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The Role Sound Plays in Games:

A Thematic Literature Study on Immersion, Inclusivity and Accessibility in Game Sound Research

Georgina Guillen*

Gamification Group, Faculty of
Information Technology and
Communication Sciences, Tampere
University
georgina.guillen@tuni.fi

Henrietta Jylhä

Gamification Group, Faculty of
Information Technology and
Communication Sciences, Tampere
University
henrietta.jylha@tuni.fi

Lobna Hassan

Faculty of Information Technology
and Communication Sciences,
Tampere University,
lobna.hassan@tuni.fi

ABSTRACT

As technologies and the sophistication of games evolve, so do the possibilities to immerse players in multi-sensorial experiences for different purposes and in different ways. The design and development of the auditory components of video games play an increasingly relevant immersive and inclusionary role within (and outside of) games. Sounds enable a deeper and more meaningful immersion, but also facilitate inclusion of and accessibility to people with different physical and psychological abilities. Sounds also provide a vehicle to challenge or overcome gender or even heritage stereotypes. Recognizing this potential, designers have often explored different means to facilitate accessibility, inclusion or sometimes intentionally challenging auditory experiences to users as, for example, seen in recent game releases where designers created a perceived mismatch between a character's voice and gender for inclusion beyond immersion. The present study aims to identify and thematically review relevant academic literature (47 studies), summarizing the perceived role of game sound design, its impact on immersion, and the way sound design enables (or hampers) inclusivity and accessibility within games. Our findings indicate that although there is research on how audio-related technology enhances immersion in games, studies about its use for increasingly relevant inclusive purposes (in terms of accessibility and social aspects like gender) are relatively scarce.

CCS CONCEPTS

• User characteristics; • People with disabilities; • Sound and music computing;

KEYWORDS

Sound design, Audio immersion, Inclusion in games, Accessibility

ACM Reference Format:

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* authors Guillen and Jylhä are both first authors as they worked equally on the research

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1 INTRODUCTION

"Music is a moral law. It gives soul to the universe, wings to the mind, flight to the imagination, and charm and gaiety to life and to everything." – Plato

Music and sound, auditory augmentations of video games, are an integral part of gaming that can alter perception of time [44], affirm the actions and experiences that the player is performing or undergoing [29], and invoke emotions, memories, and reactions. For example, combinations of low and high frequencies, as well as passive and active sounds, can steer individuals towards a specific state of mind, such as happiness, sadness or tension [29]. Such combinations of sounds are, hence, often consciously employed in musical compositions to engage listeners. They, similarly, can afford increased immersion, - i.e., feeling absorbed in an activity - when employed in game audio [30], and affect the player physiologically, psychologically, cognitively, and/or behaviorally [30, 31, 44]. Psychologically, sound can engender feelings of happiness, nostalgia, tension or suspense. Cognitively, it can help the player concentrate on the game. Behaviorally, since sounds, and especially music can cognitively absorb players, they could lead the player to spend more time playing, seek the music soundtracks on other platforms or market the game to friends and family because of its engaging music. These are all significant extensions of and enhancements to a player's experience [42].

During the past decades, auditory augmentations of video games have seen tremendous developments. The synthesized beeps of early games such as Pong [41] have turned into commercial playlists for different moods and into intricately composed orchestral pieces [31] to the extent that many game soundtracks have come to be available through music streaming services such as Spotify, which would have hardly been expected during the early days of synthesized beeps as game music. Auditory augmentations of a game, such as gameplay sound or narration, have come to be considered conduits of inclusion and accessibility, allowing players with different abilities to partake in the same game, by relying on sound and audio cues [13, 28] and, for example, challenging gender, racial, or social stereotypes as seen with perceptually trans-gender characters in recent game releases such as *The Last of Us II* [34].

When it comes to enabling player accessibility and inclusion through audio, it is important, at least for design purposes, to differentiate inclusion from accessibility. Inclusion in gameplay means

that a game is designed for players to play while having aspects of their relatively important and distinct personal identities, and cultural contexts recognized and perhaps experienced during gaming. Accessibility in games comes in the form of a game that is playable for people with different abilities. Therefore, inclusion objectives here are not limited to players with different abilities but encompasses the reduction and avoidance of exclusion in the context of video games, based on e.g., abilities, gender, sexual orientation or other personal characteristics.

While inclusionary and accessibility-facilitating video game soundtrack and audio exist, they remain relatively rare. The state of accessible gaming in general is in need of research and development [7, 23], and intentionally inclusive and arguably challenging auditory implementations are extremely rare that exceptionally and relatively inclusive games can catch media attention when they are released e.g., [34], generating positive and negative buzz depending on the situation. Perhaps the status of diversity and accessibility in games is a mirror reflection of the status of diversity in game industries, which points to most game developers being able, relatively young males and of generally homogenous demographics [3].

The needs for universal inclusion of gamers through accessibility [7] and inclusive design [17] are more pressing than ever due to the observed increased diversity of gamers and the rapid introduction and utilization of games in different aspects of life e.g., education, exercise, dating etc. Games - and especially characters' voice over - can be used for, not only inclusivity of diverse players, but also for challenging societal norms through, e.g., designing game character that deviates from classical gender sound identities. For example, a visually female character with a male voice. If games were initially a niche software in the early days of computers and the internet, they are now an integral part of daily living, whether in the explicit form of games, or the adapted forms of gamification, serious games or persuasive applications.

One main way of enhancing inclusion in videogames and consequently game-base designs that draw inspiration from games is via sonic presence and audio support. Recognizing this potential of game audio and soundtracks and building on the argument that audio is essential for immersive and inclusive experiences, this work focuses on sound design and production as precursors for the conscious facilitation of immersive, as well as accessible and inclusionary experiences from video games. The aim is to thematically review research on game sound design to identify: *How does sound design contribute to the facilitation of immersive and inclusive experience (in terms of accessibility and social aspects like gender) in games?*

In order to thoroughly investigate the topic at hand, we divided our thematic literature study into three sub-questions, as follows:

RQ1: What are the main purposes of sound design?

RQ2: How does game audio (i.e., music and sound) impact immersion?

RQ3: How can sound design enable player accessibility and inclusion?

Noteworthy is that the differentiation between sound and music remains relatively challenging and is perhaps a distinction primarily based on experiential definitions rather than on physics-related variances in sound waves. For example, some sounds or combination of sounds (e.g., screeching, crying, laughter) can have relatively

similar sound waves to what humans would otherwise consider “music”. Consequently, distinguishing between sound (a vibration that transmits as an acoustic wave) and music (a multiform complex function of sound series) [55] is beyond the scope of this research as we rather investigate and review research on both as enablers of an immersive auditory experience and as conduits of inclusionary experiences.

2 BACKGROUND

Arguably, hearing is the “second most important” sense for humans, as sound contains information that influences our emotions and behaviors in combination with factors such as volume, context, frequencies and pitches [29]. When playing games, audio is often considered integral to the feel of the game. As games played via mobile devices started to become popular, increasing the reach of games into society, new gameplay concepts and methodologies emerged providing opportunities to develop the basic functions of audio as a driver of the playing experience as well [12, 39]. Prior studies suggest two parallel approaches to game sound design: 1) movie-like soundtrack, and, as an extension of this approach, comes 2) the creation and communication of spatial information to generate a deeper sense of immersion through game audio. The movie-like soundtrack strategy to immerse players [20, 31, 45] employs auditory sensory cues to provide feedback to the player to perform in the game, giving the player useful, additional information [22, 37, 45], like the sound of falling into a pit when failing to reach the other side if jumping from an edge to another. It is noted [45] that video game soundtracks are composed of several overlapping layers of non-linear sounds in a more interactive way than film and TV media have, as they are dynamically mixed in real-time as the player progresses in the game, rather than being composed beforehand based on video as is the case with, for example, movies. With the second approach to sound design, besides the audio, videogames also provide haptic cues to guidance players and additionally employ these sounds to create rich spatial representations of the gaming environment.

In particular, auditory cues convert spatial information to audio, which can lead to deeper levels of immersion – a state of deep mental involvement and absorption in the activity at hand (in this case, the activity is playing a game) [5, 23, 36]. For example, a player hiding behind a wall in a game would hear a differently muffled sound than they would hear if they were hearing the same sound standing in an open field; helping the player experience the spatial environment perhaps more similarly to physical, real-life environments. Even the general music of the game could be muffled to communicate this effect. Given this, game consoles are seen as “sound installation spaces” or “surround sound experience that becomes interactive” [45] with the distinction that the final sound mixology work happens through dynamic mixing of sounds similar to an artist’s “vision” for an installation. In other words, consoles, when enhanced with audio hardware, can also involve a larger number of users [45] in these imagined shared spaces.

Particularly relevant to these sound design strategies, it is important to note that immersion and (spatial) presence are very similar concepts but slightly different from each other, at least in the context of this study. Both notions are connected on that for

both, music and sounds are considered “mechanisms of manipulation” [1] that dynamically suspend disbelief [42], facilitating these experiences. This is because music is, in particular, a stimulus that presents emotional congruency to non-linear storytelling environments, deepening immersive experiences [24]. To, however, understand how immersion and spatial presence are often distinguished from each other, consider this as an oversimplified example that differentiates these subjective experiences: a player playing *Solitaire*, being immersed/absorbed in it, might be highly immersed in the game, however, they might not exactly feel that they are a part of the spatial environment of *Solitaire*. A player, however, playing a map-based game, such as *Call of Duty*, may feel part of that virtual environment or at least a spatial understanding of its maps. It is, nonetheless, possible to find a player playing a map-based game, being immersed in it, without experiencing a spatial presence in its virtual environment. The experiential line that distinguishes between immersion and spatial presence is very fine in experience and practice that these experiences often tend to overlap and the distinction between them is mainly for theoretical or design purposes [20, 31, 45]. Although experiences of immersion or spatial presence are often enjoyable, creating an abundance of sound sources, to facilitate immersion and presence, is often confusing for players [27] rather than heightening their positive experiences, which leads to the question of: how to design game music and sound in a way that maximizes player immersion in the game without feeling overwhelmed or disinterested?

Furthermore, as our awareness of the diversity of players increased, sound became more and more employed to facilitate accessibility [1, 5] and thought of as one means to potentially foster the inclusion of individuals of all genders, races and other personal aspects [13]. For example: sound cues could help players with visual impairments be more immersed and better able to play a game. Similarly, a game character that deviates from classical gender sound identities could be more interesting and engaging to individuals identifying as non-binary or transgender. The earlier question then becomes more complicated because it is no longer just a question of how do we balance immersion and the array of sounds a game offers, but, additionally, a question of: How do we design music soundtracks and audio to achieve said immersion and presence across this growingly diverse player demographics?

Universal Design Thinking - or “the design of products and environments to be usable by all people to the greatest extent possible, without the need for adaptation or specialized design” [47], pp. 28 could be an approach to not only understand the distinction between inclusive games and accessible games, but also provide guidelines that aim to facilitate usability and inclusivity of games to everyone. Although the academic literature on the implementation of universal design principles in game design as such is relatively small, it is possible to find some non-academic implementation instances that explain that accessibility, within universal design, is about ensuring that a game is playable for people with different abilities; whereas inclusive games are designed with mechanics that allow all players to feel capable of playing the game while having aspects of their relatively important and distinct personal identities, abilities and cultural contexts etc. recognized and experienced during gaming [13]. For example, the application of Universal Design for Learning, together with augmented reality

game design is a promising approach for engaging and motivating students with different learning abilities that could better benefit from an experiential learning approach [48]. Research in the field of gaming accessibility is in a nascent stage [7] and options for inclusion of people with different abilities in gaming remain scarce at present. A recent literature review of accessibility features to support people with visual impairments in games [23] noted that besides relying on navigation systems (more than 50% of the studies analyzed reported this), the large majority of games intended for e.g., the visually impaired present auditory features, mainly sounds, with rhythm games, simulators, music, audio and arcade games. Inclusive games based on personal aspects are barely touched upon in literature but include, for example, discussion and research of the portrayal of femininity [17] and even the presentation of ethnic characteristics that range from physical features to behaviors in video games [6].

Design for inclusion and accessibility oftentimes presents a paradox: for example, games targeted at players with visual impairment, or mainstream games designed with the inclusion of individuals with visual impairment in mind, may use mainly audio to communicate with the player. They may go as far as not to even offer features (such as video cues), that can include sighted players, altogether, thus creating less than ideal experiences for individuals without visual impairment and excluding individuals with hearing disabilities. The complete reliance on audio in game design “is still uncommon and could be considered as a subculture in itself” [54].

The objective to design a game for inclusion based on disability or personal characteristics, however, is not to create two different games that exist in different subcultures, but to develop games with features that enable players with different abilities to enjoy the same games as their peers do. Inclusion is to be considered as a method to provide multiple paths for use rather than a checkbox [46]. Against this background, we theoretically analyze the academic literature on game sound design, with the objective of presenting research on the perceived role of game sound design and the design of sound experiences for games that are not only immersive but accessible and inclusive.

3 METHODS

Arguably, hearing is the “second most important” sense for humans, as sound contains information that influences our emotions and behaviors in combination with factors such as volume, context, frequencies and pitches. A thematic literature review was performed during October 2020 in order to analyze the literature available on the study topic and to identify key themes. A thematic review focuses on studying the literature in relation to specific research questions, as outlined in the introduction of the paper, summarizing and contrasting the results to provide a holistic summary of the research on the phenomenon of interest [4]. Thematic review is a form of systematic review that is of qualitative and narrative nature. Therefore, it employs selective sampling according to the identified themes in the literature [25].

We used SCOPUS as our main search engine due to its large coverage of peer-reviewed literature. An initial search of the keywords sound AND games returned over 3000 entries. To narrow down the scope of our search, we focused on sound production aspects,

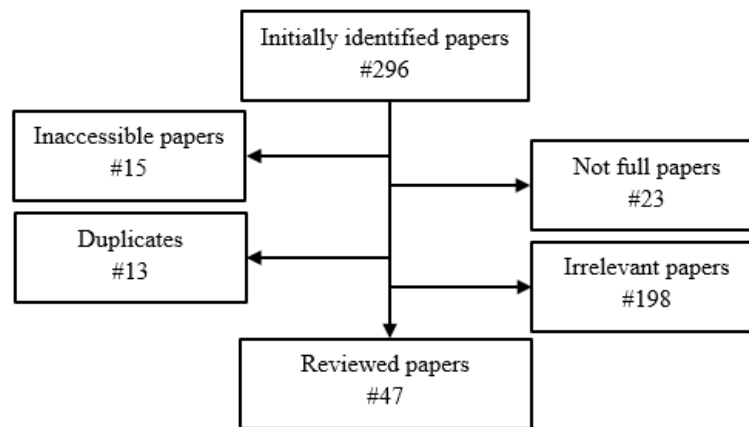


Figure 1: Thematic literature search screening process and outcomes

that is, sound design. Thus, in milieu of our research questions, we performed different searches combining the keywords: *sound, design, immersion, games, accessibility, music, inclusion and games*, yielding a total of 296 documents. The search strings used, and papers yielded were as follows:

Music AND immersion AND games = 54

Sound AND design AND immersion AND games = 52

Sound AND design AND games AND accessibility = 30

Sound AND inclusion AND games = 43

Sound AND immersion AND games = 117.

After the search, all of the studies were screened according to the following selection criteria (SC) to ensure that the results were more accurate and on topic:

SC1: Full text accessible studies (i.e., journal articles and conference proceedings). Other documents such as lecture notes or conference notes, not peer-reviewed, were excluded

SC2: Studies written in English

SC3: Studies whose central theme is music, sound design and immersion in games

SC4: Studies that explore sound design, and inclusion and/or accessibility in games.

The identified studies were individually reviewed by two researchers based on these criteria through examining the title and abstract of the identified publications. Figure 1 presents the screening process. All in all, 47 of the studies met the selection criteria. Next, these studies were analyzed and categorized according to the themes identified in the introduction by two researchers. Following a thematic literature review process [25], the identified papers were categorized according to their focus in at least one of the categories outlined in Table 1.

Next, with the research questions outlined in the introduction in mind, two researchers went through all of the identified papers, extracting answers to these research questions. Both of the researchers reviewed the papers independently, in line with the outlined research questions. During this review process, the authors discussed cases where deliberations were needed in identifying the categories to which a paper belonged or in interpreting its contributions. This was carried out collaboratively through several, lengthy

work meetings and discussions until the researchers developed a settled understanding of how the reviewed literature addressed the research questions under study. Constant dialogue between the researchers was maintained throughout the process, ensuring an iterative and co-creative process. Initial results were next presented, discussed and refined in an academic setting where students and faculty had the opportunity to comment and provide feedback on the research. The results were further reported, discussed and interpreted in collaboration with a third co-author who was not involved in the initial screening and interpretation process.

Thus, the themes around immersion, inclusion and accessibility that emerged from the analysis of the 47 articles included: 1. sound design as the main focus of the game; 2. sound design as an enhancer of the game experience; 3. game audio and its connection to immersion; 4. game audio in relation to inclusion and accessibility. In the following sections, we discuss these thematic findings more thoroughly.

4 RESULTS AND DISCUSSION

While finding accurate, credible and updated statistics on diversity of gamers is challenging for various reasons, such as fear of self-outing, bullying or harassment when potentially self-reporting on stigmatized personal aspects in connection with gaming, some statistics estimate that around 20% of gamers have a disability [33]. This figure excludes minor forms of color blindness that may affect gameplay but are not diagnosed or recognized. It also ignores reading and learning difficulties. Other statistics estimate that more than 90% of people with disabilities play games – that is 90% of around 1 Billion individuals, according to UN estimates, living with a disability [9]. Finding similar estimates on the diversity of gamers in terms of sexuality or gender is harder due to the fear and stigmas around expressing these identities in gaming settings. If these numbers and observed fears say something, it says that this is a high time to facilitate more inclusivity and accessibility in games, possibly through sound design that is the focus of this study.

Sound design research has evolved hand in hand with the sophistication of technology and games. From early studies on how audio creates recognition and provides information to the user, to

Table 1: Reviewed articles according to category

Study focus	Papers	Total
Accessibility	[1][5][7][12][22][23][36][49][50]	9
Inclusion	[54][51][47][46][36][28][17][6]	8
Immersion	[1][2][10][12][14][26][15][17][19][20][21][24][27][29] [30][31][35][38][40][43][44][46][49][50][51][53]	26
Other (i.e., these topics were not a main focus but the papers still contributed relevant findings)	[56][52][45][42][39][37][32][11][8]	9

the design of 3D sonic spaces, to facilitating player presence in virtual and augmented realities. Additionally, the side-effects of auditive experiences, sociological impacts of voicing and sounds, applications for improving learning, monetization from enhanced immersive features, to name a few themes, were also identified in the reviewed studies. These themes and discussion are presented here in three subsections in light of the outlined research questions in the introduction of this work.

Of the 47 documents reviewed, 9 of them explored sound as a means of accessibility, all of which presented solutions to facilitate the gameplay of users with visual impairment. The 8 documents that touched upon inclusion were related to gender representation in video games and outside it, ethnicity representation, cross-media efforts for inclusive learning experiences, and the design of inclusive virtual reality experiences. Moreover, 26 documents concerned immersion related to game music and sound. These articles had some overlap with the key themes that they often were included in one of the other categories identifies, as presented in Table 1. Finally, a fourth category was created for papers that contributed finding connected to the main themes under study but were accessibility and inclusion were not the main focus. This category included papers generally discussing music, sound and their effect on player experience; or sound-based games; music and sound design in games).

One of the main findings of this thematic review, is that despite the increasing efforts to enable accessibility and inclusion features in games, the literature remains scattered across a wide spectrum of topics related to the experience of playing games. Because of its sensitive nature, the research questions are answered as a summary of the findings in the literature reviewed, highlighting the reasons behind the relevance of this topic to the larger research questions investigated by this study. These summaries are followed by a series of reflections for sound designers to consider as part of their efforts to make games more accessible and inclusive.

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4.1 Main purposes of sound design in games

Within the game design realm, and the reviewed literature, it is often important to distinguish the role that the audio is thought to play in games, as that understanding of its role has an influence on how sound is designed and integrated into games (or becoming the game itself). In the reviewed studies, we identified two main themes for game sound design:

As the main focus of the game. For example, an audio game or a game whose main output is sound. It is noted [39] that the aims for designing an audio-driven game are often: immersion, suspension of disbelief; ear-focused experiences; distinguishing between what is relevant for realism and entertainment; and the development of new techniques for audio narration. Games, such as Beowulf, iSpooks, Murky Shooting, and various others, intend to bypass the limits of screen size on immersion and provide an audio-driven game. This seems to be especially relevant to mobile games, which are often played in public spaces due to the flexibility and portability of the play interfaces; they are played with the intention of killing time, allowing the player to drop in and out of game, an attribute connected to “casual games”. Audio design for these games aims to provide a balance between sufficient experience of immersion, while allowing the player to easily disconnect and return to the game whenever they want, a balance that can be achieved faster via auditory stimuli than with any other sense [12, 22, 39]. The design of these auditory interfaces considers three listening modes [22, 32]: casual listening (listening for the source of the sound, attempting to understand what caused the sound - i.e., listening in order to gather information, like the strenuous falling of an object); semantic listening (understanding auditory codes - i.e., listening in order to interpret a message, like using Morse code) and reduced listening (listening to qualities of a sound without considering its source. i.e., listening to the sound itself, like appreciating the harmony and rhythm in music), which, combined, provide “spatialized game soundtracks” that address issues of continuous display, musicality and clarity. In these ways, the discussed soundtracks differ from separated background music and game effect sounds common to other games [22].

Although they follow a similar logic for combining sounds, Virtual and Augmented Realities (VR & AR) take audio games to a presumed higher level of immersivity. These technologies are not often designed mainly just for mobile and portable devices (yet) as they include interfaces that turn the players into “performers”, as they trigger and control music through full body movements. Sensors and game engines are often used to map virtual music sounds onto physical objects in the real world so as to help the

performers create, render, loop, affect or reposition the space of sounds through their motions, expanding their environments, like the A Very Real Looper -AVRL- game [2].

Augmented Reality Audio Games (ARAG), a relatively emerging genre of games found in the reviewed literature, can include “sonic targets” and help players to get used to auditory navigation and gestural sonic interaction. This level of immersion considers not only sound design, but also the fidelity of audio augmentation, environmental conditions and synchronization of sounds and gestures as relevant for an impactful, immersive auditory experience [43]. Other design elements needed for audio games include clear navigation controls connected to individual sounds; atmospheric noises for different stages of the game, like “ambient bits” when the player needs to make decisions; the latter draws from musicalization for narratives rather than games or storytelling [39].

As an enhancer of the game experience. “Sound augmentation for digitally enhanced play” [28] has been allocated to this category. Balancing functionality and aesthetics come across as one of the main challenges for auditory interfaces design; it is important for audio to provide meta-level information to achieve the necessary complexity for a game to be engaging while providing elements of open-endedness [22]. While sounds can evoke emotions and sensations related to weather and surrounding activities in gaming, they also need to be adequate for providing the sensation of space, which is much more of a visual, rather than an auditory, characteristic. For example, one of the reviewed studies [28] indicated how children develop a different relationship with sound by making it the object of play with the help of a bracelet that augments environmental sounds of everyday life. This gadget showed how gaming with sounds seems to influence social and physical behaviors by triggering the imagination and increasing immersion. This “SoundWear” wearable revealed how the ability to pick and customize sounds help to develop and communicate personal identities, express ownership and embodiment [28]. Similar results have been reported with relatively simpler AR gaming without wearables [8]. Audio landscaping can also concentrate on “human values” rather than game mechanics, via e.g., dialogue and effects that are emotive and suggestive [39].

The “fragmented narrative” approach to game design [39] discussed in the reviewed literature gives partial explanations of the game elements and backgrounds of the characters through a strategically designed combination of audio and video that aims to provide just enough information to stimulate the player’s imagination and interpretation of events as part of the game. While this approach diminishes the designers’ control over the game narrative, it empowers the player to feel connected to the story they are creating while playing. Auditory feedback can also strengthen the interactions between games and players [12]. An example of this can be found in exergaming with music either synchronized or asynchronized to the activity, influencing player performance and perceived effort for the same performance, as well as enjoyment and motivation [21]. This finding is consistent with the results of other experiments, where players can substitute original game music with a personal playlist uploaded into the videogame, improving their gaming tactics or relieving their anxiety, although, they were unable to predict the music that would improve their immersion as

such, even though they wanted a soundtrack to accompany them in their endeavors [53].

This line of research also shows that when it comes to the enjoyment of the playing experience itself, background factors such as age, gender, or even gaming skills and music knowledge, play an insignificant role [15, 38, 53]. The dexterity to operate the devices that enable play is another story. With the exception of discussions on how to keep interfaces simple, yet engaging for audio games on small screens, none of the studies addressed the topic of the size and physical characteristics of the devices in more detail.

These findings lead to pondering the ways through which sound design can be improved to better facilitate inclusion and accessibility. Including the end users (people with different abilities) in the design process is the logical first answer [16]. There is little information, however, on how many of the games reflected upon by the reviewed research involved the end players at the very beginning of the design process and not only for prototype-testing options.

4.2 The influence of game audio on immersion

Some of the main aims of sound design are influencing the players physiologically, psychologically, cognitively, and/or behaviorally [1, 30, 31] so that they are more immersed i.e., absorbed in the game. Psychologically, sound can engender feelings of happiness, nostalgia, tension, or suspense. Cognitively, it can help the player concentrate on the game. Behaviorally, since sounds, and especially music can cognitively absorb players, they could lead the player to spend more time playing, seek the music soundtracks on other platforms or market the game to friends and family because of its engaging music. Although studies and techniques to measure these impacts keep emerging, this work mainly seems to have started after 2010 and is increasing in pace today. Several earlier studies on the relationship between video gaming experience and music noted a negative effect between different auditory conditions (with, without and music only) and performance in a game [6, 20]. Moreover, gender and age seem to have a statistically significant influence on experiences of presence facilitated by music [31]. At around the same time, the design of audio games started to take off, however, just mainly as an alternative to involve players with visual impairments and even explore tactile interactive multimedia for games to be designed as an auditory experience but only for the same group [22].

A shift in this perception of the purposes of audio game design and its impact, however, started to occur, as documented in the last section, perhaps coinciding with the popularity of mobile gaming and casual gaming. Audio (music and sound) started to be perceived as a facilitator of gaming, as means to reconnect the players to their gameplay and even as a main facilitator of games for a wider range of individuals beyond the visually impaired [12, 22, 39]. Positive and immersive emotional responses to game music came to be more prevalently discussed in the reviewed literature, such as how music and noise can influence the perception of pain [19]. Comparing algorithmically generated (using a stochastic model that describes sequences and probabilities of events known as Markov chains) background music with humanly-composed music, an experimental study concluded that algorithmic music “reinforces cognitive aspect of immersion, whereas composed music is linked to higher

aesthetic and emotional aspects of immersion” [38]. A study on educational games reported higher levels of information retention and understanding of content with music than when there was no music as music supported the creation of an immersive, virtual learning environment that supported learning [20].

Nonetheless, means for systematically measuring the impact of game audio on immersion or other psychological experiences at large (e.g., flow, gamefulness, playfulness) remain challenging and rare. For example: a recent experimental study [19] measuring the reaction to pain while playing challenge-based games, shows that the observed positive physiological reactions were more connected to the challenges of the game rather than the type of sounds accompanying the game. This study highlights the complexity of measuring the impact of sound on player experiences and highlights a methodological gap observed in the reviewed literature where the cognitive (e.g., ability to concentrate on tasks), affective (e.g., emotional responses such as happiness, sadness, tension) and psychological (e.g., immersion or flow) impacts of audio are not measured. For example, studies [10, 26, 35] related to First Person Shooter (FPS) games concluded that even if the sound or the music of the videogame do not seem to affect electrodermal activity and facial muscle activity, psychometric experiential measures of the players through a questionnaire filled out by the participants of the experiment revealed a significant effect for immersion, tension, competence, flow, negative and positive effects, and experiences of challenge.

The structural and expressive methods used for the dynamic implementation of music into video games, are still short of results related to how these sound-immersive experiences and soundscapes (digital environmental sounds) are processed at the user’s end [24] or its impacts on believability [15], flow and self-location; or even behaviors related to risk-taking or prior knowledge about the game. There is evidence that music effects and tempo, as well as experiences of mastery and challenge are related [42], however, user-centric audio design requires further exploration [12, 19, 35] to uncover causalities rather than correlations as is the current state of research.

4.3 Enabling player accessibility and inclusion through audio

It is important for designers to consider the implicit (and oftentimes explicit) sociological messages that their designs can communicate. For example, over-sexualized auditory depictions of female stereotypes denote a ‘mediated emotion’ of women being weak, sexualized, disempowered, and victimized, enrooted from pornography [17]. Facilitating an inclusive space for women in games requires game designers at large, and audio designers in specific to this study, to re-examine social issues and communications that go beyond the technical aspects of characters’ voice over. They are encouraged to consider gender embodiment and cultural norms as “the mediated voice at the intersection of technology, history and discourse” [17]. Designing for accessibility and inclusion requires a shift of mindsets - from trying to make the players follow one narrative, to opening the games for players to create their own narratives according to their own capabilities.

During the last decade, video gaming has seen a remarkable growth globally. Simultaneously, gamification and educational games have been increasingly utilized as a way of enhancing learning and fostering engagement with game-like designs in non-gaming contexts. However, in most cases, gaming technology in, both, entertainment and education fail to take into account disabled users [5, 36], or users different from the mainstream at large. As a solution, audio feedback, as a means of navigational aid, has been suggested for the inclusion of visually impaired users (i.e., individuals with low vision; color-blind; or blind) [5, 36].

Moreover, a set of recommendations for accessible game design has been introduced to ensure that both the sighted and visually impaired individuals are able to play a game [36]. The recommendations include e.g. high contrast between text and background and that no essential information is conveyed only by color. The genre of audio games, which were found to enrich the lives of people with and without impairments through creativity and social exchange [50] also emerged as inclusionary means. For example, the customization of virtual environments is an approach that helps provide safe spaces for training and developing skills, such as an audio-based game for blind children that provides cues to localize audio sources in 3D spaces, teaching spatial orientation and laterality for interacting with objects [1, 49].

Regardless of these few studies that focused on visual impairment, the reviewed literature revealed a lack of research or conscious consideration of both accessibility and inclusivity in sound design practices. However, the reviewed literature increasingly notes a need to take advantage of sound technologies for facilitating accessibility and inclusion in practice [5, 36, 50].

While many of the academic studies reviewed focus on technical elements like engineering software [7, 22, 36], or even the emotional toll in some of the actors voicing the games’ characters [17] there was nothing on the operations of a game design enterprise, such as having a person solely focused on handling accessibility and inclusion matters (i.e. “Accessibility Manager”). This practice is mentioned as part of this reflection because some of the non-academic sources consulted noted the increasing relevance that this figure plays for design purposes [18, 26].

5 CONCLUSION AND FUTURE RESEARCH

This thematic review of research on sound design for games aimed at answering the question of how does sound design contribute to the facilitation of immersive and inclusive experience (in terms of accessibility and social aspects like gender) in games. With this end in mind, section 4.1 provided a context for the purposes of sound design in games. Throughout section 4.2 we discussed how games’ music and sound impact immersion. The results presented in section 4.3 showed ways in which sound design can enable player accessibility and inclusion.

Overall, this thematic research presented how the sophistication of auditory technology goes hand in hand with increased considerations of the role that sound plays for games. It highlights differences in auditory experiences design approaches according to the purpose of the game. Narratives, plots and expected user perceptions and experiences while playing are crucial for developing the types of sounds to be embedded into the game interfaces and storylines,

all of which collectively aim at affording higher immersion and enjoyability to users and players.

Despite the increasing number of studies related to accessibility and how sound design can make games more inclusive, the very small body of literature addressing inclusion as the objective of sound design (or even other design attributes of the game) shows that there is still a need to explore more possibilities to bridge these gaps, such as pertaining to the application of Universal Design principles to the creation of video games beyond features for accessibility. Other inclusion topics, such as around gender and culture, were surprisingly hardly, if at all, covered by the reviewed research. We encourage game designers to examine implicit and explicit messaging in their game narratives together with sociologists or people who perhaps are not game experts per se but can offer constructive feedback for portraying characters and storylines that diminish discrimination within and outside game worlds. For future research, we suggest studying how the seven principles of Universal Design were, or could be, reflected in literature and practice, as they represent a relevant approach to designing inclusive games, making them approachable and customizable to the users, “providing a more meaningful and engaging experience” [46].

Inclusion is an area that covers accessibility to a wide array of people with different abilities that range from physical to mental. Due to the scope of this study, time available and space limitations, a systematic literature review was not conducted, but rather a thematic one, as these niche topics were expected to be hard to identify without a thematic process explicitly and systematically dedicated to their identification and examination. Thematic reviews, by their nature, exhibit relatively greater levels of subjectivity and lack of systematization, which are its strengths, but also a limitation. They allow researchers to seek answers to specific, pertinent research questions through interpretivism and assimilation of knowledge from different sources which are not as easily attainable through more systematic review methods. Additionally, we only used one database (Scopus) which may have limited the number of articles available. We encourage researchers to widen the scope of this search to other databases and to explore the use of systematic review methods. Our initial findings are merely an invitation to explore various other avenues that connect implications for education, social interactions. As the world is simultaneously moving toward increased utilization of games and game-based design as well as digital and online tools, this is a high time to research and foster accessibility and inclusion in games and game-based design. For example: as online learning tools are increasingly becoming a main method of education, if these tools are inaccessible and exclusionary, as is often the case nowadays, they would negatively impact the individual lives and experiences of many people.

We further encourage researchers to investigate accessibility and inclusion efforts, whether through sound or other means, in game-based, gameful and gamified applications that borrow their designs from games. We encourage not only the utilization of review methods to understand the current state of the art but additionally qualitative, quantitative, and experimental methods to understand how to uncover new means to foster accessibility and inclusion in these designs as well as in games.

As much as we would like to end this article with a musical note, we are limited by today’s technologies. Therefore, we appeal to the

reader’s imagination when invited to sing out loud “*the hills are alive with the sound of music!*”

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