



# Immersion or Disruption?

## Readers' Evaluation of and Requirements for (3D-)audio as a Tool to Support Immersion in Digital Reading Practices.

Iris Jennes

Researcher, Vrije Universiteit Brussel,  
imec-SMIT  
iris.jennes@vub.be

Elias Blanckaert

Junior researcher, Vrije Universiteit  
Brussel, imec-SMIT  
elias.blanckaert@vub.be

Prof. Dr. Wendy Van den  
Broeck

Senior researcher and professor, Vrije  
Universiteit Brussel, imec-SMIT  
wendy.van.den.broeck@vub.be

### ABSTRACT

In this paper, we aim to contribute to the understanding of how readers experience immersion in digital reading experiences, more specifically with digital reading supported by (3D-)audio tracks. We formulate user and content requirements for implementing (3D-)audio soundtracks for readers in a digital reading application. The main research question addressed in this paper is: (how) can audio aid the immersion of readers in digital fiction stories? To answer this question, three online focus group discussions were organised in Belgium and Germany. As part of the set-up of the Horizon Europe project Möbius, 18 participants tested different 3D-audio tracks while reading via the Thorium Reader application. The results first address how participants define immersion, and how the role of audio in immersion can become paradoxical. Then, the paper presents a detailed evaluation of the factors enabling or disabling immersion for the specific 3D-audio tracks, and how these insights can be implemented in reading apps via user and content requirements.

### CCS CONCEPTS

• **Human-centred computing**; • **Human computer interaction**;  
• **HCI design and evaluation methods**;

### KEYWORDS

3D-audio, immersion, phenomenological immersion, digital reading, technical immersion, reading practices, online focus group discussions

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### 1 INTRODUCTION

Extensive research has been conducted on reading and reading practices in a digital era [8],[10],[13],[22],[24],[25],[29],[33],[34],[35],[37],[50],[56]. Many authors have scrutinized the relationship between reading and the use of digital technologies, asking whether digital media displace or complement reading (books) as a leisure activity [22],[29]. In addition, studies have also revealed the differences readers experience when reading on paper, e-reader or tablet, or via audiobooks [20],[25],[37],[50]. Perhaps surprisingly, many readers still prefer paper books for in-depth reading [8],[35]. Spjeldnaes and Karlsen [50] state: “On the one hand, the central tendency is that the essential titles should be on paper. On the other hand, the affordances inbound to e-books and devices come with a great practical advantage to many readers, most notably those who read the most. Notably, no one seems neutral on the digital reading of literary texts.” However, Liu [35] noted a more general change in reading modes from ‘in-depth’ reading on paper to ‘browsing’, ‘scanning’, and ‘key word spotting’ in digital media, referring to different types of engagement with digital or paper texts.

Mangen [37] and Mangen & Kuiken [38] stress the importance of understanding how materiality influences narrative engagement, including ‘transportation’ or ‘immersion’. This provides an interesting perspective on how immersion can be triggered by both materiality and content. The type of immersion triggered by digital devices – referred to as ‘technological immersion’ – is opposed to the type of immersion triggered by reading paper books – defined as ‘phenomenological immersion’. Handling a paper book triggers a mainly hermeneutic relationship with the reader, meaning that the written text appeals to the fantasy of the reader to imagine the reality that the books take place in. In contrast, reading on a computer elicits an ‘alterity relation’ between reader and technology, meaning that the technology itself is part of the relation and acts as an agent in the fantasy, like an opponent in a game. Mangen [37] states: “When reading a hypertext fiction, however, the combination of the intangibility of the text and the prevalent haptic affordances of the computer make our hermeneutic relation – and hence phenomenological immersion – highly vulnerable to being captured by the haptic affordances of the computer and, hence, making us relate to the computer in a primarily alterity rather than hermeneutic relation.” As such, Mangen explains the challenges of achieving ‘transportation’ or ‘phenomenological immersion’ when reading on a digital device. Many initiatives already aimed to enhance the reading experience, both on paper and digitally. Interesting examples include interactive

books [14],[23],[31], digitally enhanced real books such as the MagicBook [9], the Listen Reader [6] and the Mixed Reality Book [21]; as well as augmented digital books such as the HE-Book [42]. The question remains however, how digital reading technologies can aid the reader in achieving ‘transportation’ or (phenomenological) immersion.

While the above-mentioned research is not always explicitly linked to overcoming the challenges of ‘immersion’ or ‘transportation’ [3], it is clear that immersion influences the user experiences and plays a role in the users’ acceptance of these technological innovations. Existing literature focuses on enhancing digital reading through multisensory cues where audio is implemented alongside interactive and/or visual cues [28],[42] on the role of audio immersion for reading as a learning activity [30],[33] or on the comparison of experiencing e-books, paper books and audio books [25]. Few studies focused on the role audio itself can play in enhancing (phenomenological) immersion for digital reading as a leisure activity. In their study on sonified reading on a mobile device Goldstein, Öquist and Björk [19] found that the users’ subjective rating for immersion was significantly higher when the reading experience was sonified. In their conclusions, Goldstein et al. [19] differentiate between the effect of realistic (ambient) sounds and dramatic sounds. The first they assume would increase the immersion in a story, whereas the latter would give the reader insights in the emotions of the characters: *“A realistic soundscape enhances the reading experience by adding information that brings more detail to the description of the physical environment, e.g., playing the sound of a seagull when events in the text take place at a harbour. By giving more detail to the place described in the text, one can assume that users have a greater possibility to feel immersed in the story. In contrast, a dramatic soundscape increases the reading experience by providing additional information about characters’ internal emotions and reactions or by creating dramatic tension.”* In addition, Holenderski [26] has investigated the role of adding dramatic soundtracks to digital text but found no influence on the readers immersion and indicates that the set-up could be improved, and the choice of soundtracks (dramatic, ambient sounds, narrator) could be extended: *“The opportunity of adding dramatic soundtracks to e-books is still alive and is worth a while to explore further by implementing an interface which gives control to the reader in a unobtrusive way and maybe even choice of soundtracks.”*

In this paper, we aim to contribute to the understanding of how readers experience immersion in digital reading experiences, more specifically with digital reading supported with audio tracks. We formulate user and content requirements for implementing (3D-)audio soundtracks for readers in a mobile application. Thus, the main research question addressed in this paper is: (how) can audio aid the immersion of readers in digital fiction stories? To answer this research question, we first provide a theoretical framework that explains (1) changing reading practices in light of digitisation, including differences in reading experiences from paper to audio and screen; (2) the concept of immersion and what triggers immersion for readers; (3) the possible role for audio and 3D-audio to achieve immersion. 3D-audio is known for its ‘immersive’ qualities, in comparison to ‘surround sound’ audio set-ups [47]. Following the theoretical framework, we describe the qualitative approach to our empirical research: online focus group discussions with avid

readers to evaluate digital text accompanied by a 3D-audio track. Then we present the results by discussing the participants’ definition of immersion and requirements for (3D-)audio with digital text. Finally, we conclude with an overview of the requirements and we discuss further research opportunities to assess immersion through audio tracks.

## 2 THEORETICAL FRAMEWORK

### 2.1 The Rise of New Media

Reading has always played an important role in accessing information and consuming stories. However, since the last two decades of the 20th century, we have seen radical changes in the way people consume stories and the way they interact with media. Visual media and computer media are said to generate more interest than reading literature. People are becoming increasingly familiar with new screen media, whereas print and audiovisual media were the media to receive information and consume stories in the 1970s [29],[48]. In the last few decades, we have witnessed a revolution of new media technologies [13]. Growth can be seen in digital media markets such as video games, video-on-demand, digital music and ePublishing. One of the fastest growing types of media consumption is subscription-based video on demand services (SVoD) like Netflix. These services are still in the early stages of expansion in Europe. Market research from Statista [51] shows that in 2017, the number of European SVoD users was 147.8 million. This number is expected to grow to 171.8 million users by 2024. These developments have resulted in people having more choice in their media repertoires. With so many new options for media consumption, it is worth examining whether these media are in competition or converging with each other.

### 2.2 Competition or convergence between old and new media

Research on reading turns out to be complex. The perspective from which researchers look at reading behaviour of people, has an impact on the outcome. Depending on market research of book sales, it could be argued that people in Europe are reading less [15]. In Germany, for example, the number of book buyers dropped between 2013 and 2017, with the number of book buyers in the 20-49 age group dropping by 30% [12]. In Italy, the same phenomenon can be seen between 2017 and 2019. The number of people in the 18-24 age group declaring they read for at least one hour a day fell from 23% to 13% [5].

Studies on the number of hours people read show that a growing number of people do not read books at all in their leisure time. This implies that the number of non-readers has increased [54]. Some studies express a fear that people would spend more time on visual and digital media in their leisure time than on reading books: the use of traditional media would decline as a leisure activity due to competition of new media [18],[52],[54]. In contrast, there is also another theory that rather assumes convergence between old and new media. The new media would increase interest in print media [44]. For instance, IT would act as a time enhancer, as IT users would be more productive in their use of time, which would also enrich their use of old media such as reading books [45].

Looking at possible competition between media, research of Johnsson-Smaragdi and Jönsson's [29] and Altun, Tantekin Erden and Hartman [4] show that television and books do not compete with each other. This means that watching more television would not lead to less book reading. One reason for this would be that these media have different functions for different users. This finding is not consistent with research from Fernandez-Blanco, Prieto-Rodriguez and Suarez-Pandiello [18] and Suárez-Fernández and Boto-García [52], who found that television consumption has a negative effect on book reading, meaning people who watch television will show less interest in reading books. Available research shows that Internet use does not cause a decline in reading. Internet users would even spend more time reading than non-internet users [44]. In the next section, we take a closer look at reading and readers' practices.

### 2.3 A closer look on readers and reading

Since this paper has a strong focus on readers, it is essential to take a closer look at readers and their reading behaviour. Previous research about readers has shown that interest in books and the amount of time spent on reading books are related to gender [36],[52], age, education [18] and social background [39]. In terms of gender, it appears that girls are more likely to read books than boys [36],[52]. When it comes to age and education, Fernandez-Blanco, Prieto-Rodriguez and Suarez-Pandiello [18] argue that young and old people most often belong to non-readers, while highly educated people are least likely to be a non-reader. Regarding social background, the home environment of children appears to be important for reading books. Children whose parents read to them have a greater interest in written language. In addition, children whose mothers are more educated are also more interested in reading [39].

Regarding people's reading behaviour, the kind of literature people read depends mainly on gender and age. In terms of gender, Thums, Artelt and Wolter [53] show that women read mainly for entertainment. This contrasts with men, who read more educational material such as non-fiction books and newspapers. Concerning age, market research of Okuyay Platform [41] shows that adults read on average more than 4 books every 3 months. They prefer reading fictional books with genres such as history, adventure and romance. College students read a book once a month. The most read genres for college students are romance and psychology [49]. Based on these findings, it appears that reading behaviour is strongly dependent on gender and age.

Considering how people read, the share of e-books and audiobooks in the European book market is growing. In 2011 it was only 1% for e-books [17] while the share had risen to 12,6% by 2021. As for audiobooks, the share has risen as well. In 2021 they represented 2,5% of the total turnover. For example, in Finland the share increased by 200% between 2019-2021. In Italy, it increased by 166.7% [16]. However according to the European book market statistics, collected by the Federation of European Publishers [16] this means that in 2021, printed books still generate the largest turnover (84,8%). These figures are consistent with what was found in the studies by Liu [35] and Baron [8]. Both studies found that people still prefer to read printed text rather than e-books. As mentioned in the introduction, reading via printed text is characterized by more in-depth reading and concentrated reading. While screen-based

reading is characterized by more time on browsing, scanning and keyword spotting. In addition, people like to annotate and highlight when they read. In the printed environment, this is often done. This contrasts with reading on a screen, where this is almost never done. With more and more people reading via electronic devices, the screen-based reading behaviour is emerging. We are thus heading towards a less attention-intensive way of reading [35]. This less attention-intensive way of consuming a story is also visible with the consumption of audiobooks. Audiobooks are consumed along with other activities such as driving a car, working in the house or in the garden or performing other physical tasks [50].

### 2.4 Materiality affects reading experience

As mentioned, reading today can take different forms as the reader can move from one medium to another and thus interact with different media-specific forms of expression. The materiality of the media thereby provides a different kind of reading experience. Research proves that the level of concentration of readers depends on the media's material. People are more concentrated when reading via printed books compared to reading via e-books or audiobooks [1],[8],[50]. Baron [8] argues that people who read via a screen are more quickly distracted and thus absorb less information. The same is true for audiobooks. Spjeldnaes and Karlsen [50] concluded from their research that audiobooks are more suitable for literature that does not require much concentration, as listening is less attentive than reading. According to Ackerman and Goldsmith [1], the comprehension of the text in digital reading would be lower than reading on paper due to people reading faster digitally than on paper. This supports the browsing, scanning and keyword spotting via screen-based reading that Liu [35] pointed out in his study.

The materiality of the media also has a big impact on the navigation. Printed book readers find it easier than e-book readers and audiobook listeners to find information back in the text [50],[55]. E-books and audiobooks impede the reading/listening experience because people cannot judge quickly enough where they were in the text. In a study of Mangen and Kuiken [38] e-readers generally reported more temporal dislocation within the text than printed books readers. An explanation for this would be because the sense of location of readers of printed books is enhanced by the tactile cues that printed books provide, making it a more convenient way to remember the text.

The benefits of e-books lie in the ability to look up words through dictionaries or web pages [8]. Children often use this to look up words they do not understand [33]. Audiobooks are appreciated because of their ability to use them during other activities [50] as well as by serving as an example of good pronunciation of the words in the text [33]. E-books and audiobooks can thus operate as means of language learning.

By extension of print books, e-books and audiobooks, a lot of other media products have been developed to consume information and stories. One example is the HE-Book by Rahman, Alam and El Saddik [42]. It is a special type of e-book reader, which delivers vibrotactile feedbacks in the user's reading experience. Through the use of a sofa and a jacket, vibrotactile haptic feedbacks will be provided during reading in accordance with the content. Another example is the mixed reality book by Grasset, Duenser, Seichter

and Billinghurst [21]. The content of the book is enriched with 2D graphics, video and 3D animations and spatial (3D-)audio. What these technologies have in common is the intention of a more immersive reading experience.

## 2.5 Immersion or transportation in the context of reading

It is clear that the level of ‘immersion’ or ‘transportation’ largely determines the reading experience. It is therefore paramount to define ‘immersion’ in the context of reading and digital reading experiences. In the context of reading and digital text, more emphasis is put on the duality between technological and mental aspects of immersion. Mangen [37] and Mangen & Kuiken [38] emphasise in their work how the materiality of media affects the transportation or immersion. Immersion or transportation can be seen metaphorically as ‘getting lost in a book’. The reader becomes temporarily isolated from the real world [7]. Mangen [37] talks about two different types of immersion. The first is called technological immersion. This kind of immersion is triggered by digital technologies (e.g.: when playing computer games). People get a sense of an immersive virtual world, largely created by the technical features and physical equipment (eg: headsets) involved in its display. The second type is called phenomenological immersion. In this kind of immersion, readers enter a fictional world that is largely the product of their own cognitive ability to create a virtual world out of symbolic representations. In order to have phenomenological immersion, Mangen [37] argues that our cognitive capacities should be fully occupied to prevent us from devoting too much cognitive attention to other tasks. The work of Mangen and Kuiken [38] is in line with this since it states that (phenomenological) immersion is only possible when the technology does not draw attention to itself, but to the narrative. In contrast to reading a printed book, an e-book often involves haptic interaction with the device, in the form of links via text and icons. This makes readers devoting attention to get redirected via text and icons, which makes phenomenological immersion difficult. With a printed book, the reader is not redirected via text or icons. Our intentionality is mainly focused on the narrative itself and not on the technological object as such, which makes phenomenological immersion more possible. The same finding can be seen in the work of Gorinchanaz [20]. His study shows that (phenomenological) immersion was most noticeable with paper books. Paper book readers had a deeper internalisation of the books and were more engaged. Audio books and e-books were harder to follow which negatively affected the feeling of immersion.

Mangen [37] states that the kind of immersion a user experiences, is implicated by the relationship between the technology and the user. Ihde [27] discusses three types of human-technology relations: embodiment relations, hermeneutic relations and alterity relations. In embodied relationships, technology is seen as an extension of the body. It is seen as a means through which people can experience something else rather than the technology in itself. In fact, the technology only comes into focus when it malfunctions or is missing (e.g.: eyeglasses or contact lenses). Hermeneutic relations are also experienced as a means through which something else can be experienced. However what people then experience is

not their immediate living world, but rather a representative artefact. Hermeneutic relations thus enable a represented world. This transformative relation is therefore more noticeably present as a mediator than embodied relations. A paper book has a hermeneutic relationship with the reader. Namely, based on the written text, the reader uses his imagination to picture the reality in which the books are situated. A hermeneutic relationship between the technology and the user can trigger phenomenological immersion. In alterity relations, technology is seen as ‘the other’. In contrast to embodiment relations and hermeneutic relations, technology finds its main fulfilment in its interaction with the artefact itself. Reading on a computer can be seen as an alterity relation between reader and computer since the computer acts as an agent of the reader’s fantasy. An alterity relation between the technology and the user can trigger technological immersion.

In other fields, the concept of immersion refers to technical, as well as bodily, and mental aspects of an experience. Schettino [46] and Agrawal et al. [3] define of ‘immersion’ as a combination of (1) a mental state: described as flow or focus as well as and transportation (or being inside a story); (2) a sensory experience: described as a sense of presence (being in another place), as well as embodiment (having all senses involved); and (3) an interactive experience: described as interactivity (or acting in a space and playing with other actors). It seems that technological immersion as described by Mangen [37] and Mangen and Kuiken [38] aligns with the sensory and interactive experience described by Schettino [46] and Agrawal et al. [3], whereas the phenomenological immersion aligns more with the mental state.

## 2.6 The role of audio in digital reading

The previous sections have clarified that immersion affects the user experience and plays a role in the user acceptance of technological innovations in the publishing sector. In this section, we address the role of audio in immersion, specifically for digital reading experiences. Research shows that when audio is added alongside textual or visual cues, digital reading is enhanced [28],[42]. The work of Rahman, Alam and El Saddik [42] indicates that audio, in the form of a narrator reading the text aloud, together with haptic and visual cues, can improve the reading experience. Furthermore, Issaev, Zahiri, Cao and Lu [28] argue that sound effects or background music are preferred over no audio. However, background music is valued more than sound effects because background music does not affect the user’s reading speed. In addition, background music would also provide more emotional context than sound effects. As a requirement for audio to make a positive contribution to the reading experience, the researchers argue that the audio should match the atmosphere of the story and that it should meet the user’s expectations in terms of quality.

Regarding audio-immersion for reading as a learning activity, Larson [33] argues that adding audio to the regular textual reading experience improved students’ learning activity. Students’ reading stamina improved, allowing them to read more and longer. This finding contradicts the research of Kalyuga [30], which suggests that adding audio to visual text negatively influences learning activity. The reason given by the author is that auditory addition causes working memory overload. This working memory overload often

occurs in circumstances where different sources provide similar information at the same time, but in a different form. According to the author, the auditory and visual cues would each produce more learning activity separately than when presented together.

Goldstein, Öquist and Björk [19] investigated what role audio itself can play in enhancing (phenomenological) immersion for digital reading. Their study found that the reading experience was considered more immersive when audio was added to the text presentation. Although the study used a realistic soundscape (e.g.: playing a seagull sound when an event in the text takes place in a harbour), the researchers suggest that a dramatic soundscape, which provides information about the characters' internal emotions and reactions, enhances the reading experience even more. Although research still needs to be done on these aspects, the sense of excitement and stimulation would be higher with a dramatic soundscape compared to a realistic soundscape. However, Holenderski and Hu's [26] findings on enriching reading experiences with dramatic soundtracks indicates that soundtracks do not have an enriching role during reading per se. The main factor that led to the negative reading experience in Holenderski and Hu's [26] study was that the soundtracks were perceived as more distracting by the respondents. More specifically, the soundtracks were not perfectly timed and were introduced too slowly. The sudden transition from quiet to loud and vice versa was also distracting. Moreover, respondents felt that the mood of the soundtrack and of the passage were not well matched. To improve the reading experience, the researchers argue that the user should have more control over the audio. For instance, the user should have control over the loudness of the music and the choice of soundtracks. To avoid sudden transitions in terms of audio, they suggest working with a soundtrack that plays throughout the story. This shows there is a future for adding (dramatic) soundtracks to e-books and that it is worth exploring further. At the same time, because the results of Holenderski and Hu [26] and Goldstein et al. [19] seem paradoxical, it is therefore important to understand why audio is sometimes experienced as distracting or immersive, and what factors influence this experience.

## 2.7 Stereo, surround-sound, and 3D-audio

When scrutinizing the role of audio in immersion, it is relevant to also address the technological developments in the field of audio. In recent decades, we have witnessed an evolution of spatial representation of audio signals from simple two-channel stereo to surround sound, to 3D-audio. In the case of two-channel stereo, there was only a left and right speaker effect. With surround sound, the set-up was improved by including multiple loudspeakers in the front, on the side, and/or in the rear. On top of the surround sound set up, 3D-audio adds a height dimension by adding elevated speakers to the setup. This would provide even more spatial immersion to the listener. Schoeffler, Silzle and Herre [47] examined how basic audio quality and quality of experience were perceived by listeners for the different audio set ups. For the 3D-audio set up, both basic audio quality (timbral and spatial audio quality) and quality of experience were rated highest.

In general, 3D-audio quality has been assessed in the context of immersive experiences and gaming. One example is the study of Rieger and Zingler [43] that focusses on the contribution of 3D-audio on realism in gaming. They found that 3D-audio can “help

players experience sound like in real-life” but is not as suited for narration or music: “While 3D-audio is a fantastic tool in the game developer's toolkit, if it is not used carefully, 3D-audio can become distracting. For example, mono playback is still favoured for narration and stereo is preferred for music. The reason is that when wearing headphones, you'll localize the sound within your head, not around you. This is called inside head locatedness (IHL). This is where the sounds waves traveling from the left and right loudspeakers meet – inside of our head.” The authors thus suggest that different types of audio tracks need different standards to prevent distraction and suggest that 3D-audio is put forward as more suitable for a ‘realistic soundscape’. Based on the aforementioned studies, we would suggest that there seems to be a link between the spatialization of audio and the type of immersion that is triggered: Rieger and Zingler [43] mention that 3D-audio narration works better if the narrator is personified in the game, which is in line with technological immersion, calling for an alterity relation. In contrast, the ‘issue’ of the inside-head locatedness [43] seems to refer to a hermeneutic relation, a mental image rather than an in-game character. However, it is unclear how these findings would translate to the context of digital reading practices. To our knowledge, there is no literature on immersion and 3D-audio concretely in the context of (digital) reading.

We aim to contribute to the understanding of how readers experience immersion through (3D-)audio in digital reading experiences. In the next section, we discuss the set-up of our empirical research to gather input on the participants' definition of immersion, evaluation of the audio tracks that accompany a (short part of a) fiction story, and requirements for (3D-)audio in reading applications.

## 3 METHODOLOGY

Because the research's aim was to gather in-depth insights into personal experiences and opinions, a qualitative approach was used [11]. Here, it is important to note that we aim to look beyond the evaluation of individual audio tracks as such, instead we want to identify which elements influence the participants' evaluation. This is paramount, as the research question refers to gathering requirements, thus overcoming individual needs of users of a technology, and defining common ground in contrast to personal preferences. Because of this focus group sessions were selected as the ideal method for data gathering [32]. As Acocella [2] indicates: “*The interaction allows the participants to clarify individual opinions and to compare positions [with] each other; at the same time the group synergy can favour the production of a plurality of positions and stimulate participants (...), thus allowing to raise inter-subjective representations.*”

Research activities took place in context of Möbius, a European Horizon 2020 project. Because of the international character of Möbius as a European project, the set-up required getting access to geographically dispersed target groups, which led to the decision to host these focus groups online [2],[40]. The research question posed in this paper is part of the first pilot phase within the Möbius project. Below, we discuss the set-up of this first phase, using online focus group discussions to gather (1) in-depth insights in the reading practices and (2) requirements for (3D-)audio combined with digital reading via mobile devices such as smartphones and tablets.

As mentioned, the nature of the research question and the stage of the research required the gathering of in-depth insights rather

than broad, representative data. Thus, a convenience sample was used to reach ‘avid readers’, a target group that would have affinity with the subject at hand [2]. A call for participation was shared via the Möbius social media accounts (LinkedIn), via the researchers’ personal accounts, and via email to students enrolled in the department of ‘Media & Communication Studies’ at the Vrije Universiteit Brussel (Belgium) and Media Campus at MVB (Germany). Group discussions were held online in Belgium (conducted in English on the 14th and 21<sup>st</sup> of February 2022) and in Germany (conducted in German on the 3<sup>rd</sup> of March 2022). A total of 18 participants engaged in the focus group discussions, as indicated in Table 1. Participants were between 18 and 54 years old. The meetings were organized via MS Teams and automatically transcribed. Transcriptions were then checked by the moderators of each focus group to ensure validity and to correct mistakes. The German transcription was translated to English via DeepL software and validated by the moderators. Then, the data was analysed using MAXQDA software.

**Table 1: Participants to the Online Group Discussions**

Location	Number of participants		
	Female	Male	Total
Belgium (1)	7	1	8
Belgium (2)	3	3	6
Germany	4		4
Total	14	4	18

Each of the focus group sessions was guided by two moderators who followed a semi-structured topic guide. Because online focus groups often lack visual pointers for participants to fall back on [40], several of the topics listed for the discussion were visualized via Miro, an online whiteboard. Table 2 shows the topics addressed in the discussions and which visualizations were used. It is important to note here that the moderators departed from the input of the participants, there were no questions probing specific elements such as the volume, sequence or spatial aspects of the soundtracks.

**Table 2: Visual Pointers for Participants in the Online Focus Group Discussion**

Topic	Visualisation
Introduction	Informed consent (in Qualtrics) via screenshare
Getting acquainted and sharing practices	Pictures of common reading habits presented in Miro. Participants could refer to images when presenting themselves and how they read.
Defining immersion	Visualisation of the points made during the discussion through note-taking in Miro (post-its)
Requirements for 3D-audio	
Closing	Adding final points via post-its in Miro where needed

To prepare the discussion on (3D-)audio and immersion, we asked participants to read a chapter of the book *The Influence of Blue* (translated from Italian: *L’Influenza del Blu*, by Giulio Ravizza) and simultaneously test four 3D-audio tracks accompanying the chapter (see Table 3). The chapter and audio tracks were in English and made available via Thorium Reader application. Participants received a manual on how to install the application, how to use it and how to test the (3D-)audio content via mail, at least one week prior to the online meeting. They were asked to read the text and listen to a track simultaneously, before the start of the focus group. The instructions included the use of a mobile device (tablet or smartphone) or laptop to read and headphones or earbuds to listen to the audio track simultaneously. In addition, participants were asked to listen to the tracks in the numeric order.

**Table 3: List of 3D-audio tracks**

Track name	Track content
Track 1	Narrator
Track 2	Narrator and ambient sounds
Track 3	Narrator and music
Track 4	Narrator, ambient sounds and music

While reading and listening to the audio tracks, highlights indicated word per word in the written text which parts the narrator was reading. As loudness was defined as an influencing factor [26], participants were able to adjust the volume for each track, but they could not adjust the volume of each component within the combined tracks (track 2 tot 4 in Table 3). In the following section, we discuss the results of the focus group discussion.

## 4 RESULTS

The results section first addresses the participants’ reflections on what immersion is. Then, we address the feedback on each of the audio tracks and on the combination of reading and (3D-)audio in general. Finally, we list the specific requirements for 3D-audio integration in reading applications.

### 4.1 (Re)defining Immersion

In the co-creation sessions, participants were asked to define ‘immersion’, and elaborate on what it meant for them. Interestingly, the definitions of immersion suggested by the participants, referred to the concepts of immersion as described in the theoretical framework (cfr. 2.5). However, the participants distinguish between types of immersion, not by the relation to technology (materiality) but by the appeal to their senses, referring to sensory engagement and hinting more at the hermeneutic relation with content. As such, the relation described by the respondents echo’s more the aspects of ‘transportation’, and ‘presence’ from Schettino’s definition [46]. The definitions of the participants are in line with how Mangen [37] describes the relation with books rather than with immersive technologies. As some respondents mention, immersion is strongly associated with their own imagination:

"I thought just of fiction and just an immersive book that gets you immersed into the world. I did not necessarily think of that all the digital aspects that were behind it." (NW, Male, FG 21.02.22).

"So for me personally, I guess what an immersive experience is kind of what you make of it right. I mean for me personally for a story to be [gripping] the story itself has to be interesting. I mean, I have felt immersed by reading a plane book. I've felt immersed by audio books. So I mean, I think that you can feel part of what you're reading in a variety of different forms." (MW, Male, FG 21.02.22).

However, we notice that several respondents also refer to the importance of the engagement of different senses through different technologies:

"For me it's more a book that (...) invites us to use it in more than just one sense, which is like the visual. (...) So, it's not just textual, but it allows our imagination to go further (...)" (CC, Male, FG 21.02.22).

Finally, the participants also refer to 'transportation' to a new world through Virtual Reality. Here, the participants refer to more physical immersion as well, as they refer to 'walking through' museums and paintings. This type of immersion is associated with increased use of technology to appeal to the participants' sense of touch, sound, and vision.

"(...) these exhibitions of artists as well where you can like walk through the paintings and also like experience it more than just watching it from a distance." (EB, Female, FG21.02.22).

Thus, immersion can be seen as gradual, ranging from a state of mind that appeals to one's imagination (phenomenological immersion) to a mostly technological experience (technological immersion). Figure 1 presents the concepts that were mentioned by participants on the continuum between technological and phenomenological immersion.

Figure 1 also shows that participants see a role for audio-visual content to support the immersion in a book. During the focus group discussions, several participants highlighted the role that audio in particular can play in grabbing attention and immersing in a story:

"Sometimes I put on music as well and this (...) kind of fills that space in your brain that you have. That's always worried and thinking about stuff and when you fill that up with music or a sound, it allows you to focus on what you're doing." (LK, Female, FG 14.02.22).

"I was reading a book once and they added like some opera like parts like very classical music in the background. Soon I could feel that the attention was coming, so I thought that was interesting compared to a normal audiobook when it's just someone reading it." (CVB, Female, FG 21.02.22).

"(...) what would make it more immersive would be audio. I do have a real connection with audio (...)" (CC, Male, FG 21.02.22).

However, for some participants the opposite was true. They indicated that the addition of audio tracks would become too distracting in some settings:

"I think to myself that if I were to read something (...) with music or with any sounds in the background, I wouldn't be able to do it on the train or on the road, because I would be too distracted. I think I would actually need something like on the couch or in bed or something, I can imagine that." (DW, Female, FG 03.03.22).

In addition, thinking about the concrete development of audiovisual material to accompany a book, a tension was noted between the content of the book (the story), the intention of the writer/author, and the interpretation of the reader. This leads to an 'immersion paradox': on the one hand, immersion in a book is influenced by -amongst others- the inner monologue of the reader, their interpretation of this book, their empathy with the story and its characters. Participants indicate that music and ambient sounds could help them immerse and deepen the readers understanding of and empathy with events, emotions and characters. On the other hand however, a mismatch between the readers' imagination, audio content and the story could hinder readers from becoming immersed in the story and even cause them to put the book away:

"Because I find with audio books that those little effects it makes me less immerse because I already have this narrative in my head of how footsteps and people are moving. It should sound, and then when the book adds it, it pulls me away because it's any conflict of what I've already created in my head." (CJ, Female, FG 21.02.22).

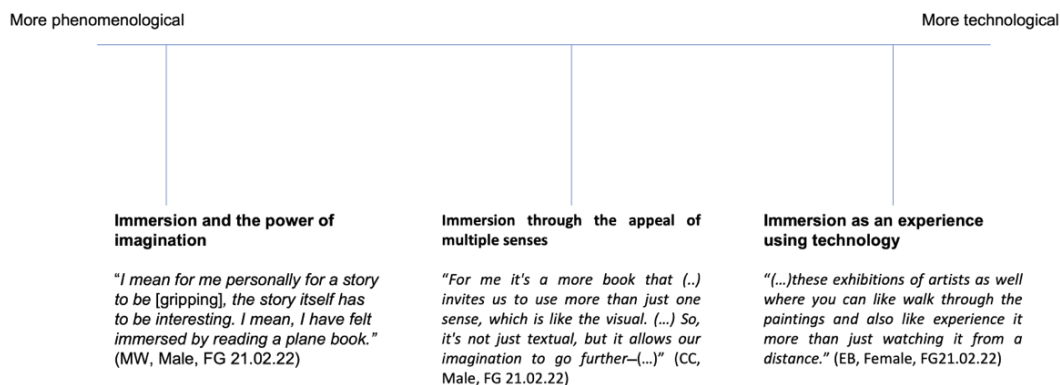


Figure 1: Defining Immersion as Gradual



“I mean sometimes the effects can really help, but I feel and it like makes the experience a lot more immersive and memorable. But I feel like more of the time it just kind of draws away from the message. And when I’m reading or listening to something, I do have my own thoughts and experience going on in my head. And when that’s added in it more often than not detracts from the substance itself.” (MW, Male, FG 21.02.22).

Three aspects thus need to be aligned when (3D-)audio is integrated in a story (1) the audio needs to convey the intention of the author; (2) the audio needs to accurately represent (‘fit with’) the story; (3) the audio needs to support the subjective experience and interpretation of the reader.

## 4.2 Evaluation of immersion through the (3D-)audio tracks

In this section, we address the feedback we received from participants on the four audio tracks. It is important to mention that the evaluation of the tracks was aimed at understanding the perspective of the users and that no suggestions were made by the moderators during the discussions. It is therefore noteworthy that the spatial (3D) aspects of the audio tracks were not mentioned in the evaluation of the audio tracks. There was also no mention of the ‘inside head locatedness’ that Rieger and Zingler [43] refer to. This does not signify that these aspects are not relevant to the evaluation of (3D-)audio in the context of reading, rather that the spatial aspects were not the focal point in the evaluation of the participants in this stage of the research. In the following paragraphs, we will thus focus on the aspects that were put forward by the participants. First, we describe how participants evaluated the tracks in terms of helping or hindering immersion. Then, we address the general and specific factors that influenced their sense of immersion when listening to each of the tracks.

In general, most participants took some getting used to the narrator and the music and ambient soundtracks. However, many participants indicated that music and ambient sounds have the potential of aiding immersion. The type of track that was considered the most ‘immersive’ differed according to the participants’ personal preferences. As this participant mentioned:

“Individually I found [the music and ambient audio tracks] a little distracting, but for some reason when you put them together it just kind of... it almost helps me like focus more on this story, I guess. I know that doesn’t really make much sense like why they wouldn’t work independently, why they would all of a sudden make the story more immersive when put together. But for me I found the [ambient sounds] and music put together to be pretty memorable, and immersive.” (MW, Male, FG 21.02.22).

Some participants mentioned the inclusion of music tracks in reading applications would save them time, as they currently combine reading with listening to music via streaming apps such as Spotify:

“You know, so for me, I think it was a really nice experience, especially [Track 4], because it actually helped me. I think it didn’t take anything away for me, but it really helped me like put me in the mood. Sometimes when (...) it’s kind of hard for me to get in the mood of the book, I try to find playlist on Spotify about the book that has like this kind of music that matches what’s in the book. This is fun because it’s actually already in the book. You don’t have to look for playlist.” (EB, Female, 14.02.22).

Obviously, personal preferences and context of the reader (such as reading skills or using music to focus) played a vital role in the 3D-audio tracks were evaluated. For example, the narrator voice was deemed ‘boring’ by most participants, whereas one participant thought the voice was pleasant and another participant indicated that the voice would be useful for non-native speakers to learn English. To move beyond the personal preferences and individual reader contexts, we separated the comments into five categories, distinguishing between (1) general aspects that apply to all audio tracks, (2) specifics for narration, (3) specifics for ambient sounds, (4) specifics for music, and (5) specifics for combined audio tracks. Table 4 below shows the aspects that participants indicated influence the level of immersion for each of these five categories. We see that all aspects indeed play a role in the perception and experience of the audio tracks by the participants.

**Table 4: (3D-)audio aspects that Influence Immersion**

General	Narration	Ambient sounds	Music	Combined audio
‘Fit’ with the story	Tempo of the narrator (speaking pace)	Adapt to the mood in the story	Adapt to the mood in the story	Synergy of the tracks
Consistency in audio quality	Dialect of the narrator	Accurately represent environment of the story	Accurately represent the story and its’ characters	
Variation in audio content	Timbre of the voice of the narrator	Adapt to the environment of the story	Build towards a climax	
Volume of the audio	Accuracy of the alignment with highlighted text	Build towards a climax		



As Table 4 shows, our findings confirm those mentioned above (see section 2.6): volume (loudness) and fit with the mood of the story are important for the experience of listening to the audio tracks while reading. One aspect that we would like to look into in this paper is the ‘fit with the story’, as it resonates with the aforementioned ‘immersion paradox’. During the evaluation of the audio tracks, this was a principal issue mentioned for each. It is closely related to the comments referred to in the table as ‘adapting to the mood’ or ‘adapting to the environment’ as well as ‘representing the story and its’ characters’. On a basic level, comments referred to finding a match between the audio track and the setting of or what is happening in the story:

“I was expecting the sound effects to go with the text, so for example, the crashing of the waves as is explained in the beginning” (LK, Female, FG 14.02.22).

surfaced when participants evaluated the audio track, as the quote below shows. These remarks were also added to the requirement list in the analysis of the transcripts.

“(...) my first thought was that I found the voice pretty annoying, but that might just be me. I felt like it was not very personal. So, maybe if you could like, maybe choose a voice that suits you more than you can get, like a better personal connection to the story (...)” (EB, Female, FG 21.02.22).

This analysis resulted in an initial set of requirements, as shown in Table 5. The table includes both requirements that should be taken into account in the production of audio content (labelled as content requirements) as well as requirements for technology developers to take into account when developing a user-friendly reading application (labelled as user requirements).

**Table 5: Requirements for (3D-)audio to Support Immersion in Reading Applications**

<b>User Requirements</b>	<p>Users should be able to choose from a variation of audio tracks, including different narrators, ambient sounds, and music.</p> <p>Users should have control over the volume of each of the audio tracks.</p> <p>Users should have control over the speed of narration.</p>
<b>Content Requirements</b>	<p>Audio tracks including narration, music and ambient sounds should fit with the story.</p> <p>All audio tracks should adapt to the mood in the story and adjust when the mood is changing</p> <p>All audio tracks should accurately represent the stories’ characters.</p> <p>Music and Ambient soundtracks should build towards a climax.</p> <p>Ambient sounds should accurately represent the environment of the story and adapt when the environment changes.</p> <p>The combination of narrator, music and ambient sounds should be balanced as a listening experience.</p> <p>A variety of audio tracks, including different narrators, ambient sounds and music should be offered for each story.</p>

But alternatively, respondents also indicated interest in added meaning from the audio tracks. This means the audio would enhance the story further:

“And what I find important in such a combination, so that also reminds me a lot of film music, that the one is not just a background to the other, but that it complements each other, so that I don’t just get information from the text, but through the sound some information is brought to me that I couldn’t otherwise get, or also through the music a mood is created that I wouldn’t even have read out otherwise.” (CB, Female, FG 03.03.22).

Below, we discuss the requirements that were put forward as a result of the discussion, based on this overview of factors that influence immersion.

#### 4.3 Requirements for the implementation of (3D-)audio tracks

To allow us to translate the personal preferences and factors of influence into requirements, we asked respondents how these aspects could be implemented in a digital reading app, considering personal preferences as well as general remarks. Some of the remarks already

Allowing variation in the audio tracks offered and users controlling the volume and speed of narration would tackle many of the personal preferences mentioned in the discussions. As such it can partially solve the ‘immersion paradox’ described above, by allowing users to tailor the audio tracks to fit their own imaginary of the text, their subjective experience. However, the requirements do not indicate how to ensure a fit with the story completely, nor how to align with the intentions of the author. In addition, the requirements do not specify what specifically constitutes a ‘fitting’ audio track. It seems difficult to pinpoint objectively when a track is considered too monotonous or when it would capture too much attention, thus taking away from the experience of reading. We will address this further in the conclusion below.

## 5 CONCLUSION

In this paper, we discussed the concept of immersion in the context of reading books, both digitally and on paper. In our theoretical framework, we underlined the importance of materiality, differentiating the experience of reading and immersing in a paper book and in a digital one. We depart from the framework of Mangen [37] to explain the diverse ways of engaging with paper books and

digital books. By looking at the differences between technological and phenomenological immersion this framework explains why it might become increasingly difficult for readers to immerse in a reading experience, due to the increase of distractions of portable devices and social media platforms. Although many efforts have been made to make books more interactive and engaging to all audiences, not just avid readers, little research has focused on the role of audio or 3D-audio in particular to enhance immersion in the context of reading. Our research therefore scrutinized if (and how) audio can support the immersion of readers in digital fiction stories. This was done by conducting online focus group sessions, set-up in Belgium and Germany with an international group of participants. The results allow us to understand the participants' subjective experiences and current reading practices. One of the main goals of the online focus group discussion was to transcend the individual experience to construct and define requirements for (3D-)audio in reading applications.

Our paper contributes to the research by first providing insights in how readers' experience immersion. On the definition of immersion, our results suggest that technological immersion and phenomenological immersion are not mutually exclusive. Rather, from the accounts of the participants, it is suggested that the difference is gradual, and that one can reinforce the other. When addressing how (3D-)audio can support or interrupt immersion in a story, our findings support earlier studies mentioned in the literature review. We noted the 'immersion paradox' participants described when it comes to adding audio to their reading experience. On the one hand, participants indicate audio could help immerse in a story. On the other hand, it could distract from the digital book and draw the participants away from reading. We identified three aspects that influence the possibility of immersion: (1) the audio needs to convey the intention of the author; (2) the audio needs to accurately represent ('fit with') the story; (3) the audio needs to support the subjective experience and interpretation of the reader. Second, we evaluated specific 3D-audio tracks to gain a deeper understanding of what aspects are relevant when it comes to allowing or disturbing immersion. Notably, the spatial aspects of the audio tracks were not mentioned by the participants of the focus group sessions. Among the aspects that were addressed, the 'fit' with the story was mentioned systematically by participants. Two important layers must be considered: (1) the basic link between the setting of and what is happening in the story (i.e. 'realistic landscape'); and (2) the added value audio can bring to set a mood, understand emotions and characters (i.e. music). Finally, our empirical research presents user and content requirements to inform technical development and content production for reading applications. Importantly, the user requirements point toward the access to variation in the audio offered, and the ability to control one's own experience.

In the following section (Discussion) we provide an overview of the next steps for Möbius and consider how further research can help us understand at what point audio becomes more of a distraction, instead of an aid towards immersion.

## 6 DISCUSSION

By focusing the requirements on the common aspects of the participants' evaluation, we managed to formulate concrete requirements

that go beyond the individuals' personal preferences. However, follow-up research is necessary to further refine these requirements. The next pilot phase of Möbius involves testing a prototype of the reading application with a larger sample of end-users. Here, the aim is to implement the requirements from the first phase reported in this paper in a mobile web application. 300 participants will be recruited across six European countries to test and evaluate the reading experience. Through an open-ended survey we aim to gather additional requirements and to refine this first set of requirements. In the final phase (pilot phase 3) of the Möbius project, approximately 600 users will be able to try the application in their daily lives to understand more on how the combination between audio and reading is influenced by the context the reader is in. For example, some participants mentioned that the ambient sounds might be too discomforting at home, or that some music tracks can be distracting when commuting (cfr. RESULTS). This deserves further attention as the user's context could influence the users' experience to a great extent. To do so, a mixed method research design will allow us to evaluate the Möbius book application on a large scale (quantitative survey) while gaining in-depth understanding of a more limited set of users (in-depth interviews).

Outside of the project scope, further research is needed to deepen the understanding of what it means to find a 'fit' between a story, its characters, and the audio tracks. Here, a human-centred design approach that includes publishers, writers, and readers -for example in the form of co-creation sessions- could unravel the creative development and practical implementations for producing, writing, and reading digital books with 3D-audio tracks. In addition, it would be interesting to test readers' audio preferences on a large scale. The insights provided in our research could help define an initial set of variables (cfr. Table 4) to be tested through an experimental research design. This could shed light on solutions for the immersion paradox. Due to the research goals and methodology implemented at this point in the project timeline, this was beyond our research's scope so far. However, it would be possible to determine preferences in an experimental setting, such as A/B-testing. Additionally, it would be interesting to compare differences in preferences based on age and gender, as literature suggests that women are more avid readers than men.

Finally, a comparative research set-up to assess the immersive qualities of 3D-audio in contrast to other technical audio standards, would enable an assessment of the added value of the 3D-effect for different types of audio tracks.

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