Spatial audio and immersive journalism: production, narrative design, and sense of presence

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Abstract

This article presents the findings from an experimental study on the use of binaural audio in two long-form journalistic features broadcast on Portuguese radio. From a production and narrative design perspective, our objective is to examine whether/how binaural audio implies a transformation of previously established news radio production work principles and practices, as well as of storytelling ideation and techniques. From a user experience viewpoint, we examine whether the use of binaural audio translates into higher levels of self-reported immersion and place illusion (n = 77). Despite the spread of new audio journalism formats, media and communication studies have until now largely neglected the role of spatial audio in the construction of immersion and the illusion of place. We argue that this epistemic omission translates into an image-centric conception and operationalization of the immersive journalism proposal, which stands out as a knowledge gap regarding the work of journalistic storytellers and relating to participants' actual experience. The original contribution of this article is threefold: (1) conceptual, by broadening the perspective of journalism studies' scholars and media professionals on the concept of immersive journalism, which, in our view, is often incorrectly considered to be synonymous with that of virtual reality journalism; (2) practical, by generating a more nuanced understanding of how actual practitioners perceive and employ immersive journalism; (3) phenomenological, by developing an examination of the factors that influence listeners' ultimate perception of the immersive experience.

Keywords

Immersive journalism; Immersive storytelling; Audio storytelling; Narrative; Binaural sound; Spatial audio; Emotional turn; Journalism; Cinematic radio; Audio documentary; Audio communication.

1. Introduction

De-la-Peña *et al.* (2010) introduced the concept of immersive journalism as

> "the production of news in a form in which people can gain first-person experiences of the events or situation described in news stories".

By experiencing the illusion of being there, proponents claimed, participants would gain an

> "unprecedented access to the sights and sounds, and possibly feelings and emotions, that accompany the news" (p. 291).

This proposal was rapidly embraced by the tech industry and virtual reality (VR) technologies, such as 360-degree video or computer-generated imagery (CGI), and proliferated in newsrooms around the world (**Godulla** *et al.*, 2021; **Marconi**; **Nakagawa**, 2017; **Pérez-Seijo**, 2017; **Pérez-Seijo**; **Vicente**, 2022).

Aiming to situate the user at the center of the narrative experience, this immersive form of non-fiction content production has been identified with an emotional turn in journalism studies, with emphasis being placed on the need for a renewed interest in audience perception (**Goutier** *et al.*, 2021; **Lecheler**, 2020; **Wahl-Jorgensen**, 2020). Nevertheless, journalism studies have, until now, largely neglected the role of spatial audio in the construction of immersion and the illusion of place. We argue that this epistemic omission translates into a limited, image-centric conception and operationalization of the immersive journalism proposal, which highlights a knowledge gap regarding the work of journalistic storytellers and the participants' actual experience.

With this objective in mind, this article presents an exploratory experimental study on the use of binaural audio for journalistic purposes by using two existing long-form features produced by the Portuguese public radio broadcaster *Antena 1*. The research is based on a mixed-method design, combining quantitative and qualitative techniques. On the one hand, a between-subject experimental study was conducted to assess whether the use of binaural audio leads to a higher level of immersion and place illusion. Focus groups were used to triangulate technique was also used to triangulate the quantitative results. On the other hand, semi-structured interviews were conducted to examine the impact of binaural audio on news radio production and storytelling. The aim is to fill the gap in the literature on immersive journalism from the perspective of both user experience and production and narrative design. The study is structured on a production–reception axis of analysis, focusing on the direct accounts of journalists to assess narrative design and production practices of spatial audio journalistic features, as well as on users' experiences, self-reported by study participants. It addresses the following research questions:

> RQ1: What narrative objectives do journalists attribute to binaural audio productions?

> RQ2: What transformations generated by using binaural audio do journalists identify in production?

> RQ3: Do binaural audio listeners report significantly higher levels of immersion and place illusion when compared with monaural audio listeners?

The original contribution of this article is threefold:

- conceptual, by broadening the perspective of journalism studies' scholars and of media professionals on the concept of immersive journalism, which, in our view, is often incorrectly considered synonymous with that of virtual reality journalism;
- practical, by generating a more nuanced understanding on how the actual practitioners perceive and put to work immersive journalism;
- phenomenological, by developing an examination on the factors that influence the immersive experience by the end listeners.

2. Theoretical framework

2.1. Virtual reality and 360-degree video

VR was recently proposed as part of reality media, i.e., a class of audio-visual media forms

> "that explicitly interpose themselves between us and our visual, auditory, or tactile perception of the everyday world and in this sense seek to redefine reality itself" (**Engberg**; **Bolter**, 2020, p. 85).

Not yet stabilized as a narrative medium and symbolizing the evolution of cinematographic language over two centuries, VR attracts both practitioners and scholars due to its visual, aural, kinetic, haptic possibilities, and, more than separately, due to the "synesthetic encounters" it allows (**Ross**, 2020) with its considerable plasticity in terms of digital representation conventions and genres (**Murray**, 2020). Nevertheless, two normative paradoxes have been pointed in 360-degree journalism: the first, the consideration that a 360-degree view provides a more accurate representation of events, while at the same time allowing viewers to freely choose a field of view that can lead to a less accurate picture of the story; the second, the expectation it generates more objective reporting, while greatly depending on staging scenes and image processing in post-production (**Aitamurto**, 2019), as well on industry standards and practices (**LaRocco**, 2020).

One of the main postulates about the narrative assets of immersive journalism concerns the rhetoric around VR as a kind of "empathy machine" (**Milk**, 2015). In fact, when **De-la-Peña** *et al.* (2010) introduced the concept of immersive journalism, it was claimed that this form of content production could serve to "reinstitute the audience's emotional involvement in current events" (p. 298).

The core argument behind this proposition is that by placing the audience at the center of the experience and offering them a first-person perspective within the story world, this generates a strong affective impact on users (**Lecheler**, 2020).

This premise has led researchers to demand further precision in defining the concept of empathy and to investigate how media users do indeed experience non-fictional immersive environments. Examples of this ongoing endeavor are the works of **Kukkaporki** and **Pantti** (2021), focusing on the potential of spatial storytelling to create emotional responses in VR news stories, or of **Clifford** and **White** (2020), drawing attention to the potential of mediated representation to evoke empathy and enhance public understandings on specific events. On the other hand, **Shin** and **Biocca** (2017) have proved that "the meaning of immersion depends on the users' traits and contexts" (p. 3), so its function is highly dependent on the user's intentions and cognition. However, critical voices have also emerged rejecting the 'empathy proposition' of VR technologies, arguing that VR storytelling further distances people from the analogue reality of the world (**Hassan**, 2020), or as **Ferjoux** and **Dupont** (2020), claiming that it symbolizes a technological utopianism.

Several studies have also addressed the human experience of VR and 360-degree video non-fiction storytelling, by focusing on the effect of these immersive pieces on subjective perceptions such as the sense of being there, immersion, realism, interaction, source credibility or story-sharing intention (**Archer**; **Finger**, 2018; **Hendriks**-**Vettehen** *et al.*, 2019; **Sundar** *et al.*, 2017; **Van-Damme** *et al.*, 2019).

2.2. Spatial audio and cinematic radio

In recent years, as part of a broader transmedia engagement and cross-media practice, as well as a result of high technologies adoption, news media organizations have also explored spatial sound– notoriously, binaural audio –as an innovative strategy to provide listeners with an immersive aural experience, both in the field of drama and entertainment, as well as in the journalistic domain (**Edmond**, 2015; **Dowling**; **Miller**, 2019; **Wincott**; **Martin**; **Richards**, 2020). Binaural audio technologies allow the creation of immersive experiences by simulating the natural hearing cues created by acoustic interaction between our physical bodies and the surrounding environment. The format is particularly suited for a stereophonic headphone hearing system, allowing the listener to be locked in and minimizing the intrusion of external undesired sounds.

A non-exhaustive list of immersive features and documentaries in the form of spatial audio internationally produced in recent years includes broadcasters *Radio France* (e.g., *Cécifoot, le sens du jeu*, 2016), *ArteRadio* (e.g., *Siffler Laos*, 2016), *BBC News World Service* (e.g., *Congo: A river journey*, 2018), *BBC Radio 3 Between the Ear's* program (e.g., *Omay*, 2018; *The NHS symphony*, 2018), *NPR* and *The National Geographic Society* (e.g., the co-produced *Radio expeditions*). In this article, we examine the production and the reception of two binaural audio journalistic features produced by Antena 1, the Portuguese public radio broadcaster: *Hearing eyes* (*Com olhos de ouvir*), produced and broadcasted in 2018, and *Imaginary line* (*Linha imaginária*), produced and broadcasted in 2019. The first was the pioneering experience of Portuguese news radios in the binaural audio domain and, among other distinctions, was nominated for the 2019 edition of the Gabo Prize (*Fundación Gabriel García Márquez*) in the Innovation category.

Both features explore the potential of binaural storytelling methods and engage with the concept of cinematic radio, the adaption of

> "filmmaking and scriptwriting practices for a dimensional audio production by drawing on a set of established story, script, and technical research questions" (**Jenkins**; **Murphy**; **Thomas**, 2018, p. 7).

Both audio features explore a journalistic framework for binaural productions, as a medium with its own storytelling form and language, restating the acknowledgment of a new technology-mediated experience in the all-audio space:

> "binaural is to radio and podcasting what virtual reality (VR) and augmented reality (AR) are to screen" (p. 3).

Despite a growing relevance to producers, and regardless the fact that binaural audio, from a reception perspective, is the most accessible immersive audio technology, only requiring a pair of stereo headphones, very few research works have addressed immersive audio –and sound, in general– as a specific cultural form and practical domain within media and journalism studies (**Wincott**; **Martin**; **Richards**, 2020), particularly when comparing to the increasing number of research articles addressing VR. This historical imbalance and epistemic gap between sound and image has been previously voiced by several scholars from different disciplines (e.g., **Aveyard**; **Moran** 2013; **Gallagher**, 2015; **Revill**, 2016; **Van-Leeuwen**, 2007). More recently, scholars started stressing the need of further research evaluating actual aural experiences, a particularly understudied topic in the scope of digital journalism, as well as of an examination of the current position of audio storytelling in journalism education (**Wake**; **Bahfen**, 2016).

> Journalism studies have, until now, largely neglected the role of spatial audio in the construction of immersion and the illusion of place

2.3. Journalism as storytelling and news stories as narrative

Since the 1970s, journalistic practice has been theoretically interpreted through news stories' production and journalists understood as storytellers who resort to more or less conventional narrative structures in order to organize in a communicative way the workings of the world (**Bird**; **Dardenne**, 2009). The conceptualization of news as storytelling represented a turning point from journalism as an objective mirror of reality toward more refined sociological and anthropological constructs of journalism as a professional occupation and culture (e.g., **Bird**; **Dardenne**, 1988; **Tuchman**, 1972). Story structures, as the organizational properties of a coherent narrative (**Vicente**, 2018), became thus fundamental devices in the social construction of reality, a key theory expressed by **Berger** and **Luckmann** (1967) in which meaning is embedded through social interaction.

For this study, we adopted **Herman**'s (2009) working definition of narrative: a representation that is situated in a specific discourse context for telling, cueing interpreters to draw inferences about a structured time-course of particularized events. These events introduce some sort of disruption/disequilibrium into a story world involving human agents. Their representation conveys the experience of living through a story world-in-flux. For the definition of the two stimuli used in the study, we considered the following story aspects identified by **Bal** (1985): the narrator, focalization, characters, time, and space. As "narrator and focalization together determine the narrative situation" it is important to precise that, while the narrator gives an account of events and experiences, the focalizor is the "specific agent of perception, the holder of 'the point of view'" (p. 18). We further adopt the concept of character as "the anthropomorphic figures provided with specifying features the narrator tells us about" (p. 112). We particularly observe if the narrative is structured around a main character or if it involves multiple characters. Regarding time, we characterize "the order of events in the story" (p. 79) and, concerning space, we register the place(s) where action takes place. It is important to specify that, since we are analyzing audio features, the realization of these story aspects is simultaneously carried out in a linguistic and auditive way. For this reason, in the scope of this article, we resort to the notion of narrative design to describe the distinct storytelling strategies adopted by the news producers to structure a representation throughout the creative assembly of ideas over time and sensory experience.

2.4. Presence and immersion

Since the 1990s,

> "presence and immersion became the measures and the often elusive goals of VR" (**Engberg**; **Bolter**, 2020, p. 82).

Both terms are often used interchangeably, to which different understandings by researchers and practitioners are added, contributing to little conceptual precision across domains such as literary, game, cinema studies, among other areas of application. The concept of presence has been permeable to multiple interpretations, leading to a multidimensional set of constructs and methodological considerations (**Laarni** *et al.*, 2015). In this study, we particularly examine place illusion, as the perception that a mediated experience is not mediated, described by **Lombard** and **Ditton** (1997), resulting in the feeling of being in the location(s) of the news story. That "feeling of being there" occurs due to the user's exposure to various sensory stimuli, usually in a virtual environment (**Nilsson**; **Nordahl**; **Serafin**, 2016, p. 127). As a subjective experience, presence also depends on the user's "internal tendencies to become involved" (**Witmer**; **Singer**, 1998; **Slater**, 1999), which means that each individual may experience a completely different sense of presence despite the fact the stimuli and the content are the same (**Ijsselsteijn**; **Riva**, 2003, p. 5).

With regard to the concept of immersion, for the operationalization of this study we adopted the taxonomy systematized by **Nilsson**, **Nordahl**, and **Serafin** (2016):

> (i) immersion as a property of the technological system (system immersion);

> (ii) immersion as the subjective response to that system (perceptual immersion;,

> (iii) immersion as a response to an unfolding narrative, the characters inhabiting the story world, or the depiction of the world itself (narrative immersion).

Since in the two journalistic works under study binaural audio is not implemented as an interactive media, i.e., the two audio pieces do not rely on the user input to generate an output, as for instance in the case of games (**Vicente**, 2020), in this article we did not operationalize immersion as a subjective response to challenges (challenge-based immersion), proposed by the authors.

3. Methods

3.1. Experimental stimuli

This study articulates a production level, overall aimed at understanding how practitioners conceive, design, and produce immersive journalism in the form of spatial audio, with a reception level, intended to examine how do listeners experience immersion in non-fiction storytelling. To serve both objectives, we have selected two different binaural audio journalistic features produced and published by *Antena 1*, the Portuguese public radio broadcaster. Both productions resorted to *Sennheiser's Ambeo Smart Headset* due to its low cost, compact and mobile binaural recording system, which can be used directly on human ears to record spatial audio (Figure 1).

The first, *Hearing eyes* (*Com olhos de ouvir*, duration: 00:30:37), was originally broadcasted in 2018 and portrays Telmo Baldé who blinded three years ago due to a brain injury, while undergoing rehabilitation. In the description of the feature author, reporter Rita Colaço explains that the piece aims to

> "tell the story from the protagonist point of listening. Telmo is the one telling and guiding the listener in a first-person story, narrating the difficulties that a blind person feels in daily life. Furthermore, I wanted to know and try to reproduce in the most realistic way possible how does a blind person listen".

The second, *Imaginary line* (*Linha imaginária*, duration: 00:31:46 minutes), by journalist Isabel Meira, was broadcasted in 2019 and takes the listener to Santa Cruz do Bispo women's prison where a rugby project aimed at the inmates' daughters was implemented. The key objective of this report was, in the words of its author,

> "to create sound-images and transport the listener to this narrative space. I was interested in exploring the idea of observing reality in layers of sound".

Image 1. *Sennheiser Ambeo Smart Headset* binaural audio system used in the journalistic productions studied

Both audio features share the purpose of placing the listener at the center of the narrative experience –a foundational idea in immersive journalism– as well as the dimensional plasticity associated to spatial audio by cinematic radio. Nevertheless, following the previously mentioned story elements, they adopted distinct narrative designs, as summarized in Table 1:

Table 1. Narrative design elements of the stimuli

Stimuli	Narrative Situation		Characters	Time	Space
	Narrator	**Focalizor**			
Hearing eyes	Yes. Extradiegetic (reporter)	Main character (internal focalization)	One main character	Use of analepsis and prolepsis	Multiple
Imaginary line	No	Multiple characters (internal focalization)	Multiple characters	Linear/chronological	One main space

3.2. Interviews with practitioners

Due to constraints imposed by confinement in the face of the Covid-19 pandemic, in May 2020 via e-mail we conducted online semi-structured interviews with each of the two journalists who authored the binaural audio journalistic features under study. The interviews included five questions and were designed to gather the perspectives of two experienced radio reporters, both with several national and international awards and distinctions received throughout their professional careers, about:

(a) objectives and expectations about the combination of spatial sound and journalistic narrative, in particular with regard to the creation of the sound experience for listeners;

(b) strategies and techniques adopted for production and if/how they changed the way of conceiving and telling the story, field recordings, editing, and mixing procedures.

These interviews were conducted and later transcribed into a single digital document, offering researchers a series of qualitative insights.

3.3. Experimental design and procedure

Regarding the self-reported listening experience, a total of 77 participants (65% females, 34% males) were recruited through institutional email from *Universidade Nova de Lisboa* (Portugal) to participate on a study about binaural audio applied to a journalistic context. Participants ranged in age from 19 to 55 years old (*M*=29,53; *SD*=9,66), being the 20 to 24 age group the largest of the sample. We designed and conducted a between-subject experiment with two listening conditions: participants randomly assigned to condition 1 experienced an audio feature in binaural audio (*N*=40); participants randomly assigned to condition 2 experienced an audio feature in monaural audio (*N*=37). Contrary to binaural audio, which presents a separate auditory stimulus to the left and to the right ear, monophonic audio reproduction emanates from one single position. A computer program (randomizer) was used to create the random composition of the experimental groups. Each participant experienced only one of the experimental conditions.

> News media organizations have explored spatial sound –notoriously, binaural audio– as an innovative strategy to provide listeners with an immersive aural experience

This experimental design aimed at isolating binaural audio as an independent variable (system immersion) and monaural audio as the control condition. It was deployed to isolate system immersion (the property of the technological system) from the previously mentioned different conceptualized types of immersion, namely perceptual immersion (perceptual response to the technological system), narrative immersion (response to an unfolding narrative, the characters inhabiting the story world, or the depiction of the world itself). To prevent participants from being cognitively conditioned by the anticipated knowledge of specific technological properties, the modality of the audio stimuli (binaural/monaural) was not disclosed as they were randomly assigned to different experimental groups.

Once registered, participants were informed that they would participate in a one-hour session, consisting of an individual listening session (approximately 30 minutes), immediately followed by filling in an online questionnaire (10 minutes), and participating in a focus group (20 minutes). The experiment was carried out under laboratory conditions and sessions took place at *iNOVA Media Lab*. During the individual listening session, participants were assigned a dedicated audio station with closed-back headphones. The online questionnaire was completed at the same station using a computer for that purpose. Table 2 summarizes the random distribution of participants by experimental condition, stimuli, and demographics.

Table 2. Sample distribution of participants by experimental condition, stimuli, and demographics

		Experimental condition				Stimuli							
		Binaural (N=40)		Monaural (N=37)		*Hearing eyes* Binaural (N=20)		*Hearing eyes* Monaural (N=20)		*Imaginary line* Binaural (N=20)		*Imaginary line* Monaural (N=17)	
		N	%	N	%	N	%	N	%	N	%	N	%
Gender	Male	17	43%	9	24%	8	40%	4	20%	9	45%	5	29%
	Female	23	58%	27	73%	12	60%	15	75%	11	55%	12	71%
	Non-binary	-	0%	1	3%	-	0%	1	5%	-	0%	-	0%
Age	19	1	3%	-	0%	1	5%	-	0%	-	0%	-	0%
	20-24	14	35%	21	57%	10	50%	11	55%	4	20%	10	59%
	25-29	9	23%	4	11%	2	10%	3	15%	7	35%	1	6%
	30-34	7	18%	2	5%	3	15%	2	10%	4	20%	-	0%
	35-39	2	5%	3	8%	-	0%	-	0%	2	10%	3	18%
	40-44	5	13%	2	5%	3	15%	1	5%	2	10%	1	6%
	45-49	-	0%	3	8%	-	0%	2	10%	-	0%	1	6%
	50-54	2	5%	1	3%	1	5%	1	5%	1	5%	-	0%
	55-59	-	0%	1	3%	-	0%	-	0%	-	0%	1	6%
	>60	-	0%	-	0%	-	0%	-	0%	-	0%	-	0%
	M	29,95		29,08		29,6		28,5		30,3		29,76	
	SD	8,91		10,52		9,86		10,42		8,1		10,91	
Level of education	BA student	12	30%	4	11%	5	25%	2	10%	7	35%	2	12%
	MA student	22	55%	25	68%	12	60%	14	70%	10	50%	11	65%
	PhD student	6	15%	8	22%	3	15%	4	20%	3	15%	4	24%
Prior experience listening binaural audio	Yes	22	55%	19	51%	11	55%	8	40%	11	55%	11	65%
	No	18	45%	18	49%	9	45%	12	60%	9	45%	6	35%

3.4. Measures

1) Perceptual immersion. We measured the participants' subjective response to the properties of the technological system (**Nilsson**; **Nordahl**; **Serafin**, 2016), using a single-item 5-point Likert scale (e.g., "The sound experience made me feel immersed").

2) Narrative immersion (Cronbach's α = .741). We measured the participants' response to an unfolding narrative, the characters inhabiting the story world, and the depiction of the world itself (**Nilsson**; **Nordahl**; **Serafin**, 2016) with a three-items 5-point Likert scale adapted from psychology and literary studies (**Gorini** *et al.*, 2010; **Martínez**, 2014) (e.g., "The

way the story is narrated made me want to know what was going to happen next"; "The way the story is narrated made me feel connected to the characters"; "The way the story is narrated made me feel immersed in the world of the characters and events depicted").

> " Binaural technologies are having an impact on journalism, leading to a whole reconfiguration of how information can be produced, distributed, and even listened to "

3) Place illusion. We examined participants' sense of "being there" using a single-item 5-point Likert scale (e.g., "While listening, I had the feeling of being present in the place where the action of the story was taking place), based on **Wirth** *et al.* (2007) and **Laarni** *et al.* (2015).

3.5. Online questionnaire

After listening to the audio features, participants completed an online questionnaire, designed using the *Qualtrics Survey* web-based platform and containing five sections: (i) perceptual immersion, (ii) narrative immersion, (iii) place illusion, (iv) socio-demographics, (v) level of previous experience. Sections (i), (ii) and (iii) were used to answer the research questions of this article, using a five-points Likert scale ranging from "Never" to "Always". Sections (iv) and (v) were used to establish background information about the respondents.

The online questionnaire was pretested with a group of 10 master students. This sample of potential respondents assessed any needs for revision and improvement in the survey design. The main objective was to check wording, technical jargon and conceptual clarity, spell checking, and navigation structure. According to the pilot group feedback, minor adjustments were implemented to optimize the comprehension and readability of the instructions (e.g., normalization of expressions in Portuguese), as well as the questionnaire's digital user experience (e.g., introduction of a backspace button). After operationalizing these adjustments, the definite data collection instrument was created. The internal consistency of the questionnaire was assessed by Cronbach's alpha (.742). *SPSS V23* statistics software package was used for the data analysis. To determine if significant differences exist between listening conditions 1 and 2 (binaural and monaural) related with perceptual and narrative immersion (RQ3), as well as with place illusion, independent-samples *t*-tests and non-parametric Mann-Whitney tests were conducted, as specified in the results' section.

3.6. Focus groups

After completing the online questionnaire, a randomized sample of participants from condition 1 (N=10; 50%) and condition 2 (N=10; 50%) participated in four separated focus groups aimed at generating descriptive insights into the listening experience and eliciting a narrative self-report about the overall aural experience, with five participants per group. The composition of a small random sample size was decided in order to make it logistically feasible to conduct the study under laboratory conditions. The size of the groups was decided in a way that would allow all participants an equal opportunity to speak during the discussion sessions. Table 3 summarizes the random composition of the focus groups. Focus groups took place under laboratory conditions at *iNOVA Media Lab*, ensuring proper privacy and a tranquility ambient able to encourage informal sharing. The principal investigator adopted the role of moderator, facilitating the group discussion between participants,

Table 3. Focus groups' random sample distribution of participants by experimental condition and demographics

		Experimental condition			
		Binaural (N=10)		Monaural (N=10)	
		N	%	N	%
Gender	Male	2	20%	5	50%
	Female	8	80%	5	50%
	Non-binary	-	-	-	-
Age	19	1	10%	-	-
	20-24	3	30%	4	40%
	25-29	2	20%	3	30%
	30-34	1	10%	-	-
	35-39	-	-	2	20%
	40-44	3	30%	-	-
	45-49	-	-	1	10%
Level of education	BA student	4	40%	2	20%
	MA student	6	60%	8	80%
	PhD student	-	-	-	-

while taking a peripheral role. Conceived as a qualitative counterpart to the quantitative statistical data generated by the online questionnaire (triangulation), the moderator role strictly followed a script including the following preselected topics:

(i) perceptual immersion;
(ii) narrative immersion;
(iii) place illusion.

Answers were recorded in a digital audio format and later transcribed to an electronic text document that served as the basis for coding the key themes using *Nvivo 12* software package.

4. Findings and analysis

4.1. Narrative objectives that journalists attribute to immersive audio productions

To address RQ1 regarding the narrative objectives that journalists attribute to binaural audio productions, the content of the two semi-structured interviews was analyzed, which allowed the identification of three exploratory thematic categories: the realism through sound; the sense of identification between listener and protagonist; and the emancipation of sound in non-fiction storytelling.

First, interviewees consider that binaural audio affords a better depiction of the real world compared to other sound modalities. And because of this one of the main objectives are pursued by journalists when using spatial audio for storytelling purposes is to convey a sense of realism. Since it allows for a more accurate capture and therefore representation of sound, as it would be heard at the recording location, producers associated 3D stereo audio with a more realistic experience:

> ' The experimental design revealed no evidence that binaural sound by itself leads to a more immersive experience than a monaural sound story. We found no difference in the three types of immersion under study and no significant difference in the illusion of place '

> "The idea [was] to reproduce the world as all normal hearing people really hear it. The sounds do not reach the two auditory channels at the same time, nor with the same intensity. There are sounds that come from the right, others from the left, behind, ahead, some louder, others lower. And it is this sense of listening in layers that a person who has just blinded needs to develop to gain autonomy on the street" (Rita Colaço, *Hearing eyes*).

The ultimate aim is to contribute to the immersion in the story, seeking to provide listeners with a sense of plausibility and a higher feeling of being there:

> "I had the expectation of achieving the creation of sound images in a more crude and effective way and transport the listener to that narrative space" (Isabel Meira, *Imaginary line*).

Second, interviewees relate the possibility of listening to the events as if the listener were there with a deeper understanding of the story and a more emotional bonding with the others. Binaural audio allows the depiction of reality in a way audience can gain a first-person experience of what is portrayed in the story, and this is associated with a stronger affective impact on listeners:

> "My idea was that the listeners would realize the difficulties that a blind person has in listening to the world or, on the other hand, how this learning to listen to the world is done in order to be able to walk on the street safely" (Rita Colaço, *Hearing eyes*).

Journalists agree that the experiential nature of this immersive audio productions can lead to stronger emotional responses to distant realities. In this regard, the realism attributed to the experience is seen as an enhancer of the sense of identification between the listener and the protagonist(s) of the story. And, at the same time, it is considered that this process of emotional recognition reinforces the feeling of transportation to where the events occur:

> "I wanted the listener to feel transported, to be able to immerse him/herself in the different layers of sound that the story contains" (Isabel Meira, *Imaginary line*).

Third, interviewees confirm that, from a narrative point of view, spatial audio opens renewed possibilities for non-fiction storytelling and for placing the audience at the center of the news story. It allows to turn sound into a primary element, a role traditionally attributed to narration, in order to create a suggestive and engaging experience:

> "It is not always possible to produce reports without narration, for example, but I had already done it and I tried to do it in this production with binaural audio, because I feel that drawing the story in this way allows me to explore the limits of sound, as an autonomous tool: narration can sometimes give sound a more 'secondary' role, leaving it only to respond to the narrator" (Isabel Meira, *Imaginary line*).

It is the experiential dimension of binaural sound which also could afford listeners an unprecedented access to the sounds that come with the news story. In this sense, and closely related to the prior objective pursued, the immersive potential of audio storytelling is used to place the audience in the shoes of another, so they can experience firsthand distant realities and even develop awareness about socially serious issues:

> "For a blind but hearing person, the volume [of a street sign] may be too low and even dangerous if the audible warning of this signal is absent. Another example, for a blind person to cross a treadmill, one must be attentive to the sounds: listen for cars coming from the right or left side so you can make the decision to cross. And I wanted the listeners to feel these difficulties, without me telling them. I wanted them to feel themselves in the middle of the sound action" (Rita Colaço, *Hearing eyes*).

The three emerging thematic categories establish direct points of contact with the founding proposal of immersive journalism. As a realistic mediated narrative mode and evolving grammar of transporting the audience to the time and space in which the action takes place, the narrative awareness of journalists about storytelling devices and the effects desired by their use is evidenced.

4.2. Transformations generated by using spatial audio that journalists identify regarding news production

To address RQ2 regarding the transformations in news production, the content of the two semi-structured interviews was analyzed and allowed the exploratory identification of three categories: journalist's stance during field recording; scripting the spatial orientation of audio listening; and multi-layered editing.

On the one hand, interviewees agree that creating news stories with spatial audio forces to reconsider prior established principles and practices in radio production due to the inherent particularities of the technology used. And this introduced new difficulties when producing non-fiction content:

> "Field recording was the biggest difference, starting with my own position in relation to the protagonists of the story and the need to place supplementary microphones (*Lavalier*, for example). It is not at all evident" (Isabel Meira, *Imaginary line*).

Binaural sound demands a careful planning, including decisions such as where the journalists will be at the scene and where the microphones will be placed during the recording. From a narrative point of view, the format allows for the disappearance of the figure of the journalist –understood as the narrator or mediator– on certain occasions. When this occurs, the first-person narration of the characters becomes a key element, inviting the listener to hear the other's story as a witness:

> "In field recording, there was a substantial change in the collection of sounds. I am usually the one who holds the microphone and the one who decides where to point the microphone. Here, the microphone and the recording were almost always in the ears of the protagonist. In addition, on the field I am almost always at the side or in front of the interviewee and here I had to be behind, without actively participating in the recording. For example, when Telmo was having the training sessions, I always had to come a few meters back so that my steps would not be heard in the recording and kept looking from afar and taking notes like 'now the technician is on his right' or 'now a car has passed on the left'" (Rita Colaço, *Hearing eyes*).

On the other hand, to enhance the realism of the listening experience, interviewees highlight that spatial audio scenes must be carefully orchestrated and planned. Both note that it becomes crucial the scripting of spatial orientation, for both placing the listener where the events occur and strengthening the credibility and accuracy of reporting. In fact, the use of binaural sound leaves little margin for error and improvisation in the field:

> "Binaural audio is an extra ingredient that allows a more realistic listening and that demanded greater care in the collection of sounds and interviews and in the writing of the report. As I was not able to fully "deliver" the story to Telmo [focalization] and had to appear at times with my voice describing what was going on, I was careful to direct the listening to the right or to the left or other directions" (Rita Colaço, *Hearing eyes*).

Furthermore, the postproduction process of binaural audio content is more time-consuming as it requires a multi-layered editing, oriented to create a more vivid and plausible depiction of reality or news event and, in the end, to create an immersive experience:

> "In editing, the biggest difficulty had to do with the fact that binaural audio registers several layers of sound that we were unable to separately isolate, which poses some problems in the cuts. Traditionally, we record an interview, then some ambient sound from the environment where the interview happened, so that later the cuts will not be noticed so much [by the end listener]. With binaural recording, the cut would have to be done in all layers at the same time. It was possible, of course, to record the environment separately, but guaranteeing the exact same recording elements is more difficult: the same wind, the same traffic, the same position of the head, etc." (Rita Colaço, *Hearing eyes*).

4.3. Perceptual immersion, narrative immersion, place illusion

To address RQ3 regarding audio listeners' reported levels of perceptual immersion, narrative immersion, and place illusion we report the statistical results from the independent-samples t-tests and non-parametric Mann-Whitney tests – when the equality of variances could not be assumed ($p < .05$)– implemented across conditions (binaural and monaural), as well as the analyzed descriptive insights (qualitative) into the listening experience and self-report about the overall aural experience generated in the focus groups.

4.3.1. Perceptual immersion

In the scope of this article, system immersion has been defined as a property of a technological system (binaural/monaural) and perceptual immersion as the subjective response to that system. During the focus groups, both participants exposed to condition 1 (binaural) and condition 2 (monaural) verbalized feelings associated to a sense of spatialization coming from the environments where the story unfolds:

> "I really enjoyed the feeling of movement. You could feel that the characters were moving from left to right. I really got that feeling through the audio" (*Hearing eyes*, Binaural condition, Female, 22 years-old).

> "The voices [that we hear] during the game ... it's like we're there. We are listening to what people are feeling in that same moment. We are entering the [playing] field" (*Imaginary line*, Monaural condition, Female, 25 years-old).

Indeed, no statistically significant differences between binaural and monaural conditions were found regarding participants' perceptual immersion (t (75) =.414, p > .05), i.e., binaural audio did not lead to higher levels of perceptual immersion. In fact, the mean scores of both binaural (M = 4.12, SD = 0.852) and monaural participants (M = 4.05, SD = 0.621) are equally high. From these results, when compared to the monaural condition, it is possible to state that the immersive technological properties of the used binaural audio system did not lead to higher levels of self-reported subjective response to that system.

4.3.2. Narrative immersion

In this study, narrative immersion was defined as a composite variable including the response to (1) an unfolding narrative, (2) the characters inhabiting the story world, and (3) the depiction of the world itself. The concept of narrative was operationalized around five elements: the narrator, focalization, characters, time, and space. Two different stimuli with distinct narrative designs were used to isolate their specific effect on the listeners. Focus groups' participants exposed to condition 1 (binaural) particularly reported a positive effect on narrative immersion generated by using an intradiegetic narrator (one that is inside the narrative, in this case the characters themselves) with the associated internal focalization:

> "The story was told by the characters themselves, [which meant that] there was greater contact and greater immersion in the whole story" (*Imaginary line*, Binaural condition, Female, 22 years-old).

> "The fact that there is no [external] narration made it easier to feel closer to the testimonies. When the characters were talking, I had the feeling they were talking to me" (*Imaginary line*, Binaural condition, Female, 24 years-old)

Conversely, focus groups' participants exposed to condition 2 (monaural) mostly stressed the negative impact on narrative immersion coming from the use of multiple characters and from scene transitions between various spaces and times:

> "I was a little confused on the first [narrative] jump between the prison and the school. I was thinking: 'but what is the story going to be about after all?'. I felt it more at the beginning and realized that I would have to be more attentive to understand the connection between the characters and the locations" (*Imaginary line*, Monaural condition, Male, 26 years-old).

> "I thought it was a little confusing to start talking about the children and, suddenly, it goes to prisons. I was missing the connection between the two topics. When the end is reached, the objective is understood. It was very dispersed. There are many characters that are introduced, even inside the prison: there is the director, the trainer. There was a dispersion for four different characters that appear to us" (*Imaginary line,* Monaural condition, Female, 36 years-old).

> "[The construction of the narrative] is something that requires attention, because if one gets distracted, he may be a little lost and then it takes a few seconds to realize 'Ok, we are already here. We are no longer talking about the same case'" (*Imaginary line,* Monaural condition, Female, 46 years-old).

Statistical results reveal that binaural audio listeners (M = 3.90; SD = 0.819) do not account for significant higher levels of narrative immersion than those who participated in the monaural condition (M = 3.93; SD = 0.632). Looking at the three variables integrated in the narrative immersion composite variable, no statistically significant differences were also found regarding the specific response to the unfolding narrative, the characters inhabiting the story world, or the depiction of the world itself. Therefore, binaural stimuli did not lead to higher levels of self-reported narrative immersion (Table 4):

Table 4. Narrative immersion (mean scores by variable)

Variable	Binaural	Monaural
Unfolding narrative	M = 3.82; SD = 0.957	M = 3.83; SD = 0.799
Characters	M = 3.77; SD = 1.07	M = 3.91; SD = 1.01
Depiction of the story world	M = 4.12; SD = 0.822	M = 4.05; SD = 0.621

4.3.3. Place illusion

Place illusion was defined in our study as the subjective impression that the mediated experience is not mediated, resulting in the feeling of being in the location(s) of the news story. During the focus groups, participants exposed to condition 2 (monaural) expressively reported being transported to the place where the actions took place:

> "At the [metro] station, that scene of the opening of the access door. I felt transported to the train platform. It also happened during the television scene, when you hear cartoons" (*Hearing eyes*, Monaural condition, Female, 31 years-old).

> "The report, despite being audio, was very visual. The movements in the field… I almost felt like a spectator watching what was going on. I would say that as a participant no, but as a spectator on the spot, yes. I was not able to understand if I was feeling present in that place by technical means or if by the very nature of the story, because there is a lot of emotion in the story and I was attentive to those details" (*Hearing eyes*, Monaural condition, Male, 23 years-old).

The same feeling of being there was equally a constant in the responses by the participants exposed to condition 1 (Binaural):

> "As soon as I put on the headphones, I completely stopped listening to what was around me and I felt that I was exactly on the field where [the characters] were training" (*Hearing eyes*, Binaural condition, Female, 24 years-old).

> "In the scene at the station, where the person is going to press the button, I felt that I was at the station pressing the button myself" (*Hearing eyes*, Binaural condition, Male, 25 years-old).

Complementarily, the sense of co-presence, i.e., the illusion of being together with others in an environment, was also expressed by the participants exposed to the binaural stimuli during the focus groups:

> "The entrance to the prison, to go to the camp, gave me the impression that I was side-by-side accompanying the person who was entering. When the characters were talking, I had the feeling they were talking to me" (*Imaginary line*, Binaural condition, Female, 41 years-old).

Statistically, the *t*-test results reveal no significant differences between participants in the binaural and monaural conditions regarding the sense of place illusion while listening the story (t (75) = -.195, > .05). Binaural audio listeners (M = 3.82, SD = 0.957) did not account for significant higher levels of place illusion than those who participated in the monaural condition (M = 3.86, SD = 0.821).

5. Discussion and conclusion

This paper has sought to address the significant under-theorization of sound in the domain of journalism, media, and communication studies, aiming at the expansion of scholars' and media professionals' perspectives on the concept of immersive journalism, usually restricted to the production of non-fiction content using VR technologies. Therefore, the purpose of this study was to generate a more nuanced understanding of how current professionals perceive and put into practice immersive journalism and developing an examination of the factors that influence the immersive experience to the end listeners.

Binaural technologies are having an impact on journalism, leading to a whole reconfiguration of how information can be produced, distributed, and even listened to. The creation of non-fiction binaural sound stories demands its own grammar development, as the goal is to create an atmosphere of realism to foster immersion. For this reason, audio capture and editing are more than ever key steps, as for creating a 3D stereo sound feeling producers must work with several layers of sound to vividly represent a fact-based story just through audio. Immersive audio journalism requires a carefully planification of each scene, which leaves little ground for improvisation and mistakes. A constraint shared with those of VR non-fiction content and called into question for its ethical implications (**Kool**, 2016).

The findings also indicate that three main qualities are attributed to binaural audio productions. First, a higher sense of realism throughout the listener experience. A variable which some studies have in fact associated with a sense of presence in VR reporting (**Sundar** *et al.*, 2017) or pointed out as a contributor to the user's immersion in the story (**Domínguez**, 2013). Second, an enhanced sense of identification between the listener and the characters, turning the user in a sort of immersive witness (**Nash**, 2018), being a position also argued in research on VR journalism (**Sánchez**-**Laws**, 2020). And third, the power of sound to act as a suggestive and primary element, even in the absence of a narration itself, which opens renewed possibilities for non-fiction audio content production and engaging audiences through an immersive experience.

In terms of user experience, it is not possible to conclude that technologically immersive formats, i.e., the binaural audio journalistic productions, have a positive effect in terms of perceived immersion and sense of presence. In particular, the experimental design revealed no evidence that binaural sound by itself leads to a more immersive experience than a monaural sound story. We found no difference in the three types of immersion under study and no significant difference in the illusion of place.

From the results of the study emerges a new research question: can we consider that the very experience of concentrate to listening to a story represents an immersive capacity as soon as the listener accepts to abstract from his immediate, physical world to surrender to the world he is listening to? The idea of transporting the reader/user to the time and space in which events take place has been commonly studied from a narrative theory perspective. In this regard, narrative worlds have been conceived as a sort of mental places where a user, listener, viewer, or reader arrives as the consequence of a series of psychological processes activated by a narration (**Domínguez**, 2013). This is in fact the premise of the narrative transportation theory proposed by the cognitive psychologist **Richard**-**Gerrig** (1993), considered the folk theory of immersion (**Ryan**, 2015). The journey to the new world (narrative) starts when the experiencers become lost in the story, when it succeeds in absorbing them in such a way they are turned into travelers being transported to the place where the events take place. In fact, transportation has been defined as a convergent mental process where attention, imagination and feelings come together and converge (**Green**; **Brock**, 2000).

Further research on immersive audio journalism is required, as the findings of this study suggest. This leads us to consider two main future lines of investigation. On the one hand, methodological, advancing the hypothesis that there was an intervention of cognitive conditioning in the results obtained, i.e., that by being randomly assigned to experimental groups without being informed of their experimental condition (binaural OR monaural), the participants may have reported a "placebo effect". Thus, in a future replication of the experiment we should consider creating two additional

experimental groups (Binaural Informed AND Monaural Informed), composed of participants who, maintaining the randomization of their assignment, will be informed of the aural condition to which they will be exposed. This will allow us to cross-check the results obtained and make the hypothetical exposure to self-inflicted conditioning measurable. On the other hand, the results of this study point to the need to address the effect of narrative design on immersive audio experiences. In particular, more experimental research is needed to try to isolate the effect of narrator, focalization, characters, time, and space on listener experience.

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