speed Sonic Across the Span: Building a Platform Audio Game. In *CHI '07 Extended Abstracts on Human Factors in Computing Systems (CHI EA '07)*. ACM, New York, NY, USA, 2231–2236. DOI: <http://dx.doi.org/10.1145/1240866.1240985>
- [21] Niklas Röber and Maic Masuch. 2004. Interacting with Sound: An interaction Paradigm for virtual auditory Worlds. Georgia Institute of Technology.
- [22] Niklas Röber and Maic Masuch. 2005. Leaving the screen New perspectives in audio-only gaming. Georgia Institute of Technology.
- [23] Emmanouel Rovithis, Andreas Floros, Andreas Mniestris, and Nikolas Grigoriou. 2014. Audio games as educational tools: Design principles and examples. In *2014 IEEE Games Media Entertainment*. 1–8. DOI: <http://dx.doi.org/10.1109/GEM.2014.7048083>
- [24] Jaime Sánchez, Nelson Baloian, Tiago Hassler, and Ulrich Hoppe. 2003. AudioBattleship: Blind Learners Collaboration Through Sound. In *CHI '03 Extended Abstracts on Human Factors in Computing Systems (CHI EA '03)*. ACM, New York, NY, USA, 798–799. DOI: <http://dx.doi.org/10.1145/765891.765998>
- [25] Jaime Sánchez and Mauricio Lumbreras. 1999. Virtual Environment Interaction Through 3D Audio by Blind Children. *CyberPsychology & Behavior* 2, 2 (1999), 101–111. DOI: <http://dx.doi.org/10.1089/cpb.1999.2.101>
- [26] W. Scacchi. 2004. Free and Open Source Development Practices in the Game Community. *IEEE Software* 21, 1 (Jan 2004), 59–66. DOI: <http://dx.doi.org/10.1109/MS.2004.1259221>
- [27] Adrienne Shaw. 2010. What Is Video Game Culture? Cultural Studies and Game Studies. *Games and Culture* 5, 4 (2010), 403–424. DOI: <http://dx.doi.org/10.1177/1555412009360414>

- [28] Viktor Stadler and Helmut Hlavacs. 2018. Blind Adventure - A Game Engine for Blind Game Designers. In *Proceedings of the 2018 Annual Symposium on Computer-Human Interaction in Play (CHI PLAY '18)*. ACM, New York, NY, USA, 503–509. DOI: <http://dx.doi.org/10.1145/3242671.3242703>
- [29] Anselm L. Strauss and Juliet M. Corbin. 1998. *Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory* (2nd ed.). Sage Publications, Inc., Newbury Park.
- [30] Blastbay Studios. 2012. *Blastbay Game Toolkit*. Software Development Toolkit [Windows]. (2012). <http://www.blastbay.com/bgt.php>. Accessed 29th July, 2019.
- [31] Sue Targett and Mikael Fernstrom. 2003. Audio games: Fun for all? all for fun!. In *Proceedings of the 2003 International Conference on Auditory Display*. Boston, MA, USA.
- [32] Unity Technologies. 2012. *Unity*. Software Development Toolkit [Cross-platform]. (2012). <https://unity3d.com>. Accessed 29th July, 2019.
- [33] Michael Urbanek, Peter Fikar, and Florian Güldenpfennig. 2018a. About the Sound of Bananas - Anti Rules for Audio Game Design. In *2018 IEEE 6th International Conference on Serious Games and Applications for Health (SeGAH)*. IEEE, 1–7. DOI: <http://dx.doi.org/10.1109/SeGAH.2018.8401361>
- [34] Michael Urbanek and Florian Güldenpfennig. 2017. Tangible Audio Game Development Kit: Prototyping Audio Games with a Tangible Editor. In *Proceedings of the Eleventh International Conference on Tangible, Embedded, and Embodied Interaction (TEI '17)*. ACM, New York, NY, USA, 473–479. DOI: <http://dx.doi.org/10.1145/3024969.3025077>
- [35] Michael Urbanek, Florian Güldenpfennig, and Manuel T. Schrempf. 2018b. Building a Community of Audio Game Designers - Towards an Online Audio Game Editor. In *Proceedings of the 2018 ACM Conference Companion Publication on Designing Interactive Systems (DIS '18 Companion)*. ACM, New York, NY, USA, 171–175. DOI: <http://dx.doi.org/10.1145/3197391.3205431>
- [36] VGStorm. 2016. *Manamon*. Game [Windows]. (20 July 2016). VGStorm, US.
- [37] Etienne Wenger. 1999. *Communities of practice: learning, meaning, and identity*. Cambridge Univ. Press, Cambridge.
- [38] Jacob O. Wobbrock, Shaun K. Kane, Krzysztof Z. Gajos, Susumu Harada, and Jon Froehlich. 2011. Ability-Based Design: Concept, Principles and Examples. *ACM Trans. Access. Comput.* 3, 3, Article 9 (April 2011), 27 pages. DOI: <http://dx.doi.org/10.1145/1952383.1952384>
- [39] Bei Yuan, Eelke Folmer, and Frederick C. Harris. 2011. Game accessibility: a survey. *Universal Access in the Information Society* 10, 1 (01 Mar 2011), 81–100. DOI: <http://dx.doi.org/10.1007/s10209-010-0189-5>