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# Accessibility as Lived Experience: Understanding Low Vision Across Physical, Digital, and Emerging Interaction Contexts Through ECAM-VI

Yuliya Chystaya , Fotios Spyridonis  and Gheorghita Ghinea 

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## ABSTRACT

Accessibility efforts have traditionally addressed low vision through feature-based solutions and compliance guidelines, with less attention to how accessibility is experienced across physical, digital, and emerging environments. This study investigates the lived experiences, coping strategies, and technology expectations of people with low vision to develop an experience-centred understanding of accessible interaction. Semi-structured interviews were analyzed using thematic analysis. The findings show that accessibility emerges from five interrelated dimensions: perceptual variability, emotional and social experience, coping behaviours, technological mediation, and socio-environmental context. Participants described accessibility as a continuous experience shaped by personalization, adaptive practices, environmental negotiation, and integrated technologies. Although participants' views of immersive technologies largely reflected perceived assistive potential rather than direct experience, the findings identify considerations for future immersive accessibility design. We introduce the Experience-Centred Accessibility Model for Visual Impairment (ECAM-VI), an empirically grounded framework that conceptualizes accessibility as a relational, experience-centred phenomenon and informs the design of inclusive interactive systems.

## KEYWORDS

Accessibility; low vision;  
inclusive design;  
experience-centred design;  
immersive systems

## 1. Introduction

Ensuring accessibility for people with visual impairments (VIs), including blindness and low vision, remains a fundamental challenge across physical and digital environments, as well as emerging immersive systems. It is often assumed that as technology progresses, accessibility advances at a similar pace and becomes equally sophisticated. Unfortunately, this is not true in most cases, and as a result, disabled people tend to own fewer electronic devices (Kaye, 2000) and are less likely to be active Internet users (Fox, 2011). Therefore, visually impaired individuals continue to encounter unpredictable, inconsistent, and emotionally burdensome interactions in their everyday lives (Botelho, 2021). Specifically, prior research has documented visual impairment as a heterogeneous condition characterized by diverse perceptual effects, functional abilities, and interaction patterns (Manduchi & Kurniawan, 2018). At the same time, emotional and psychological factors such as confidence, anxiety, and trust strongly influence how people engage with technology, yet they remain relatively under-explored in accessibility research (Branham & Kane, 2015a, 2015b). Such factors become more pronounced when navigating spatial interfaces or using multimodal interactions that require rapid environmental interpretation (Giudice & Legge, 2008).

In parallel, as interaction paradigms evolve, spanning mobile interfaces, multimodal systems, and immersive technologies such as Extended Reality (XR), so do the accessibility demands placed upon designers of such solutions. Understanding these demands requires a grounded understanding of the lived experiences, coping strategies, and expectations of people with visual impairments, as well as

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reported accessibility barriers. While accessibility challenges within XR have increasingly attracted research attention, including issues relating to navigation, visual information access, multimodal interaction, and accessibility guidance (Dudley et al., 2023; Killough et al., 2024; M. Mott et al., 2019; Rubano & Vitali, 2021; Zhao et al., 2019), much of this work remains focused on technical adaptation or system-level design challenges rather than everyday lived accessibility experiences. However, despite growing interest in accessible XR design, there remains limited understanding of how broader lived experiences of accessibility shape expectations toward emerging immersive technologies, or how existing coping practices developed in physical and digital environments may translate into future immersive contexts. Importantly, the present study does not seek to evaluate XR systems directly. Rather, XR is treated as part of a broader landscape of emerging accessibility technologies that may benefit from a deeper understanding of lived accessibility experience.

Accordingly, this study adopts a qualitative, lived-experience approach to examine how individuals with low vision experience accessibility barriers, develop coping strategies, and engage with technologies across interconnected physical and digital contexts, while also exploring perceptions and expectations regarding future immersive systems. The focus on low vision enables deeper exploration of how accessibility is shaped through ongoing interaction between perception, environment, and technology. Addressing these challenges requires a more holistic understanding of accessibility that connects experiences across physical and digital domains with expectations toward future technologies. Specifically, we explore the following four research questions:

**RQ1.** What accessibility challenges do individuals with low vision encounter across physical and digital environments, including perceptions of emerging immersive contexts?

**RQ2.** What coping strategies do they employ to navigate these challenges?

**RQ3.** What accessibility features, interaction preferences and technology expectations do they consider most or least valuable across current and emerging interaction contexts?

**RQ4.** How do individuals with low vision experience the emotional and social impacts of accessibility barriers?

Accordingly, semi-structured interviews with 42 participants with low vision were conducted and data were analyzed using a reflexive thematic analysis approach (Braun & Clarke, 2019, 2021) resulting in six themes: (1) Perceptual diversity and lived visual experiences, (2) Emotional and psychological dimensions of visual impairment, (3) Living accessibility across physical and digital worlds, (4) Assistive technologies as enablers and constraints, (5) Personalized accessibility and perceptual control, and (6) Attitudes toward digital and emerging technologies. While these themes echo elements of prior work, their combination reveals a deeper interpretive structure that connects perceptual variability, emotional load, coping practices, and technology expectations. As the participants predominantly consisted of adults with low vision conditions, the findings and resulting framework primarily reflect lived experiences shaped by fluctuating and residual visual perception in later-life contexts.

We further synthesize these findings into the **Experience-Centred Accessibility Model for Visual Impairment (ECAM-VI)**, which conceptualizes accessibility as the interplay of perceptual, emotional, behavioral, and technological dimensions. This model advances theory by highlighting cross-context continuities in accessibility experiences and offering a structured lens through which future technologies, such as XR, can be designed. Beyond theory, we also develop a **set of design implications** derived from lived experiences, outlining actionable implications for designers. This article therefore makes the following three contributions to Human-Computer Interaction (HCI) and accessibility research:

1. A holistic account of lived accessibility experiences that integrates physical, digital, and emerging immersive contexts.
2. A conceptual framework (ECAM-VI) that links perceptual, emotional, behavioral, and technological dimensions to accessibility needs.
3. Actionable design implications for inclusive digital and spatial computing systems.

This article is structured as follows. [Section 2](#) lays out the background for this work in the context of visual impairments. [Section 3](#) discusses the methodology employed for the study, while [Section 4](#) presents the main findings. Finally, [Section 5](#) presents a concluding discussion and the contributions, limitations, and directions for future research.

## **2. Background and related work**

Accessibility research for people with low vision spans diverse domains, including physical mobility, digital interaction, assistive technologies, and more recently, immersive environments. This section synthesizes prior work across these domains to position the contributions of this study, highlighting gaps in understanding how lived experiences, emotional factors, and cross-context coping strategies shape accessibility needs.

### **2.1. Diversity of visual impairments and the role of emotions**

Visual impairments are very common and affect a large part of the population (Pladere et al., 2022). Yet, they are often misunderstood, and it is not uncommon that sighted people often have misconceptions about blindness and low vision (Thevin & Machulla, 2020). This could be attributed to the fact that visual impairment is not a single condition, but a spectrum ranging from reduced acuity to blindness, which are often accompanied by glare sensitivity, contrast loss, visual field restrictions, and fluctuating symptoms (Manduchi & Kurniawan, 2018). Interestingly, people with a visual impairment are sometimes unaware of the extent of their impairment (Pladere et al., 2022). As a result, interaction challenges within digital environments vary substantially based on the type and severity of a visual impairment, environmental conditions, task complexity, and assistive technologies used. While past work documents this variability and its impacts on functional vision, there is limited work examining how it affects emotional load and trust in technology, including in immersive environments such as XR. These experiential dimensions, highlighted strongly in our findings, represent an under-explored aspect of accessibility research. Furthermore, accessibility research has increasingly recognized the role of emotional well-being in shaping interaction experiences. Decreased quality of life, frustration, and a feeling of helplessness have all been reported among visual impaired individuals (Heinze et al., 2021; Merenda et al., 2025) as factors influencing how they engage with technology; yet such affective dimensions also remain relatively under-explored in accessibility research. For example, although smartphones incorporate many accessibility features, users continue to report usability challenges that contribute to cognitive and emotional strain when using assistive tools (Senjam et al., 2021). As a result, emotional states are rarely integrated into design guidelines or conceptual models, which is a key element of our work.

### **2.2. Barriers in physical and digital environments**

People living with a visual impairment also encounter persistent and multifaceted accessibility challenges in many daily aspects, both in physical and digital contexts. When it comes to the former, they are often faced with challenges in navigation, mobility, obstacle avoidance, public transport, signage, and lighting conditions (Giudice & Legge, 2008), among others, that impede independent mobility, participation, and overall quality of life. Despite considerable past work, these remain challenging due to environmental design features that rely primarily on visual cues. For instance, prior studies about indoor navigation showed that visually impaired individuals encounter difficulty with obstacles, lack of tactile and auditory way-finding cues, and unpredictable spatial layouts that undermine confident travel, especially in unfamiliar buildings and public spaces (Jeamwathanachai et al., 2019a, 2019b, 2019c). Likewise, similar research has shown that outdoor environments often lack sufficient detectable guidance markings, have inaccessible pedestrian crossings and uneven surfaces, and present frequent obstacles that hinder active mobility (Barasche-Berdah et al., 2023). These environmental barriers contribute not only to practical navigation difficulties, but also to emotional well-being as result of spatial anxiety and reduced confidence in mobility (Remillard et al., 2024).

Similarly, with respect to the latter, digital environments also present a range of persistent accessibility challenges that directly impact the independence and task success of people with visual impairments (Droutsas et al., 2025b). Whilst digital accessibility has improved with the adoption of long-standing standards and guidelines such as the Web Content Accessibility Guidelines (WCAG), over 96% of the most popular websites still contain detectable accessibility errors such as poor contrast, missing alternative text, empty links, and navigation issues that screen readers cannot reliably interpret, creating obstacles for users relying on non-visual interaction methods (WebAIM, 2026). For example, inaccessible online job application portals often prevent visually impaired applicants from completing critical employment tasks independently due to inconsistent screen reader support (Reuschel et al., 2023). A recent comprehensive review further identifies mental and functional gaps in how accessibility is approached across the life cycle of web systems, suggesting that design attitudes frequently fail to bridge the gap between guidelines and real user experiences (Droutsas et al., 2025a). Such digital challenges can amplify exclusion when paired with physical environment challenges, such as the ones discussed earlier. Collectively, the above work demonstrates that physical and digital environments frequently fail to provide accessible spatial information and detectable cues needed for safe navigation, issues that underpin the need for identifying navigational strategies and coping behaviors in this work.

Finally, it should be also noted that more recent and less mature digital mediums, such as immersive technologies, which blur the boundaries between the physical and virtual worlds (H.-G. Lee et al., 2013; Y.-C. N. Lee et al., 2013; Suh & Prophet, 2018), often present unique accessibility challenges due to their inherently visual-centric nature (Andrade et al., 2018, 2019; Iren et al., 2023; Ji et al., 2022; Montagud et al., 2020; Or & Maidenbaum, 2024; Zhang et al., 2020). For example, South et al. explored accessibility limitations and barriers faced by people with photosensitive epilepsy (PSE) in Virtual Reality (VR) showing that while participants' experiences varied depending on the severity of their condition, there were evident barriers associated with VR hardware, interfaces, content, and design considerations in specific applications (South et al., 2024). These challenges are further amplified due to the lack of established accessibility guidelines, standards, and tools for developers of such immersive technologies (Dudley et al., 2023). As a result, there is a clear need to also examine immersive technologies not merely as a novel interface modality, but as an experiential extension of the same accessibility challenges encountered in physical and digital environments.

### **2.3. Visual accessibility challenges in emerging immersive systems**

XR environments, encompassing VR, Augmented Reality (AR), and Mixed Reality (MR), introduce new interaction paradigms that blend spatial navigation, digital augmentation, and multimodal feedback. These technologies have increasingly attracted attention within accessibility research due to their potential to support navigation, environmental awareness, training, and assistive interaction for people with visual impairments. However, existing work also demonstrates that many accessibility challenges experienced in physical and digital environments (see Section 2.2) remain unresolved within immersive systems, while new perceptual, cognitive, and spatial demands are simultaneously introduced (Creed et al., 2024). Existing research has explored a range of perceptual adaptation approaches intended to improve accessibility within immersive environments, including magnification, contrast adjustment, recoloring, peripheral remapping, edge enhancement, gaze-adaptive correction systems, and multimodal feedback techniques (Dang et al., 2023; Jhangiani et al., 2022; Kreimeier & Götzelmann, 2020; Masnadi et al., 2020; Nikolaos et al., 2023; Omary, 2024; Zhao et al., 2019). While these approaches demonstrate the potential of adaptive and multimodal interaction, they often assume stable perceptual requirements and may not fully account for the changing, context-dependent, and lived nature of low vision experiences.

Research has also explored audio-based navigation support, echolocation-based interaction, haptic feedback systems, gesture-supported interaction, and cane-based navigation techniques intended to transfer familiar orientation and mobility practices into immersive environments (Andrade et al., 2022; Gonzalez Penuela et al., 2022; Lang et al., 2022; Omary, 2024; Omary & Mehta, 2022, 2024; Robern et al., 2021; Siu et al., 2020; Zhang et al., 2020; Zhao et al., 2018). These studies highlight the importance of supporting non-visual interaction and adaptive navigation strategies within immersive systems. However, immersive environments frequently disrupt coping mechanisms commonly used in everyday

physical and digital contexts, such as reliance on predictable layouts, environmental familiarity, and stable spatial cues (Naranjo-Puentes et al., 2022; Neugebauer et al., 2024).

Accessibility challenges within immersive systems further extend beyond interface visibility alone and involve broader issues relating to spatial interpretation, locomotion, cognitive load, and environmental navigation. Existing work has explored a range of navigation and locomotion approaches, often incorporating multimodal feedback to reduce spatial disorientation and cognitive demands (Kreimeier & Goetzmann, 2019; Ribeiro et al., 2024; Thevin et al., 2020). At the same time, immersive technologies have shown potential for mobility training, accessibility education, object recognition, contextual guidance, and visual impairment simulation (Baas et al., 2019; Guarese et al., 2023; Krösl et al., 2020; Laviole et al., 2018; Maeda et al., 2022; Mambu et al., 2019; Thevin & Machulla, 2020). Nevertheless, many immersive accessibility solutions remain visually dominant, relying heavily on overlays or interface adaptations that may offer limited benefit for blind and low vision users (Creed et al., 2024). Existing research also highlights the importance of supporting residual vision and adaptive multimodal interaction rather than assuming exclusively non-visual interaction approaches (Zhao et al., 2015).

Collectively, the literature demonstrates that accessibility within immersive systems cannot be fully addressed through interface-level adaptations alone. Instead, immersive accessibility is closely connected to perceptual variability, emotional and cognitive demands, adaptive coping practices, and environmental context. These observations motivate the need for experience-centred approaches that ground future immersive accessibility design in the lived experiences of people with low vision. Accordingly, this work positions and presents immersive systems within the broader accessibility landscape rather than discussing them as an empirical evaluation of XR accessibility.

#### **2.4. Toward experience-centred accessibility**

Accessibility has traditionally been approached through standards, most notably the World Wide Web Consortium's Web Content Accessibility Guidelines (WCAG) (Henry, 2026), and through inclusive design frameworks such as Microsoft's Inclusive Design Toolkit (Microsoft, 2025). While these approaches have been instrumental in improving baseline accessibility, they primarily conceptualize accessibility as a **set of technical requirements or interface properties**, often providing comparatively less emphasis on the lived experiences of users. Parallel work in accessibility and disability studies has highlighted the experiential nature of accessibility, emphasizing that barriers emerge from interactions between individuals, technologies, and environments rather than from impairments alone. For example, earlier work by Newell and Gregor (2000) argued for "user-sensitive inclusive design" stressing the importance of understanding diverse user capabilities in context. Similarly, Lazar et al. (2015) frame accessibility as a socio-technical challenge that extends beyond compliance to also encompass organizational processes and user practices.

Within HCI, a growing body of work has examined the lived experiences of accessibility, particularly for blind and low vision users. Studies have documented the "invisible work" required to navigate digital systems (Branham & Kane, 2015b), the reliance on adaptive strategies and workarounds (Bigham et al., 2010), and the importance of contextual and social factors in shaping interaction (Kane et al., 2011). These studies collectively demonstrate that accessibility is not a static property of systems, but an ongoing, situated accomplishment. At a broader theoretical level, HCI has increasingly moved toward relational and situated accounts of interaction. Concepts such as situated action (Suchman, 1987), distributed cognition (Hutchins, 1995), and embodied interaction (Dourish, 2001), emphasize that interaction emerges from the interplay between users, tools, and environments. These perspectives are particularly relevant to accessibility, where interaction is often shaped by adaptation, environmental navigation, and the use of assistive or coping practices. As a result, this gap highlights the need for accessibility frameworks that conceptualize accessibility not solely as compliance or interface usability, but as an experience-centred approach grounded in lived interaction across physical, digital, and emerging environments.

## 2.5. Summary and gaps

Across physical, digital and emerging immersive systems, existing research consistently demonstrates that systems often lack meaningful alignment with the lived experiences, adaptive practices, and coping strategies that people with visual impairments develop in everyday life. Although past efforts have explored multimodal feedback, auditory navigation cues, and impairment simulation solutions, these efforts remain fragmented and largely disconnected from the everyday lived experiences of visually impaired users (Neugebauer et al., 2024). In response, this study adopts a lived-experience approach to understanding accessibility. Rather than evaluating digital systems in isolation or focusing solely on technical accessibility features, we position lived experience as the primary empirical foundation for inclusive design by prioritizing participants' first-person accounts of how accessibility is encountered, interpreted, and negotiated in everyday life. Such approaches seek to understand how individuals make sense of their experiences within specific social, environmental, and technological contexts (Creswell & Poth, 2016; Manen, 2016). It is therefore necessary to move beyond isolated solutions and toward integrated approaches that reflect the dynamic and relational nature of real-world interaction. This gap motivates the need for a framework that integrates multiple dimensions of accessibility, captures their interdependencies, and reflects accessibility as it is lived across physical, digital, and emerging interaction contexts. In response, this article introduces the Experience-Centred Accessibility Model for Visual Impairment (ECAM-VI), an empirically grounded framework that conceptualizes accessibility as an experience-centred phenomenon.

## 3. Methodology

An exploratory study employing a qualitative approach through semi-structured online interviews with low vision participants was conducted, which are generally more appropriate for investigating accessibility experiences, as they enable the exploration of subjective, embodied, and context-dependent phenomena that shape real-world interaction (Braun & Clarke, 2021). This section discusses the participants, the study protocol and the analysis approach followed.

### 3.1. Participants and recruitment

In total, 42 participants were recruited and interviewed from the 10<sup>th</sup> of February to the 1<sup>st</sup> of May 2025. Twenty-six of the participants identified as female and 16 as male, and the mean age was 64.4 years (range 18-86; SD 13.53). While some participants reported having previous experience with immersive technologies, this was not a requirement for this study. Tables 1 and 2 provide an overview of the participant group. The inclusion criteria were broad by design to recruit a diverse sample of visually impaired users, including (1) having a type of visual impairment (but not complete blindness), (2) being over 18 years old at the time of the interview, and (3) being able to speak and understand English. The exclusion criteria were (1) not being able to speak and understand English, (2) complete blindness, and (3) not being able to give consent independently. The decision to focus on participants with low vision rather than also include individuals with complete blindness was made to enable an in-depth investigation of how accessibility is experienced through the interaction between remaining visual perception, environmental conditions, and assistive technologies. Many of the phenomena discussed in this study, such as contrast sensitivity, glare, distortion, and the use of residual vision alongside digital tools are specific to low vision experiences and would not be directly applicable to individuals with no functional vision. This focus allows for a detailed examination of a substantial and prevalent user group.

All participants were recruited through relevant organizations and their social media. Snowball sampling was then used until saturation was achieved. Recruitment and analysis proceeded iteratively throughout the study, with ongoing consideration of thematic richness, diversity of lived experiences, and interpretive depth. Consistent with reflexive thematic analysis, the study did not treat saturation as a fixed numerical stopping criterion but instead focused on achieving sufficient variation and depth across participants' accounts. Participant recruitment therefore continued until the dataset was considered sufficiently rich and conceptually developed to address the aim of the study. Participants who were interested in participating contacted the first author, and if they qualified based on the inclusion

**Table 1.** Participant characteristics and self-reported experiences.

PID	Age range	Gender	Severity	Self-reported VI(s)
01	36–45	F	Severe	Tunnel vision, nystagmus, ocular albinism
02	66–75	M	Moderate	Dry macular degeneration
03	66–75	M	Severe	Best disease (Viteliform macular dystrophy)
04	66–75	M	Mild	Dry macular degeneration
05	66–75	M	Severe	Dry macular degeneration
06	66–75	F	Moderate	Myopic macular degeneration
07	56–65	M	Severe	Wet macular degeneration, cataracts
08	56–65	F	Moderate	Dry macular degeneration
09	66–75	M	Moderate	Dry macular degeneration
10	66–75	F	Moderate	Vitreous detachment, cataracts
11	66–75	M	Moderate	Dry/wet macular degeneration, red-green color blindness
12	56–65	M	Mild	Macular dystrophy in right eye
13	66–75	M	Mild	Macular degeneration
14	46–55	F	Moderate	Myopia, central and peripheral vision, cataracts, light sensitivity
15	66–75	F	Moderate	Dry macular degeneration, cataracts
16	76–85	F	Severe	Severe myopia, retinal detachment
17	66–75	F	Severe	Retinal hemorrhage
18	56–65	F	Moderate	Genetic macular dystrophy
19	76–85	M	Moderate	Genetic macular dystrophy
20	66–75	F	Severe	Wet macular degeneration
21	46–55	M	Moderate	Geographic atrophy
22	66–75	F	Mild	Macular degeneration, cataracts
23	66–75	M	Severe	Retinal hemorrhage
24	66–75	M	Severe	Wet macular degeneration
25	66–75	F	Severe	Myopic macular degeneration, cataracts
26	56–65	F	Moderate	Stargardt disease
27	76–85	F	Severe	Congenital cataracts, severe myopia, retinal hemorrhage
28	66–75	M	Moderate	Wet macular degeneration
29	56–65	F	Severe	Macular dystrophy, cataracts, photophobia
30	66–75	F	Severe	Glaucoma, damaged cornea
31	18–25	F	Moderate	Aniridia, photophobia, cataracts, nystagmus
32	56–65	F	Mild	Myopic macular degeneration
33	66–75	F	Moderate	Detached retina, wet macular degeneration
34	66–75	F	Moderate	Macular degeneration, glaucoma
35	46–55	F	Severe	Glaucoma
36	36–45	M	Mild	Impaired cornea, nystagmus
37	46–55	F	Severe	Meningitis, stroke
38	76–85	F	Moderate	Retinal hemorrhage
39	66–75	F	Moderate	Wet and dry macular degeneration
40	46–55	F	Severe	Retinitis pigmentosa
41	76–85	F	Moderate	Macular degeneration
42	26–35	M	Mild	Corneal scarring

and exclusion criteria, they were then handed a participant information sheet, and informed consent was obtained before proceeding to scheduling an interview. Potential participants were also informed that interviews would be recorded. The ethics protocol was approved by the authors' institutional Research Ethics Committee (Ref: 49316-LR-Jan/2025- 53537-4) and the methods were carried out in accordance with relevant guidelines and regulations.

The severity categories presented in Table 1 (mild, moderate, and severe) were used as broad descriptive classifications based on participants' self-reported visual functioning and perceived impact on everyday activities, rather than formal clinical or ophthalmological thresholds. Similarly, the digital confidence levels (low, medium, and high) and XR attitudes presented in Table 2 were categories derived interpretively from participants' self-reported familiarity, comfort, and frequency of engagement with digital technologies, as well as their expressed attitudes toward immersive systems during the interviews. Specifically, XR attitude levels reflected participants' perceived usefulness of, openness toward, or concerns regarding emerging immersive technologies. These classifications were included to provide contextual understanding of the participant sample and were not reported as standardized or objectively measured categories.

### 3.2. Interview protocol

The interviews were carried out online using Zoom or Microsoft Teams, depending on participants' preferences and accessibility needs. Prior to the interview, participants were asked to complete and sign the consent form, or to give their consent verbally if the written format was inaccessible to them.

**Table 2.** Participant technology profiles and adaptive coping strategies.

PID	Digital confidence	Visual strategies	Non-visual strategies	XR attitude
01	Low	Contrast, custom color schemes	Screen reader	High
02	Low	Contrast, custom color schemes, anti-glare screens, dark mode	Screen reader, haptics	XR as assistive tech
03	High	Magnification, increased contrast, anti-glare screens, custom color schemes, dark mode	Audio notifications, haptics	High
04	Medium	Magnification, increased contrast, custom color schemes, dark mode	Prefers use of remaining vision	Neutral
05	High	Magnification, increased contrast, anti-glare screens, custom color schemes, custom text layouts	Prefers use of remaining vision	High
06	Medium	Magnification, increased contrast, anti-glare screens, custom color schemes, custom text layouts	Screen reader, audio cues, haptic feedback, voice commands	High
07	Medium	Magnification, increased contrast/brightness, custom color schemes, custom text layouts	Screen reader, audio cues, haptic feedback, voice commands	XR as assistive tech
08	Medium	Magnification, increased contrast, custom color schemes, custom text layouts	Screen reader, voice commands	XR as assistive tech
09	Medium	Magnification, increased contrast, custom color schemes, custom text layouts	Screen reader, voice commands	Neutral
10	Low	Magnification, increased contrast, custom color schemes, dark mode, custom text layouts	Screen reader, voice commands, haptics	High
11	Medium	Magnification, increased contrast, custom color schemes, dark mode, anti-glare screens, custom text layouts	Screen reader, voice commands	Neutral
12	High	Custom color schemes, custom text layouts, large fonts, increased brightness	Prefers use of remaining vision	Interested
13	High	Custom color schemes, custom text layouts, large fonts, increased brightness	Prefers use of remaining vision	Interested
14	Medium	Custom color schemes, increased contrast, dimmed screen, dark mode, custom text layouts, large fonts	Prefers use of remaining vision	Interested
15	Medium	Magnification, custom color schemes, increased contrast, dark mode, custom text layouts, large fonts	Prefers use of remaining vision	Neutral
16	Medium	Magnification, custom text layouts, large fonts	Prefers use of remaining vision	Neutral
17	Medium	Magnification, additional light, dark mode, custom text layouts, large fonts	Haptic feedback	Interested
18	Medium	Magnification, dark mode, adjustable brightness, custom text layouts, large fonts	Haptic feedback, screen reader	Interested
19	Medium	Magnification, dark mode, adjustable brightness, anti-glare screens, custom text layouts, large fonts	Screen reader	Interested
20	Medium	Magnification, light mode, increased brightness/contrast, custom text layouts, large fonts	Screen reader, voice commands	Interested
21	Medium	Magnification, adjustable brightness, increased contrast, custom text layouts, large fonts	Screen reader, voice commands, haptic feedback	Interested
22	High	Magnification, increased contrast, custom text layouts, large fonts	Prefers use of remaining vision	Interested
23	Medium	Magnification, increased contrast, anti-glare screens, custom text layouts, large fonts	Voice commands, dictation	Interested
24	Low	Magnification, increased contrast, reduced brightness, anti-glare screens, custom text layouts, large fonts	Haptic feedback	Interested
25	Low	Magnification, increased contrast, extra saturated colors, reduced brightness, anti-glare screens, custom text layouts, large fonts	Voice commands, screen reader, haptic feedback	Interested
26	Low	Magnification, increased contrast, reduced brightness, anti-glare screens, custom text layouts, large fonts	Voice commands, screen reader	Neutral

*(continued)*

Table 2. Continued.

PID	Digital confidence	Visual strategies	Non-visual strategies	XR attitude
27	Medium	Magnification, dark mode, increased contrast, saturated colors, reduced brightness, anti-glare screens, custom text layouts, large fonts	Voice commands, screen reader	Interested
28	High	Magnification, dark mode, increased contrast/brightness, saturated colors, custom text layouts, large fonts	Voice commands, screen reader	Neutral
29	Medium	Magnification, dark mode, increased contrast, saturated colors, decreased brightness, custom text layouts, large fonts	Voice commands, additional audio cues, screen reader, haptic feedback	Interested
30	Medium	Magnification, dark mode, increased contrast, saturated colors, decreased brightness, anti-glare screens, custom text layouts, large fonts	Voice commands, additional audio cues, screen reader, haptic feedback	Interested
31	High	Magnification, dark mode, increased contrast/brightness, saturated colors, anti-glare screens, custom text layouts, large fonts	Voice commands, additional audio cues, screen reader, haptic feedback	Interested
32	High	Magnification, increased contrast, custom text layouts, large fonts	Prefers use of remaining vision	Neutral
33	Medium	Magnification, dark mode, increased contrast/brightness, saturated colors, anti-glare screens, custom text layouts, large fonts	Voice commands, additional audio cues, screen reader, haptic feedback	Interested
34	Low	Magnification, dark mode, increased contrast/brightness, saturated colors, anti-glare screens, custom text layouts, large fonts	Voice commands, additional audio cues, screen reader	Interested
35	Low	Magnification, dark mode, increased contrast/brightness, saturated colors, anti-glare screens, custom text layouts, large fonts	Voice commands, additional audio cues, screen reader, haptic feedback	Interested
36	High	Magnification, dark mode, increased contrast, anti-glare screens	Prefers use of remaining vision	Interested
37	Low	Magnification, dark mode, increased contrast, saturated colors, reduced brightness, anti-glare screens, custom text layouts, large fonts	Voice commands, additional audio cues, screen reader, haptic feedback	Interested
38	Low	Magnification, dark mode, increased contrast, saturated colors, reduced brightness, anti-glare screens, custom text layouts, large fonts	Voice commands, additional audio cues, screen reader, haptic feedback	Neutral
39	Low	Magnification, dark mode, increased contrast, saturated colors, reduced brightness, anti-glare screens, custom text layouts, large fonts	Voice commands, additional audio cues, screen reader	Interested
40	Medium	Magnification, dark mode, increased contrast, saturated colors, reduced brightness, anti-glare screens, custom text layouts, large fonts	Voice commands, additional audio cues, screen reader	Interested
41	Low	Magnification, dark mode, increased contrast, saturated colors, reduced brightness, anti-glare screens, custom text layouts, large fonts	Voice commands, haptic feedback	Neutral
42	High	Dark mode, reduced brightness, anti-glare screens	Prefers use of remaining vision	Not interested

A semi-structured interview format was followed (see Appendix) to encourage participants to share their personal lived experiences and insights. The participants were asked questions about their visual impairment, their overall functional vision, adaptation strategies for overcoming barriers in both physical and digital environments, as well as to share their experience and thoughts on accessibility features, or technologies they use or would like to be able to use. Finally, they were asked about their experience with immersive technologies as a means of eliciting their perceptions and expectations of emerging technologies, including XR. Given that many participants had limited direct experience with such systems, these questions served as a concrete reference point to facilitate discussion. The study therefore captures attitudes and expectations toward XR rather than direct interaction experiences. Each

interview lasted between 40 min and 1.5 hr, and they were audio recorded while the first author was also taking notes by hand. The goal of the interviews was to understand lived experiences of people with low vision and learn about the challenges they are facing in their everyday life. Toward the end of an interview, participants were also asked demographic questions. While a set of specific semi-structured questions was used, the interviews were conducted in a flexible way to accommodate each discussion and how it progressed always guided by the participants' experiences and insights.

### 3.3. Data analysis, trustworthiness, and reflexivity

In total, close to 45 hr of interviews were recorded and transcribed. Interview transcripts were analyzed by the first author following Braun and Clarke's reflexive thematic analysis approach (Braun & Clarke, 2019, 2021), which emphasizes individual researcher subjectivity as the desired resource for knowledge generation, as opposed to other thematic analysis approaches relying on the involvement of multiple coders for bias mitigation (Byrne, 2022). Trustworthiness is established in this work through transparency, reflexivity, and depth of analysis rather than through inter-coder reliability. To support analytical rigor, the first author conducted the primary coding and maintained a detailed audit trail, including coding notes, theme iterations, and analytic notes. The second author was involved throughout the analytic process through regular discussions of coding decisions, theme development, and interpretation. These discussions functioned as *peer debriefing*, supporting critical reflection and refinement of the analysis. Reflexivity was an integral part of the analytic process, with the researchers actively reflecting on their assumptions, interpretations, and positionality in relation to the data. This ensured that themes were not treated as emerging directly from the data, but as constructed through a systematic and theoretically informed interpretive process (Table 3). While member checking is commonly used in some qualitative approaches, it was not employed in this study, as it is not universally considered necessary within reflexive thematic analysis, where participants are not positioned as validators of the researcher's interpretation (Braun & Clarke, 2026). Instead, the goal was to develop a coherent and theoretically grounded account of patterns across the dataset. This approach was also chosen for its flexibility and suitability for capturing rich, nuanced meanings, which are relevant and consistent to lived experiences of participants with low vision in their interactions with physical and digital environments. Moreover, reflexive thematic analysis requires the researcher to reflect on their own active role in data analysis, coding, and development of the themes.

Accordingly, an inductive approach to the analysis was adopted to identify key themes. NVivo 12 (Lumivero, 2026) was used to facilitate coding of the interviews following an iterative and reflective process whereby the data were examined, and the codes were refined with every iteration. A list of 70 codes was produced as a result of this process, which were later revised by the first author through the

**Table 3.** Reflexive thematic analysis phases and descriptions.

Phases of reflexive thematic analysis	Phase adaptation description and trustworthiness
Phase 1: familiarization with the data	The first author revisited the notes taken during the interviews, listened to the recordings, and reviewed the transcripts. This phase was fundamental to deepen understanding of the data corpus.
Phase 2: generating the initial codes	The first author generated initial codes for the entire data corpus to avoid missing links between data items (Braun & Clarke, 2006). Latent and semantic coding approaches were used in equal measure to ensure a balance between meanings derived from the participants and from researcher's interpretation (Patton, 1990).
Phase 3: generating themes	The first author used NVivo software (Lumivero, 2026) to create lists of codes with shared meaning to generate themes and their subthemes.
Phase 4: reviewing potential themes	The first author created and refined the list of themes using Patton's dual criteria, namely, internal homogeneity within the themes and external homogeneity among the themes (Patton, 1990). Six themes were conceived in the analysis of the entire data set.
Phase 5: defining and naming themes	The first author reviewed and refined the themes. The names of the themes were also optimized to ensure that they capture the essence of the themes and are not merely descriptive (Braun & Clarke, 2021).
Phase 6: producing the report	The first author then produced an analytic report, following steps outlined by Braun and Clarke (2019). The report features extracts from the gathered data, viewed through the lens of our RQs. The narrative was then reviewed by the second author to ensure coherence and trustworthiness.

phases discussed in Table 3 below to arrive at the broader themes presented in the findings. Specifically, in line with Braun and Clarke's approach, the process begun with the generation of initial codes, which were then transitioned into themes using latent or semantic coding, approaches that rely on interpretation, or remain descriptive (Braun & Clarke, 2016), as well as the generation of sub-themes. It is important to note that reflexive thematic analysis does not involve a predetermined or correct number of themes, but balance is crucial: excessive themes can compromise coherence, while insufficient themes may lack analytical depth and scope (Byrne, 2022). Therefore, Lichtman's recommended guideline of limiting themes to five to seven per dataset was followed in order to maintain this balance (Lichtman, 2023).

## 4. Findings

In this section, the analysis of the themes using key data extracts is reported, while also anchoring them to the literature and the research questions. Furthermore, the insights which emerged from the data were used to synthesize a framework and practical design implications.

### 4.1. Lived experiences of visual impairment and experiential dimensions of accessibility

This discussion is organized around six interrelated themes that capture the lived experiences of participants with predominantly low vision conditions and should therefore be interpreted within this context. It must be noted that as accessibility experiences were highly interconnected, several themes contributed to multiple research questions simultaneously rather than mapping to a single isolated research question.

#### 4.1.1. Theme 1. Perceptual diversity and lived visual experiences (RQ1, RQ4)

This theme captures the highly varied and dynamic nature of visual impairment as lived by participants, the majority of whom had low vision conditions associated with residual vision, most commonly age-related central vision loss. Rather than experiencing impairment as a single, stable condition, participants described a wide range of perceptual phenomena, including loss of central vision (macular degeneration), tunnel vision (glaucoma, retinitis pigmentosa), blurry vision (corneal scarring, cataracts, congenital conditions), visual distortions, glare sensitivity, hallucinations (e.g., Charles Bonnet syndrome), and double vision. Notably, participants reported seeing blurry patches in the middle of their vision, describing it like "having Vaseline smudged over your glasses" (PID 5), "like having two grey tennis balls hanging in front of your eyes" (PID 5), and "like looking through a heavy film, or static on TV" (PID 17). Interestingly, 36 participants also described it as "nothingness" with many emphasizing that the brain fills in the picture with information it gets from the peripheral vision (PID 9, PID 15, PID 40), but that the brain is not always accurate in its estimations, so there is a lot of distortion in the vision in a way that "Letters are getting mangled when I'm trying to read" (PID 15).

Participants further described their visual impairment as a complex and fluctuating experience, in which multiple symptoms often occurred both independently and in combination, changing in response to environmental conditions such as lighting and time of day. Several participants reported experiencing double vision alongside other symptoms, illustrating the layered nature of perceptual disruption. One participant vividly described looking at the moon and seeing multiple overlapping images: "I was looking at the full moon last night because I'm a bit of a sad old hippie, and I noticed through my left eye it was reasonably round and clear. I could probably see six or seven moons all overlapping and with a huge rainbow around it. It was like a crazy Venn diagram if that means anything to you. It was like snippet moons all overlapping over each other" (PID 14). These perceptual experiences were not determined solely by diagnosis. In fact, participants with the same formal clinical conditions often reported different lived experiences, shaped not only by their visual impairment but also by social context, personal history, family support, and financial security. Visual impairment was thus experienced as a situated and relational phenomenon, rather than a uniform medical condition. However, these accounts primarily reflect experiences of residual vision and partial visual access and may differ in important ways for individuals who rely exclusively on non-visual modalities.

Glare, flashing lights, and visual distortion were also commonly reported. One participant described their visual experience as “...like a bad acid trip” (PID 10), while others compared their vision to “Christmas lights” or a “kaleidoscope” (PID 30). For many, noticing distortion in their surroundings was the first indication that something was wrong with their vision. One participant described seeing a street light pole as curved (PID 38), while another noticed irregularities while watching a foreign news broadcast, when subtitles suddenly appeared to have missing letters (PID 13). In fact, noticing distortion in their surroundings is how many participants realized that there is something wrong with their vision.

Although macular degeneration is often described in the literature as a black dot in the center of vision (Saratoga Ophthalmology, 2026), one participant reported experiencing such a distinct dark scotoma that felt as “...having a smudge of mascara over a contact lens,” (PID 17) rather than a clear black spot. Several participants expressed uncertainty about whether their symptoms were actually related to macular degeneration, noting that their lived experiences did not align with the descriptions commonly presented in brochures and leaflets aimed at patient education (PID 11, PID 29). This mismatch between clinical representations and lived perception can contribute to confusion, delayed recognition, and misinterpretation of symptoms. Some participants also reported experiencing hallucinations associated with Charles Bonnet syndrome. One participant explained this as “This is how brain fills the gap left by the scarring on retina” (PID 29), and notably, these hallucinations were not always experienced as frightening. Instead, some participants spoke about them with humor and acceptance. For example, one participant described seeing baskets of flowers and reflected “...it all depends on what your brain is filled with. Some people see scary things, but my hallucinations are actually quite pleasant” (PID 27).

Changes in color perception were another commonly reported indicator of their visual impairment. One participant noticed this while watching television, realizing that the Romanian flag appeared to have incorrect colors (PID 19). For some participants, color vision deficiencies were congenital (PID 1, PID 3, PID 18, PID 19, PID 27, PID 31, PID 40), while for others they developed later in life, often in association with conditions such as cataracts or macular degeneration. For instance, one participant with cataracts described their vision “... as though the saturation has been reduced. You know, when you’re editing photographs and you tweak the saturation, it’s like that’s just been turned down a few notches. It’s not sepia, not yet anyway. The color is still there, but it’s not so intense. Everything is just blurry and desaturated” (PID 14).

Together, these accounts illustrate that visual impairment, as experienced by the participants in this study, is lived as a dynamic, unstable, and deeply personal perceptual experience, shaped not only by clinical symptoms but by environment, identity, and context. Rather than a singular loss of function, participants described their visual impairment as an evolving perceptual condition characterized by fluctuation, distortion, adaptation, and reinterpretation of the visual world. At the same time, these findings are grounded in low vision contexts, where accessibility needs emerge from the interaction between residual perception and environmental conditions. Participants also noted that their symptoms did not align with common medical descriptions used in patient education materials, leading to confusion, delayed recognition, and misinterpretation of their own condition. This diversity demonstrates that accessibility needs emerge from perceptual experience, not diagnostic labels, highlighting the limits of diagnosis-based accessibility categorization, while also indicating that different patterns may emerge for individuals with complete vision loss. These findings are therefore most directly reflective of accessibility as experienced through residual vision, rather than non-visual interaction.

#### **4.1.2. Theme 2. Emotional and psychological dimensions of visual impairment (RQ4)**

Participants shared diverse and personal accounts of living with their visual impairment, revealing that severity is not experienced as a fixed or objective category but as a subjective and relational condition. Perceptions of visual impairment varied widely across individuals, with some participants with severe visual impairments demonstrating exceptional resilience and adaptability and did not consider themselves to be severely disabled in everyday life. One participant with severe age-related macular degeneration described navigating a busy street with a white cane as “People clear the way. They see the white

stick, it's like Moses parting the sea" (PID 24). On the other hand, other participants with comparatively less severe visual impairments reported having their quality of life drastically impacted, illustrating that emotional and psychological impact does not map directly onto medical severity. Across accounts, many participants described a sense of vulnerability associated with their visual impairment, which was closely tied to how they were perceived by others. Notably, one participant observed "without a white cane I look like a force to be reckoned with, whereas when I carry it people see me as weak" (PID 19), while others described experiences of anxiety, embarrassment, and shame arising from social misinterpretation: "people see a normal-looking woman who can't open a door and they think that she must be drunk or stupid" (PID 14) and "when I'm on the bus and I ask a fellow passenger what stop it is, they can sometimes be rude and say 'are you blind?', and I could almost say 'well, actually, I am'" (PID 26). These experiences reveal how invisibility of impairment often produces misunderstanding, stigma, and exclusion. Professional identity and credibility were also frequently affected, as one participant working with high-value contracts described feeling increasingly vulnerable in professional settings: "I am now asking my son to accompany me to the customers' offices, because if I can't find the right door people think I am stupid or incompetent" (PID 28). Other participants share similar experiences, noting that education, professional status, and competence are often erased by visible disability. For instance, PID 25 noted that "... many visually impaired people are highly educated and had good jobs, but because they are blind, people don't realize that, they just see their disability."

Participants generally reported adopting different strategies in managing the visibility of their impairment. While some preferred discretion, others embraced visibility as a form of social signaling. One participant described their experience of using a symbol cane<sup>1</sup>: "... people see a white stick and they think there's something wrong with this woman's eyes. I'm told in Canada this stick is called a symbol stick, and it just means there's something wrong with this person. Be kind, you know. But it does work. I find that if I don't have the little white stick, people treat me as if I'm either mad, old, or drunk, you name it" (PID 10).

Despite these differing approaches, a consistent motivation emerged across participants: the desire to maintain independence, build confidence, and minimize reliance on others. Some participants also described distress arising from perceived lack of empathy from medical consultants. One participant expressed frustration with clinical detachment: "... my consultant, he doesn't seem to be interested in my vision. If I could put that VR headset on him with cataracts simulator switched on for a week or so!" (PID 14). This reflects a previously reported perceived disconnect between clinical assessment and lived experience (Brown, 1999). Finally, emotional impact also extended into relational domains. Many participants spoke about the distress of losing visual connection with loved ones and the social consequences of altered perception. For example, PID 16 disclosed "I can't see my grandchildren's faces any more", with similar accounts from other participants: "it's difficult to talk to someone when you don't see their reactions" (PID 28) and "people can feel awkward and thinking I'm not looking at them when I'm trying to use my peripheral vision" (PID 4). These emotional experiences however are closely tied to late onset vision loss and may differ in nature and intensity for individuals with congenital or early-life visual impairments. These accounts show that visual impairment affects not only mobility and access, but emotional connection, social presence, and relational identity. Together, these insights position visual impairment as an emotional, psychological, and identity-shaping experience. Accessibility, in this sense, is not simply about functional access to environments or technologies, but about preserving agency, confidence, and social belonging in everyday life.

#### **4.1.3. Theme 3. Living accessibility across physical and digital worlds (RQ2, RQ3, RQ4)**

Almost all participants in this study, apart from those with mild impairments, described persistent difficulties navigating inaccessible environments across both physical and digital contexts. Participants expressed a range of emotional responses, ranging from anxiety and frustration to determination and resilience, with many emphasizing their commitment to making the best possible use of their remaining vision and maintaining independence. One participant with severe visual impairment reflected on the confidence required to navigate public spaces: "You have to be quite confident with your cane skills. Otherwise, you know, you've got all these sighted people looking at their iPhones falling over your

white cane. You have to be quite confident in a kind of making yourself known. So, I get around, but I do need help, because I can't see any detail. I kind of know directions in London, which I'm quite familiar with from a previous sighted life, but I don't know where I am" (PID 37). Public transport was unsurprisingly one of the most reported challenges to navigate. Participants described station timetables as being positioned too high to be legible (PID 13), and color schemes as inconsistent and often inappropriate, with some preferring yellow-on-black (PID 1), which others found inaccessible and favored white-on-black alternatives (PID 2). The lack of clear and reliable audio announcements was another significant challenge for participants who could not see timetables at all. In fact, many reported being unable to read approaching bus numbers or, in some cases, not seeing the bus itself when it fell within their blind spot (PID 25). As many participants were not "visibly disabled", i.e., did not carry a white cane, they frequently experienced frustration when fellow passengers and even transport staff failed to recognize their impairment and responded with impatience or rudeness (PID 35). Cultural and public spaces were also commonly described as inaccessible. Museums and art galleries were frequently perceived as inaccessible environments, particularly due to lighting conditions and exhibit design. In particular, participant PID 37 explained: "... museums tend to be quite dark, and I need a lot of light to be able to see" for the former, while participant PID 12 noted that: "... writing text in exhibits tend to be in small print, really difficult for me to read. Besides, I would need to stand there really close, and it prevents other visitors from viewing it as well. Audio descriptions are usually inefficient and do not make up for it, for the latter. Physical navigation challenges were further compounded by impaired depth perception and reduced contrast levels. Many participants described difficulty with stairs, especially in low-lighting conditions. One participant noted: "I struggle to go down the stairs if there is no contrast marking on them, especially when it gets dark" (PID 31).

Finally, many participants also reflected on institutional and organizational support. While many were members of support groups and charities dedicated to visual impairment, several expressed dissatisfaction with how these organizations operated. For example, one participant described a disconnect between service provision and lived need: "... some of the groups that are set up for helping people with visual problems don't have many visually impaired staff. I know there are some jobs that you can't do if you are visually impaired, but these organizations completely miss the mark of what they are supposed to be doing. They come across as arrogant, they give us what they think we need, but not what we actually need" (PID 25). It should be noted again that these barriers are primarily described in relation to navigating environments using residual vision and may manifest differently for individuals relying predominantly on non-visual interaction. In summary, these accounts reveal that living with a visual impairment is a continuous lived condition, characterized by ongoing negotiation, adaptation, and resilience across environments. Physical spaces, digital systems, and institutional structures interact to shape everyday experience, producing layered barriers that demand constant cognitive, emotional, and behavioral effort.

#### **4.1.4. Theme 4. Assistive technologies as enablers and constraints (RQ1, RQ2, RQ3)**

While some participants with relatively mild impairments reported using their devices largely on default settings, many described a strong reliance on assistive features to make digital technologies usable. Across accounts, digital technology was widely perceived as enabling independence and access, allowing participants to carry out everyday activities that would otherwise be difficult or impossible. One participant with severely impaired central vision described using the camera on her smartphone as a form of visual extension: "I have a really sharp camera on my phone, so I take pictures of the flowers in my garden, so I can see them" (PID 10). In contrast, individuals with complete vision loss may rely more extensively on non-visual assistive technologies such as screen readers, which were less prominent in this dataset.

Most participants expressed a preference for using their remaining vision, wherever possible, and were reluctant to use text-to-speech technologies. In particular, one participant with macular degeneration explained: "I'm not at that stage yet, but maybe in the future when my sight deteriorates further" (PID 4). This reluctance reflected not rejection of assistive technology, but a desire to preserve

independence. There were, however, exceptions with one participant with multiple visual impairments (PID 31) describing how audio support was transformative in an educational context: "... getting my computer reading PDFs to me really helped me to get through my university studies". In fact, across participants, magnification, increased contrast, and brightness adjustment emerged as the most commonly used and valued accessibility features. At the same time, some participants reported limitations in the assistive technologies provided to them, particularly in professional contexts. Notably, one participant reflected: "I had to read a lot of PDFs for my job, and I was given training on using this assistive program, and it was horrible, clunky, totally unusable" (PID 38). Another participant with a genetic visual condition (PID 26), described how inaccessible professional software directly affected her livelihood: "I am a freelancer, and the software that I have to use for my work has very small icons and low contrast. I increased the size to the maximum, but it's useless. My income has decreased and I needed to hire an assistant".

Finally, when discussing accessibility needs, participants consistently expressed a desire for greater personalization and control over visual settings. The use of customizable interfaces, adjustable visual parameters, and adaptable layouts are in fact repeatedly emphasized as essential in the literature (M. E. Mott et al., 2020), which is in line with our findings. The idea of additional audio cues was also widely supported, while haptic feedback was generally viewed as less helpful, despite many using this, with one participant describing it as the least useful (PID 10). However, many participants expressed interest in voice commands; yet they also noted that using voice interaction would often feel socially awkward, particularly in public settings, reflecting the social dimensions of accessibility design. These accounts position assistive technologies as both enabling and constraining, as they support independence and access, while simultaneously introducing new forms of friction, dependency, and limitation. Digital accessibility, in this sense, is not simply about feature availability, but about meaningful integration into everyday practices, identities, and social contexts.

#### **4.1.5. Theme 5. Personalization, control, and contextual adaptation (RQ2, RQ3)**

Participants expressed a wide range of design preferences, reflecting the diversity of perceptual experiences and accessibility needs across the group. Many participants stated that accessibility features should be included straight out of the box (PID 17, PID 26) and embedded by design, rather than treated as optional add-ons. At the same time, others emphasized the importance of flexibility and customization (PID 4, PID 14). While participants generally supported the principle of 'accessibility by design', many expressed skepticism about industry commitment to accessibility, describing it as a secondary concern or an additional expense rather than a core priority (PID 5).

Preferences regarding typography and color schemes also varied substantially. Most participants favored clear fonts (e.g., Sans Serif) and simple color schemes with high contrast levels (PID 3), but there was no consensus on a single optimal color configuration. Reported color scheme preferences included white on black, yellow on black, black on white, and black on yellow, whilst color schemes involving blue backgrounds or blue fonts were disliked (e.g., PID 28). Similarly, low-contrast designs, particularly those using pastel hues, were criticized. For instance, one participant described such designs as visually appealing but inaccessible: "They are currently very trendy, and, of course, beautiful, but totally unreadable" (PID 26). Several participants described specific and individualized accessibility needs. In particular, one participant with tunnel vision reported being unable to read train timetables after they were changed from white-on-black to yellow-on-black (PID 1), while another participant experienced the opposite problem, finding white-on-black unreadable (PID 2). Although black-on-white was commonly preferred for printed and digital media, the majority favored darker visual setups for digital devices. Therefore, personalization was not limited to perceptual adjustment alone, but extended to emotional comfort, technology use, and adaptation across changing environments.

Across accounts, a consistent desire emerged for customization and control. Almost all participants expressed the need to customize their digital devices by adjusting visual settings to suit their individual perception and environmental conditions. Preferences were not static: participants described wanting to change configurations depending on time of day, lighting conditions, and brightness levels.

Accessibility, therefore, was not framed as a fixed design solution, but as a dynamic, user-controlled process of adapting technologies and environments to changing perceptual, emotional, and contextual needs. Importantly, personalization was not only a perceptual issue. These findings therefore position personalization as a cross-cutting accessibility challenge, rather than as a single design preference or perceptual adjustment.

#### **4.1.6. Theme 6. Technology expectations across every day and emerging contexts (RQ1, RQ2, RQ3)**

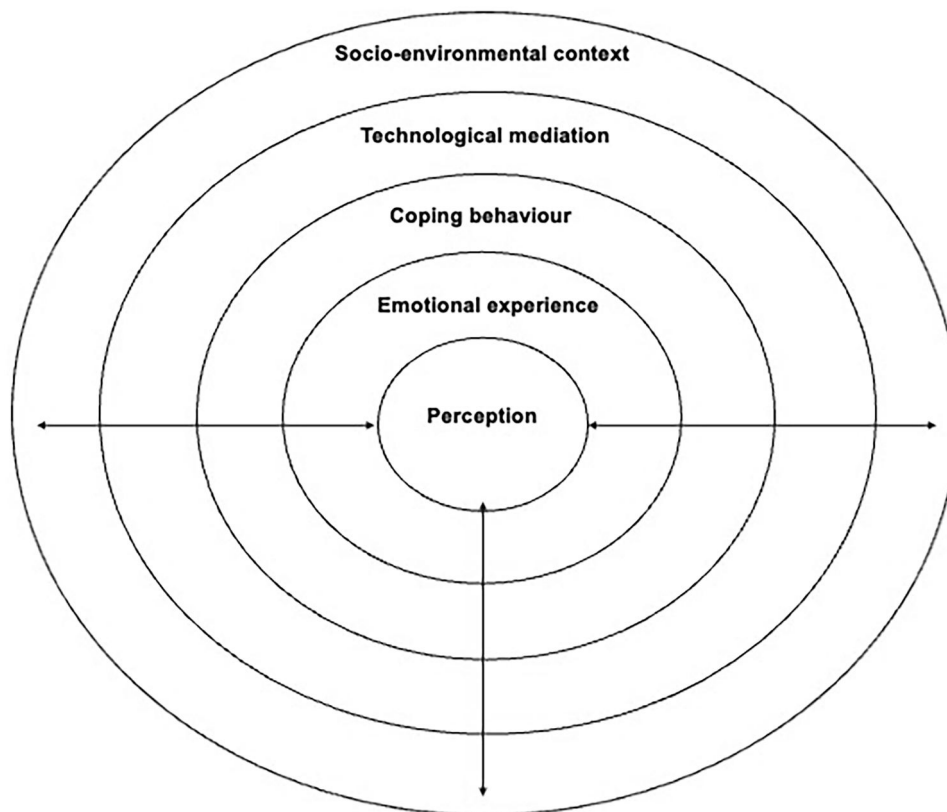
Many participants expressed broadly positive attitudes toward digital technologies and were open to the potential of emerging immersive systems, such as XR, although most accounts reflected expectations rather than direct XR experience. Their interest in these technologies was predominantly instrumental rather than experiential: several participants did not frame XR as entertainment or novelty, but as a potential form of assistive technology that could meaningfully support independence, access, and everyday functioning. XR was thus understood primarily in terms of its potential to improve quality of life, rather than as a new mode of experience. Mobile devices, particularly smartphones, were central to participants' daily lives and functioned as primary tools for communication and daily tasks. In fact, for many participants, smartphones had already become an informal assistive technology embedded in everyday practice. For instance, participants described routinely using their phones for magnification tasks, such as photographing train timetables, price tags, and printed information to enlarge and interpret visual content (PID 13). Notably, one participant with severe visual impairment described the centrality of digital connectivity: "I'm very engaged online. It's like an absolute lifeline to me, but all my interactions are done through my iPhone, which I've had for over four years. Obviously, there's lots happening with AI, so they're constantly updating the iPhone. I think accessibility is going from strength to strength" (PID 39).

These findings position digital technologies not as optional tools, but as essential support integrated into daily routines. Engagement with emerging technologies is therefore best understood as an extension of existing assistive practices rather than a shift toward immersive media consumption. However, because most participants had limited direct experience with XR, these findings should be interpreted as expectations about possible assistive value rather than evaluations of immersive interaction. These technology expectations were not purely technological, as they were shaped by participants' existing coping practices, emotional concerns about independence and stigma, and experiences of navigating inaccessible environments. Theme 6 therefore informs technological mediation, but also cuts across emotion, coping behavior, and socio-environmental context.

## **4.2. From empirical themes to conceptual insights: The ECAM-VI framework**

The six empirical themes discussed above do not function as discrete categories of experience, but as interdependent facets of how accessibility is lived in everyday life. Perceptual variability, emotional and identity-related experiences, continuous navigation across environments, adaptive coping practices, technological mediation, and personalized design needs were consistently intertwined in participants' accounts. Therefore, rather than describing isolated challenges, the findings reveal a connected experiential structure in which accessibility is produced through the interaction of perception, emotion, behavior, technology, and environment. This interdependence motivates a shift from thematic description to conceptual synthesis. Accordingly, in this section, these empirically grounded themes are integrated into a coherent **experience-centred framework** - named **ECAM-VI** (Figure 1) - that translates lived experience into design-relevant insight, providing a theoretical and practical model for understanding accessibility as a relational phenomenon. In doing so, ECAM-VI moves beyond feature-based and compliance-driven accounts of accessibility by conceptualizing it as an emergent property of interaction.

Importantly, the six themes do not map directly onto the five ECAM-VI dimensions in a one-to-one manner. Instead, the framework was developed through a process of conceptual abstraction, in which themes were interpreted and synthesized into higher-level constructs capturing patterns of interaction across the dataset. In this sense, the themes represent empirical patterns grounded in the participants' lived experiences, while the ECAM-VI dimensions represent analytical constructs that organize these



**Figure 1.** The five lived-experience dimensions of ECAM-VI (read from inner → outer).

patterns into a coherent conceptual model. As a result, several themes inform multiple dimensions, and some themes, particularly those related to personalization (Theme 5) and attitudes toward technology (Theme 6), are best understood as cross-cutting, reflecting interactions between perceptual, emotional, behavioral, technological, and socio-environmental factors. The mapping between themes and ECAM-VI dimensions is therefore many-to-many rather than one-to-one, as summarized in Table 4.

Furthermore, although this study focuses on individuals with low vision, the ECAM-VI framework is not restricted to vision-based interaction alone. Rather, it provides a conceptual structure for understanding how accessibility emerges through the interplay of perception (including non-visual modalities), emotional and social experience, coping strategies, technological mediation, and environmental context. For individuals with complete blindness, these dimensions may manifest differently, for example, with greater reliance on auditory and tactile perception, but the relational structure of the model remains applicable.

#### **4.2.1. Theoretical and empirical integration**

The synthesis of the six themes into the proposed framework in Figure 1 positions accessibility as an experiential system rather than merely a feature of systems. Specifically, the framework is represented as a set of concentric and interrelated layers, illustrating that accessibility is not located within any single component, but emerges through the dynamic interaction between lived-experience dimensions. Importantly, the structure should not be interpreted hierarchically or causally. Instead, we argue that changes in outer rings can reshape inner rings (and vice versa). For example, changes in one dimension (e.g., environmental lighting or technological design) can propagate across others, altering perception, emotional response, and behavioral adaptation, and as such, the framework can be used to trace breakdowns and design needs. In this sense, accessibility is conceptualized as a relational and continuously negotiated process, rather than a fixed attribute of users or systems. ECAM-VI should therefore be understood as a conceptual synthesis that organizes lived experience into a framework for analysis and design, rather than a direct grouping of empirical categories.

**Table 4.** Mapping between empirical themes and ECAM-VI dimensions.

Empirical theme (Section 4.1)	Emotional and social experience			Technological mediation	Socio-environmental context	How the theme informs ECAM-VI
	Perception	Coping behavior	social experience			
T1. Perceptual diversity and lived visual experiences	X	X		X	X	Perceptual variability shapes how participants interpret environments, use tools, and adapt behavior. Grounded in residual vision and low-vision interaction.
T2. Emotional and psychological dimensions of visual impairment		X	X	X	X	Emotional responses influence coping strategies, technology adoption, and social interaction. Shaped by late-onset vision loss in this sample.
T3. Living accessibility across physical and digital worlds	X	X	X	X	X	Accessibility barriers emerge across interacting systems requiring continuous adaptation. Reflects accessibility as a distributed and cumulative experience.
T4. Assistive technologies as enablers and constraints	X	X	X	X	X	Technologies extend perception and support coping but also introduce friction and social constraints. Reflects integration (or lack) of assistive tools in everyday life.
T5. Personalization, control, and contextual adaptation	X	X	X	X	X	Personalization operates as a cross-cutting response to variability across all dimensions, supporting adaptation to changing perceptual, emotional, technological, and environmental conditions.
T6. Technology expectations across every day and emerging contexts		X	X	X	X	Technology expectations are shaped by existing coping practices, emotional concerns, and environmental challenges. XR is understood primarily as potential assistive support, based on expectations not direct experience.

Specifically, our findings have shown that accessibility is shaped by lived perceptual experience (**inner ring**) rather than sensory function alone. Participants' accounts of fluctuating vision, distortion, and perceptual variability show that visual impairment is experienced as a change in how people perceive and relate to the world, rather than simply a loss of ability (Merleau-Ponty et al., 2013). This is empirically grounded in Theme 1 (*Perceptual diversity and lived visual experiences*), where impairment is shown to be heterogeneous, unstable, and context dependent. Accessibility, therefore, is not anchored in diagnosis or impairment categories, but in lived perceptual experience, and it emerges not from fixed perceptual states, but from how individuals interpret and negotiate incomplete or unstable sensory information in context.

Emotional and social experience (**second ring**) further structure accessibility as both a social and psychological phenomenon. Participants' accounts of vulnerability, stigma, dignity, and confidence demonstrate that accessibility is inseparable from social meaning and identity formation. This reflects earlier perspectives, in which meaning and identity are produced through social interaction rather than individual attributes (Suchman, 1987). This dimension is empirically grounded in Theme 2 (*Emotional and psychological dimensions of visual impairment*) and highlights that it is not secondary to functional access, but rather, it directly shapes how individuals engage with environments and technologies, influencing willingness to adopt tools, disclose impairment, or navigate social situations.

Participants' coping behavior and adaptive practices (**third ring**), such as reliance on remaining vision, memorization of environments, confidence-based navigation, and adaptive use of assistive tools, reflect everyday adaptive practices rather than simple compensatory strategies. These findings align with embodied cognition and embodied interaction theory, which conceptualize interaction as bodily engagement with the world rather than abstract information processing (Dourish, 2001). Empirically, this is grounded in Themes 3 (*Living accessibility across physical and digital worlds*) and Theme 4 (*Assistive technologies as enablers and constraints*), where navigation, adaptation, and assistive practices are shown to be integrated into everyday routines and action. Further, this demonstrates that the perceptual foundation of the framework is inseparable from emotional experience and coping behaviors. Rather than compensating for deficits, these practices represent active adaptation within a dynamic environment.

Additionally, technological mediation (**fourth ring**) functions not only as an access tool, but as a social symbol that shapes how individuals are perceived and treated. In particular, assistive technologies are described as both enabling and constraining, embedded within everyday practices while simultaneously introducing new challenges and dependencies. This is grounded in Theme 4 (*Assistive technologies as enablers and constraints*), where digital systems are shown to function as both infrastructures of support and sources of limitation. Further, participants' engagement with digital technologies and their expectations of emerging technologies position future systems, including XR, as extensions of existing assistive practices rather than novel interaction paradigms. XR is framed as a potential support infrastructure for everyday living, not as an immersive experience technology alone. Similarly, this is empirically grounded in Theme 6 (*Attitudes toward digital and emerging technologies*) and situates XR within the same accessibility ecosystem rather than as a separate domain. As a result, this positions technology in our framework not as a solution layer, but as a mediating structure that reshapes experience and interaction. Accessibility therefore depends not on the presence of features, but on how seamlessly technologies are embedded within everyday practices.

Finally, our findings demonstrate that accessibility is produced across interconnected physical, digital, institutional, and social systems (**outer ring**). Participants experience accessibility not as isolated challenges, but as cumulative and continuous interactions across environments. This aligns with socio-technical and distributed cognition perspectives, which conceptualize human activity as distributed across people, artifacts, and environments (Hutchins, 1995). Empirically, this is grounded in Theme 3 (*Living accessibility across physical and digital worlds*), where accessibility emerges as a continuous condition rather than a situational disruption. Accessibility is thus distributed across contexts, requiring continuous negotiation and adaptation. This dimension also emphasizes that accessibility is systemic, shaped by the alignment, or misalignment, between individuals, environments, and technologies.

Design preferences and accessibility needs further reinforce the experience-centred nature of accessibility. Participants' emphasis on configurability, adaptability, and control demonstrates that accessibility

cannot be standardized through universal design solutions alone. Instead, it must remain dynamically configurable and responsive to individual perception and context. This is grounded in Theme 5 (*Personalization, control, and contextual adaptation*) and supports an experience-centred design perspective in which accessibility is treated as a dynamic, user-regulated process rather than a fixed design state. Collectively, these theoretical and empirical dimensions converge in the proposed framework, ECAM-VI, which conceptualizes accessibility as relational, embodied, socially mediated, and systemically produced. Accessibility is not something systems deliver to users, but something that is co-produced through lived interaction between individuals and socio-technical environments. The framework therefore shifts accessibility from a feature-based paradigm to an experience-centred accessibility approach, grounded in lived experience and sustained through everyday practice. This integration provides the conceptual foundation for treating accessibility design not as compliance checking, but as experience design where perception, emotion, coping behaviors, technology, and environment are treated as structurally interdependent dimensions of access. Together, these dimensions conceptualize accessibility as an emergent property of interaction, produced through their continuous and interdependent relationships.

#### **4.2.2. Positioning and novelty of ECAM-VI**

While the dimensions of ECAM-VI are individually grounded in prior research, the contribution of this framework lies not in introducing entirely new constructs, but in **how these dimensions are integrated, related, and applied to accessibility**. First, ECAM-VI provides an integrative account of accessibility. Existing work has examined perceptual challenges (e.g., low vision interaction), emotional and social impacts (e.g., stigma and confidence), and technological mediation (e.g., assistive tools), but these are typically addressed in isolation or within domain-specific approaches. By contrast, ECAM-VI brings these elements together into a single, coherent structure, enabling a more holistic understanding of accessibility as a multi-dimensional phenomenon. Second, the framework advances a relational perspective on accessibility. Rather than treating accessibility as a property of systems (e.g., compliance with guidelines) or as a user limitation, ECAM-VI conceptualizes accessibility as emergent from the interaction between dimensions. This aligns with situated and distributed views of interaction (Hutchins, 1995; Suchman, 1987) but also extends them by explicitly articulating how perceptual, emotional, behavioral, technological, and environmental factors co-constitute accessibility experiences. Third, ECAM-VI introduces a cross-context perspective, explicitly spanning physical, digital, and emerging environments such as XR. While existing accessibility research typically focuses on a single context (e.g., web accessibility or assistive devices), our findings show that accessibility is experienced as continuous across environments. The framework therefore provides a conceptual bridge between domains that are often treated separately. Finally, the framework is empirically grounded in lived experience, capturing not only barriers but also adaptive practices and user agency. This complements prior work on coping strategies and “invisible work” (Branham & Kane, 2015b) by embedding these behaviors within a broader interactional structure.

Overall, ECAM-VI should be understood as a **conceptual synthesis** that offers explanatory and design-oriented value, rather than as a predictive or formal model. It is derived from a thematic analysis of interview data and follows established qualitative research practices in HCI, where empirical findings are used to develop conceptual models and frameworks (e.g., Braun & Clarke, 2006; Lazar et al., 2017). In this context, the role of the framework is interpretive, as it synthesizes recurring patterns across participants’ experiences and provides a structured way to understand their relationships. Its purpose is to structure understanding of accessibility as a lived experience, guide the design of inclusive systems, and provide a foundation for future empirical and theoretical development. We therefore do not claim that ECAM-VI is exhaustive or universally generalizable. Rather, it represents a grounded conceptualization that can be refined, extended, and evaluated in future work. Importantly, the ECAM-VI dimensions should not be interpreted as direct groupings of themes, but as higher-level constructs that capture relationships between them.

### 4.3. From conceptual insights to design implications

The previous sections discussed that our findings and the ECAM-VI framework reposition accessibility from a feature-level concern to an experience-centred design challenge. Design must therefore address accessibility as a holistic and adaptive process that unfolds across systems, environments, and everyday practices. Accordingly, the findings of this study extend existing accessibility and inclusive design frameworks, such as WCAG and user-sensitive inclusive design approaches. Specifically, existing guidance often focuses on interface-level requirements and functional usability (Harper & Yesilada, 2008; Lazar et al., 2015; Newell & Gregor, 2000). Participants' accounts in this study revealed forms of accessibility negotiation that are often underrepresented in standards-based guidance, particularly the emotional, behavioral, and socially situated dimensions of interaction. In this section, we next discuss the implications of each ECAM-VI dimension, and further link these directly to both the empirical findings and established theory, all of which are summarized in Table 5. The design implications presented below focus not only on technical accessibility requirements, but on how accessibility is lived, negotiated, and maintained across real-world contexts. Table 5 therefore contrasts existing accessibility assumptions with the lived-experience insights emerging from this study, highlighting opportunities for more experience-centred accessibility design.

#### 4.3.1. Design implication 1: Design for dynamic perceptual variability (not diagnostic labels)

As highlighted throughout Section 4, participants' perceptual experiences were diverse and varied. In fact, individuals with the same visual impairment often reported different functional needs.

**Table 5.** Experience-centred design implications derived from lived-experience themes and the ECAM-VI framework.

ECAM-VI dimension	Empirical findings from themes	Accessibility gaps highlighted by findings	Experience-centred design implication
Perception	Diverse and fluctuating perceptual experience; glare, distortion, field loss; contradictory contrast/color preferences (Themes 1,5)	Often assume stable impairment categories and fixed "accessible" visual configurations (e.g., universal contrast recommendations).	Dynamic perceptual adaptation rather than fixed accessibility presets. Support continuous user-controlled adjustment of visual parameters across changing contexts and conditions.
Emotional and social experience	Vulnerability, stigma, embarrassment, reluctance to use assistive tools in public; desire for independence (Theme 2)	Accessibility is frequently evaluated primarily through usability and task completion, with limited consideration of emotional comfort or social visibility.	Treat emotional accessibility as a core design concern. Features should support discreet interaction, reduce social exposure, and allow users to control how assistive functions are deployed across contexts.
Coping behaviors	Informal adaptive practices, e.g., photographing text, memorizing routes, relying on remaining vision (Themes 3,4)	Often treat coping practices as external workarounds rather than meaningful interaction behaviors.	Design with existing coping strategies rather than against them. Embed and augment adaptive practices through features such as contextual magnification, OCR integration, and cross-device accessibility continuity.
Technological mediation	Smartphones as embedded assistive infrastructures, existing assistive technology incompatible, workplace barriers reduce productivity (Themes 4,6)	Assistive technologies are frequently designed as isolated specialist tools rather than seamlessly integrated interaction infrastructure	Treat accessibility technologies as integrated components of everyday interaction ecosystems. Minimize workflow disruption, reduce cognitive and social friction, and operate consistently across environments and platforms
Socio-environmental context	Barriers across transport, signage, lighting, public venues, workplaces (Theme 3)	Often focus on isolated interfaces rather than cumulative interaction across environments.	Design accessibility as a continuous cross-environment experience. Support multimodal continuity, context-aware adaptation, and reduced interaction burden across physical and digital settings.

Importantly, participants frequently reported contradictory preferences regarding contrast levels, color schemes, brightness, and lighting conditions, with preferences changing depending on fatigue, time of day, or environmental context. This points to the need for more dynamic and adaptive approaches to accessibility whereby accessibility design is parameterized rather than predefined. Early research has shown that perception constitutes the primary way individuals encounter the world (Merleau-Ponty et al., 2013). Therefore, it can be surmised that if perception changes, interaction changes accordingly. Indeed, there is a risk of a potential mismatch between lived experiences and static visual accessibility features, which is supported by prior work by Lazar et al. (2015) who argue that adaptability and personalization are central to inclusive systems. System design should therefore prioritize adjustable, configurable, and user-controlled visual parameters (e.g., contrast, brightness, color schemes, magnification, typography) and support context-aware adaptation rather than fixed accessibility presets and compliance with static visual standards alone.

#### ***4.3.2. Design implication 2: Design for emotional comfort and socially situated accessibility***

Beyond perceptual challenges, participants further disclosed accessibility challenges relevant to emotional and social experiences. Emotional aspects such as stigma and embarrassment were mentioned as hindering their use of assistive technologies. In particular, participants expressed hesitation about using voice commands in public due to concerns about appearing dependent, attracting attention, or disrupting social interaction. This suggests that accessibility technologies cannot be evaluated only in terms of usability or technical effectiveness, as their social acceptability and emotional implications are equally important, despite that it is well-recognized in HCI research that emotional and social acceptability are core aspects of usability and adoption of technologies (Dourish, 2001). Designers should therefore consider accessibility as a socially situated experience shaped by confidence, identity, visibility, and perceived judgment from others. Accessibility features should minimize unnecessary social exposure, support discreet interaction where appropriate, and provide users with control over how assistive functions are deployed in different contexts. These findings further indicate that emotional accessibility should be treated as a core design consideration rather than a secondary usability concern.

#### ***4.3.3. Design implication 3: Design with existing coping practices not against them***

Our findings revealed that participants often relied on learned behavioral coping strategies such as photographing text, memorizing routes, and using environmental familiarity. Importantly, these strategies were not simply compensation mechanisms, but adaptations that enabled their independence. Rather than treating such behaviors as evidence of user compensation alone, these findings suggest that coping practices can reveal unmet accessibility needs and opportunities for design innovation. In support of this, early work by Suchman (1987) showed that human behavior and actions are often shaped by context and adaptation, which can extend across people, tools and environments. Systems should therefore recognize, support, and integrate existing adaptive behaviors into interaction design. For example, interfaces could better support rapid image capture, contextual magnification, or environmental text recognition across devices and settings. Accessibility design should not aim to eliminate adaptation, but to meaningfully augment the strategies users already employ in everyday life.

#### ***4.3.4. Design implication 4: Treat assistive technologies as integrated interaction infrastructure (not add-ons)***

It is worth highlighting that participants valued the use of digital technologies, particularly smartphones, which they often use as assistive tools instead of more conventional assistive technologies, which they described as unreliable or poorly integrated. At the same time, participants frequently reported frustration with assistive technologies that were poorly integrated into professional workflows or everyday routines, with several accounts indicating that inaccessible workplace software directly limited their employability and income. Past work by Lazar et al. (2015) emphasized that technology must be ubiquitously integrated in existing workflows and infrastructures to be effectively utilized. Similarly, systems should allow for personalization and adaptation as environmental conditions change. As such, and in line with established knowledge, we reiterate that accessibility features should be seamlessly

integrated at system level rather than implemented as external add-ons with reliability and compatibility being prioritized over specialized assistive tools. Accessibility support should minimize workflow disruption, reduce cognitive and social friction, and operate across contexts rather than within isolated applications. Interestingly, our participants further framed immersive technologies, such as XR, as a potential assistive tool, which suggests that immersive systems could be also considered in existing accessibility ecosystems. Importantly, participants' responses regarding XR should be understood as indicative of expectations and perceived potential, rather than based on direct experience with immersive systems.

#### **4.3.5. Design implication 5: Design accessibility as a continuous cross-environment experience**

Finally, it should be noted that participants' accessibility challenges did not stem from digital systems alone, but instead, they were accounted to inaccessible streets, transport systems, public venues, workplaces, and institutions, which shows that inaccessibility is impacted by the broader socio-environmental context in which an interaction occurs. Accessibility was therefore experienced not as a sequence of isolated interface encounters, but as a continuous negotiation across interconnected environments. This is in line with past work which identified that accessibility emerges from the interaction between people, tools, organizations, and environments rather than from isolated artifacts (Hutchins, 1995; Lazar et al., 2015). For example, an accessible journey planner app is insufficient if station signage or announcements are inaccessible, which indicates that accessibility challenges propagate across touch-points. Designers should consequently move beyond interface-level accessibility thinking and consider how accessibility can be maintained across transitions between physical and digital contexts. This includes consistency of interaction, multimodal continuity, environmental adaptability, and support for context-aware accessibility features. Importantly, the findings indicate that accessibility failures often accumulate cognitively and emotionally over time, suggesting that accessibility design should consider long-term interaction burden rather than isolated task completion alone.

## **5. Concluding discussion**

This section discusses the overall findings and presents the identified implications and contributions of this work. It also highlights avenues for future work.

### **5.1. Overall findings and contributions**

In this work, a qualitative study with 42 participants living with visual impairments was conducted through semi-structured interviews to gain valuable insights into their lived experiences and accessibility challenges they encounter in everyday life and across physical and digital environments, as well as their expectations for emerging technological environments. A reflexive thematic analysis approach was followed (Table 3) presenting an analytic narrative anchored to relevant theory. The findings were structured around five interrelated experiential dimensions that highlighted a wide variety of feelings and attitudes among the participants, ranging from stoic acceptance to sadness and despair. They further revealed that accessibility is not encountered as isolated technical failures, but as a continuous lived condition shaped by perceptual variability, emotional and social factors, adaptive coping behaviors, technological infrastructures, and socio-environmental contexts. Rather than describing accessibility primarily in terms of missing features and non-compliant interfaces or add-ons, participants consistently framed it as the ongoing work required to interpret, navigate, and adapt to their surroundings.

In particular, a key finding is the variability of perceptual experience which was reported as diverse and fluctuating that varied by time of day, lighting, fatigue, and even visual impairment. Similar variability has been reported in past research, which emphasizes functional diversity rather than diagnostic uniformity (Hersh, 2013; World Health Organization, 2019). Our findings extend this understanding by showing how such variability directly shapes digital and environmental interaction needs, whilst challenging the effectiveness of fixed accessible features. A second finding highlighted the importance of emotion and social dimensions with participants often discussing stigma, and reduced confidence and independence when navigating inaccessible digital and physical contexts. Importantly, it was identified

that such emotional responses had an impact on adopting technologies, suggesting that accessibility should be also considered alongside usability, which is in line with past work demonstrating that accessibility barriers often include social and psychological costs alongside functional ones (Kane et al., 2011). Our results, therefore, strengthen this by showing that emotional safety and dignity are not peripheral outcomes, but core determinants of whether accessibility features are practically usable. In addition to the above individual characteristics, which are typically shaped by personal, subjective factors like personality, culture, mood, and past experiences, participants also described accessibility as a cognitively demanding navigational effort across environments. External barriers were reported across transport systems, public venues, workplaces, and online systems, which shows a rather systematic experience, echoing earlier findings that blind and visually impaired people must put in substantial effort to manage everyday tasks across technologies and spaces (Branham & Kane, 2015b). Our study broadens this perspective by demonstrating that such effort spans not only digital systems, but the combined physical-digital ecosystem of everyday life.

Coping and adaptive strategies were also discussed with participants routinely coming up with adaptive mechanisms, such as photographing text for magnification, memorizing layouts, or cross-checking information through multiple modalities, often across everyday routines. Similar patterns have been identified in past studies where users creatively adapted conventional tools to meet their accessibility needs (Bigham et al., 2010). Our findings further suggest that these behaviors should be interpreted not as issues that need to be fixed, but as valuable signals for accessible design, revealing where systems may fail to support natural interactions. For instance, our participants expressed that the use of smartphones was particularly helpful, as opposed to existing assistive tools that were often described as fragmented, unreliable, or poorly integrated into professional workflows. This is in line with past findings showing that integration and interoperability are persistent accessibility challenges (Harper & Yesilada, 2008). Our results illustrate the real-life implications of this fragmentation, including reduced independence and employability.

Finally, participants expressed a cautious optimism toward emerging technologies, such as XR, viewing them primarily as potential assistive tools. This important framing suggests that future systems will be judged not by novelty, but by their ability to integrate into established accessibility practices. The finding contributes early empirical evidence to discussions about inclusive immersive technologies, which remain comparatively under-explored in accessibility research. Collectively, the findings address the four research questions by demonstrating that accessibility for people with low vision emerges through the interaction of perceptual variability, emotional and social experience, adaptive coping practices, technological mediation, and socio-environmental context. RQ1 and RQ2 revealed that accessibility barriers and coping strategies are deeply interconnected across physical and digital environments, while RQ3 highlighted the importance of personalization, multimodal interaction, and integrated accessibility support. RQ4 further demonstrated that accessibility experiences are shaped not only by functional barriers, but also by emotional, social, and identity-related factors. Together, these findings position accessibility as a lived and relational experience rather than a static property of interfaces or systems alone. Accordingly, the main three contributions of this work are:

1. **A rich account of lived accessibility experiences.** An in-depth empirical account of how people with low vision experience accessibility across everyday life and across digital and physical contexts. While previous work has documented barriers in either physical or digital contexts separately, our findings highlight their continuity and interdependence by moving toward a holistic understanding of accessibility as a lived experience.
2. **The Experience-Centred Accessibility Model (ECAM-VI).** A synthesis of this work's findings into the Experience-Centred Accessibility Model (ECAM-VI), which conceptualizes accessibility as emerging from five interacting dimensions: perception, emotion, coping behavior, technological mediation, and socio-environmental context. Rather than approaching accessibility as a checklist of features, the framework positions it as a relational and systemic property of lived interactions and experiences. Importantly, the dimensions identified in ECAM-VI should be understood as modality-agnostic at a structural level, even though their empirical instantiation in this study reflects low vision experiences.

3. **A set of actionable design implications.** A set of concrete design implications (Table 5) that can be used to extend existing accessibility guidance by grounding recommendations directly in lived experiential evidence from this work.

Taken together, our findings indicate that accessibility is best understood not as a property of systems, but as a quality of lived interactions and experiences. Accessibility arises from how the identified five dimensions in this work interrelate over time. This empirical grounding motivates the need for experience-centred models, such as the ECAM-VI, that conceptualize accessibility as systemic, adaptive, and relational rather than feature-based or compliance-driven.

## 5.2. Limitations and future work

This work and findings present limitations that also need to be considered. First, while this study allowed to gain valuable insights into visually impaired people's interactions and experiences, it relies on self-reported interview data. Even though interviews provide rich insight into lived experience, they may under-represent experiences of visually impaired people. For instance, our participant sample reflects diversity in visual impairments and experiences, but remains contextually bounded, as experiences may differ across geographic regions, cultural settings, or technological infrastructures. Broader sampling could improve generalization, while observational or longitudinal methods could further capture behavior in real contexts. Second, we acknowledge that the sample size may not allow for wider generalizations to be drawn from the reported conclusions. In line with past research (Muehlbradt & Kane, 2022), the characteristics of the target sample made it difficult to recruit a larger pool of participants; however, it must be noted that repetition was observed in the answers after 35 participants. As this study adopts a qualitative lived-experience approach, the findings are intended to provide depth, contextual understanding, and conceptual insight rather than statistical generalizability. Future work using larger-scale quantitative or mixed-methods approaches may help examine the prevalence and broader applicability of the identified themes, accessibility experiences, and design implications across more diverse populations of people with low vision and blindness.

Third, an additional limitation concerns the demographic and clinical composition of the participant sample which shape the findings. The majority of participants were aged 66–76 years or older with central vision loss, primarily associated with macular degeneration, which was the most represented visual impairment. This reflects our recruitment through organizations such as the Macular Society (2026), and consequently, may under-represent younger visually impaired individuals. As a result, the themes reflect experiences characteristic of low vision, as well as adjustment processes associated with late-onset impairment. For example, perceptual variability (Theme 1) is grounded in residual visual function and may differ for individuals with peripheral or congenital impairments. Similarly, emotional experiences (Theme 2) often reflect adaptation to vision loss later in life and may not fully capture the experiences of individuals with lifelong impairments. While the study provides depth within a prevalent and practically significant user group, the findings should not be interpreted as representing the full spectrum of visual impairment.

However, it must be noted that our study set out to investigate lived experiences in the **context of impairment-driven phenomena, not age-driven phenomena**. Nevertheless, as a result, the findings may not fully capture lived experiences specific to early onset, developmental, or non-age-related visual impairments. At the same time, this mirrors broader epidemiological patterns, as age-related vision loss is one of the most prevalent causes of visual impairment globally, disproportionately affecting older adults (World Health Organization, 2019). Our sample, therefore, represents a population that constitutes a substantial proportion of real-world accessibility users. In fact, older adults often experience the combined effects of sensory, cognitive, and environmental challenges when interacting with digital systems, making their accessibility needs more pronounced and representative of everyday contexts (Czaja & Lee, 2007). From this perspective, this study provides particularly strong insights into the accessibility lived experiences of a practically significant user group. Therefore, rather than treating this solely as sampling bias, it can be instead understood as offering insights into a population that is both highly affected by visual impairments and frequently under-served by mainstream technology design. Future

work, however, should extend this investigation to younger users, people with congenital or peripheral vision loss, and more diverse visual impairment profiles to examine how accessibility experiences vary across life stages and conditions.

Further to the above point, a separate consideration is the exclusion of participants with complete blindness. As a result, the findings primarily reflect the experiences of individuals with low vision and may not fully capture interaction patterns that rely exclusively on non-visual modalities. Accessibility experiences for blind users may differ significantly, particularly in relation to perceptual interaction, coping strategies, and technological mediation. Consequently, the ECAM-VI framework should be interpreted as most directly applicable to low vision contexts. Future research should extend this work to include participants with complete blindness to examine how the identified dimensions generalize or require adaptation across the full spectrum of visual impairment.

Another consideration that should be acknowledged is that while participants discussed digital and emerging technologies, most had limited direct experience with XR systems. Consequently, our implications for immersive environments are **anticipatory** rather than evaluative. Controlled evaluations of immersive systems are therefore needed to assess how perceptual variability and emotional factors may influence interaction in spatial and multimodal immersive environments. Future research should also explore participatory and co-design approaches with visually impaired users to ensure that emerging technologies reflect lived needs rather than assumed solutions. Therefore, as most participants had limited direct experience with XR, these findings should be interpreted as indicative of perceived potential rather than evaluated interaction.

Finally, the ECAM-VI framework is a result of a conceptual synthesis of our findings rather than predictive. It therefore aims to provide structure for understanding accessibility based on lived experiences and interactions but does not quantify or formally model relationships between the proposed dimensions. Future empirical validation is therefore required so that ECAM-VI can be operationalized through design toolkits or evaluation frameworks that allow designers to systematically assess perceptual, emotional, behavioral, technological, and socio-environmental dimensions. In doing so, the framework can be translated into practical instruments that could bridge research and practice. Overall, this study reframes accessibility from a feature-based engineering problem to an experience-centred design approach. By grounding accessibility in lived experiences framed around the five dimensions of the ECAM-VI framework, we argue that inclusive systems must be designed not only to function, but to fit meaningfully into everyday life. The ECAM-VI framework provides a conceptual bridge between qualitative lived experiences and practical design actionable implications, supporting the development of accessible systems that are adaptive and sustainable across both current and emerging interaction paradigms.

## Note

1. A symbol cane helps alert other people to the holder's sight and/or hearing impairment (*Symbol Canes for Partially Sighted People* | RNIB Shop, 2026).

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## Author contributions

CRedit: **Yuliya Chystaya**: Data curation, Formal analysis, Investigation, Validation, Writing – original draft, Writing – review & editing; **Fotios Spyridonis**: Conceptualization, Methodology, Project administration, Supervision, Validation, Writing – review & editing; **Gheorghita Ghinea**: Project administration, Supervision, Validation, Writing – review & editing.

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## Data availability statement

Due to ethical and privacy restrictions, qualitative interview transcripts are not publicly available. Participants did not provide consent for full transcript sharing or public repository deposition. Relevant anonymized excerpts supporting the findings are included within the manuscript. Additional anonymized data may be available from the corresponding author upon reasonable request and subject to institutional ethical approval.

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## Appendix – data collection instrument

### Interview questions

This section contains a pool of questions used for the semi-structured interviews.

#### General experience and environment

- Can you please tell me about your visual impairment? How long have you had it?
- Please tell me about your day-to-day experience navigating public spaces (e.g., museums, public transport).
- What are the main barriers you encounter? Do these barriers differ in severity depending on the situation (e.g., time of day, unfamiliar layout)?
- How does your visual impairment impact your everyday activities? Do you have issues with contrast levels, color schemes, depth perception, or blind spots (scotomas)?

#### Digital technology and accessibility

- Tell me about your experience with digital technologies (Web, PC, mobile, etc.).

- Have you ever been unable to use a digital product or service because of a lack of accessibility? If so, was the barrier connected to software, hardware, or both?
- Do you often find yourself relying on another person's help with setting up your devices?
- What changes or features would make it possible for you to use technology independently (e.g., voiceover, higher/adjustable contrast, alternative color schemes, or haptic elements)?
- Do you use any "hacks" to mitigate the lack of accessibility in digital technology?
- Would you prefer these features to be optional (switch on/off) or integrated into the experience by design?

### **Gaming and communities**

- *For participants who play games:* If you play games online, do you usually disclose your impairment? Why or why not?
- If you did disclose your impairment, did you feel the attitude of other players changed?
- Are you part of any online community (e.g., Twitch, Reddit) that helps players with disabilities connect or share tips?

### **XR-related questions**

- What is your experience with XR?
- Would you say that you are interested in XR technology?
- Have you ever used any of the XR branches, VR, AR, or MR?
- Which branch of XR do you feel is the most/least accessible and why?
- Which do you think are the most helpful features to have, e.g., customizable visual settings, additional audio cues, haptic feedback, voice commands, or other?
- How do you feel about using VR/MR headsets?
- How often do you need assistance setting up or using XR?
- How would you evaluate the accessibility level of your most-recent XR experience?