"Remove the Floor, Remove the Chair": Co-Designing Minimalist VR Offices with Low Vision Users

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Abstract

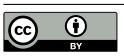
Virtual Reality (VR) workspaces promise flexible, immersive alternatives to physical offices, yet existing designs are designed for fully sighted users and often overload the visual channel with high levels of realism. To identify which customization options actually support sustained productivity, we conducted an in-VR co-design study with 11 low vision participants. Using four pre-built office scenes (abstract to realistic) as starting points, each participant iteratively configured displays, color schemes, and environmental elements. Quantitative analysis revealed that participants arranged between one and five monitors, combined inverted and non-inverted screens, and employed large "colossal" displays to balance detail and context. Qualitative results showed that participants relied on individualized strategies to manage visual load, including sparse environments, and heterogeneous multi-display setups, while separating immediate work areas from peripheral "resting" zones. From these findings, we derive three design implications for accessible VR offices: (i) provide fine-grained, end-to-end controllability, (ii) support heterogeneous multi-display configurations, and (iii) offer a continuum of environment abstractions with tunable visual parameters. Together, these contributions demonstrate that personalized user-driven customization is essential to mitigate visual overload and foster comfortable VR office environments for low vision users that support both accessibility and aesthetic self-expression.

CCS Concepts

• **Human-centered computing** → **Accessibility design and evaluation methods**; **Empirical studies in accessibility**; *HCI design and evaluation methods.*

Keywords

VR, Co-Design, Low Vision, VR Office Environment, Work



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1 Introduction

People with low vision rely on their residual vision for many workplace tasks and often prefer visual information over other modalities, such as aural presentation [41]. However, common office interfaces and environments are optimized for fully sighted users. Everyday activities such as reading and writing emails, editing documents, navigating complex web applications, or comparing information across multiple windows can become slow and exhausting when text is small, contrast is insufficient, or important cues are hard to discriminate. Even when assistive technologies are available, such as magnification, browser zoom, high-contrast themes, or custom color schemes, people with low vision often struggle to continuously adjust to changing visual content. In addition, magnification tools often trade detail for context. Higher zoom levels reduce the amount of information visible at once, increase the need for constant zooming in and out for detail and overview, and can make it harder to maintain spatial and task context [3]. In general, this can lead to loss of control and disorientation [25, 41].

These challenges are amplified in modern knowledge work, where productivity depends on monitoring several streams of information such as email, chat, calendars, and multiple browser windows, and where visual clutter accumulates through toolbars, notifications, and densely packed layouts. As a result, low vision users [1] may expend disproportionate effort on visual search and interface management rather than on the primary task, with consequences for comfort, speed, and sustained work performance [25, 41].

[1] We aim to write respectfully about disabled people. As language use differs in various countries and between individuals, we decided to use identify-first language as Sharif et al. reported this as a slight preference of visually impaired people [38]. However, we are aware of personal and cultural preferences for person-first language.

Virtual reality has the potential to overcome these barriers [13, 14] because Virtual Reality (VR) interfaces are fully rendered, visual properties such as size, contrast, luminance, and level of detail are theoretically under programmatic control, enabling work environments that can be adapted to individual visual needs [31]. In particular, VR could enable minimalist workspaces that reduce non-essential visual detail while preserving the cues needed for task performance and orientation.

However, many current VR office environments mirror visually rich real-world settings and conventional desktop metaphors [49]. Instead of leveraging VR to selectively simplify, these designs often reproduce or even amplify visual clutter through dense interface elements and detailed backgrounds, while offering few mechanisms to systematically reduce visual load.

Crucially, low vision users have rarely been included in the design of VR office environments, and prior work hardly incorporates them as active designers. As a result, we lack grounded guidance on how a minimalist VR office should be structured in practice and which forms of visual reduction remain compatible with task-relevant information and orientation.

Therefore, this paper investigates how minimalist design can be leveraged to improve visual accessibility in VR office workplaces. We address two research questions:

- **RQ1:** What needs, preferences, and design concepts do people with low vision articulate when they can directly shape an ideal VR office in a co-design process?
- **RQ2:** What design implications follow for accessible, low-distraction VR workspaces based on these co-design outcomes?

To answer these questions, we contribute (i) a design-elicitation study in which low vision participants request real-time changes to a live VR scene, yielding needs, preferences, and concrete design concepts for minimalist VR offices (Section 3); and (ii) design implications derived from synthesizing these co-design findings with related work on VR offices, visual clutter, and low vision accessibility (Section 4).

2 Related Work

Barrier-free access to information is essential in workplace environments. For low vision users, efficiently finding information in digital workplaces is a major challenge. In this section, we first review solutions that aim to reduce visual clutter, then introduce approaches that investigate office environments in VR, and last, we point to previous work on how visual accessibility can be integrated in Extended Reality (XR).

2.1 Visual Clutter and Information Access in Productivity Interfaces

Clutter refers to situations where information is difficult to find because the overall layout is poorly organized or the amount of information is very high [29, 44], which can negatively affect task performance in general. The reason is that disorganized display elements can cause visual crowding or even occlusion, which in turn reduces recognition performance [36]. As a result, visual search tasks become more challenging.

Various techniques, such as zooming or focus-plus-context displays, can be used to mitigate this issue [2] when documents are too large and detailed to fit entirely on a user's screen. However, these general techniques are not well suited for low vision users, who typically prefer to access information visually rather than through auditory means (e.g., screen readers) [41] and therefore rely on screen magnifiers. In this case, a document often not only fails to fit on the screen but also obscures parts of the display. As a result, getting a basic overview of the content becomes time consuming. In addition, magnification disrupts spatial continuity, making it more difficult to find specific information and maintain an understanding of how different elements are semantically related. Additionally, there is no universal solution, since low vision users have diverse requirements and thus need customizable interfaces [3]. Therefore, specialized tools and techniques are needed to support low vision users. Current accessibility tools for low vision users fail to meet their needs, as they can be difficult to use, require constant adjustment for changing visual tasks and display configurations, and may lead to inefficiency, disorientation, and a loss of sense of control [41].

There are solutions such as SteeringWheel [3], SpaceX Mag [16] or MagPro [23] which aim to address the spatial problems of current magnifiers by using content semantics to preserve local context [3], by optimizing the space of an User Interface (UI) [16], or by clustering relevant elements as close as possible to current user focus (e.g., text cursor) [23] to reduce the search effort. AccessFixer expands beyond spatial optimization by automatically adapting color, spacing, and the size of interface elements and fonts in Graphical User Interfaces (GUIs) [50].

Apart from cluttered arrangement of information, data visualizations can also be difficult and demanding for users of screen magnifiers. According to Wang et al. [46] screen magnifiers are inadequate for reading data visualizations because they require constant zooming in and out to access either an overview or detailed information. Another approach [34] presents a smartphone tool for low vision users that turns static graphs into interactive slideshows with predefined magnified views, but users requested more control over data navigation.

Clutter is also a relevant issue in XR. As visual clutter affects information presentation in HMDs using a real-world overlay, it requires careful design, especially when real-world information is important [47]. With a three-dimensional world-locked Augmented Reality (AR) cue, clutter can be reduced by simplifying the visual scene and highlighting relevant objects [9].

In general, interface clutter is a well-researched topic, and there are numerous strategies aimed at reducing it. Yet, these general methods do not appear to adequately meet the needs of low vision users. As a result, dedicated tools are developed for this target group, focusing primarily on improving the overall accessibility of productivity applications.

2.2 Office Environments in VR as Productivity Apps

VR has been investigated as a potential office replacement, particularly with the increasing relevance of home office and mobile work in recent years. Latini et al. [22] show that VR office environments

can serve as a substitute, offering productivity and comfort comparable to physical offices and eliciting similar behaviors during short work sessions. Along the same lines, Ofek et al. [31] suggest that VR can transform the way information workers operate by allowing highly personalized workspaces that minimize distractions and recreate familiar configurations. Aufegger et al. [1] likewise contend that adapting environments to individual needs and preferences is not only feasible but essential to maintain productivity.

However, in addition to these advantages, VR can also introduce additional stressors, cause greater visual fatigue than conventional screens, and contribute to cognitive overload [40]. Souchet et al. [40] therefore emphasize the necessity of a deliberate trade-off between the benefits and the newly emerging risks. To address these challenges, research is being conducted on well-being in VR office environments. Ciervo et al. [5] examine aspects of comfort and restorative features, such as virtual windows providing an external view. In line with this work, the role of greenery in virtual offices is also being explored. Latini et al. [22] report that the presence of virtual plants positively affects visual attention while simultaneously enhancing information search and overall performance.

Another contributor to stress and fatigue can be the use of large displays and the exploitation of the "unlimited" space in VR [26], as this often leads to increased physical effort, for example through more extensive head movements. Pavanatto et al. [33] compare a single, unlimited canvas display with a more conventional multi-monitor setup and find no clear overall advantage, since both offer distinct benefits. A canvas display allows finer control over the position and size of elements in 3D space, which can help minimize head rotation, whereas a multi-monitor configuration simplifies window management and supports a more structured layout.

Distractions are also a key factor in office settings. While VR can help reduce external distractions in the real-world, the presence of a virtual environment can introduce new sources of distraction [24]. Consequently, Marx et al. [24] argue that technological affordances must be customizable to support the desired results of work. In this context, Sanaei et al. [37] show that the complexity of the perceived visual scene depends on the specific task being performed. As scene complexity and visual clutter increase, so does cognitive load, suggesting that visual complexity should be aligned with the requirements of the work task [37].

Regarding different virtual room configurations, Kiluk et al. [20] conducted a study in which participants evaluated a dark room, an empty room and a furnished room. Participants reported the highest levels of focus in the dark room, while the empty room was associated with the greatest relaxation. The furnished room was perceived as the most visually pleasing.

These findings underscore the importance of customization to not only user preferences but also situational demands. In general, granting users control over visual elements and potential distractions is a key strategy to mitigate stress in virtual environments [24, 40].

2.3 Integration of Visual Accessibility in XR

The existing literature clearly indicates that XR technologies can improve visual accessibility in general [17], and more specifically for visually impaired people in educational contexts and in various domains related to reading and comprehension of information [14].

Pamparău and Vatavu [32] introduce FlexiSee, an AR-based system designed to support vision rehabilitation, which also includes a web interface enabling further personalization of the user experience. Similarly, Kaya et al. [18] present MagniVR, which offers a comparable experience by magnifying real-world content. This system likewise provides a user interface that allows users to adjust camera settings and display positions. Regarding information placement, Fox et al. [9] report on a study involving low vision participants that 3D world-locked AR cues are more effective than head-up displays.

In the domain of work and education, the role of VR has been examined showing that VR can successfully meet the needs of visually impaired users and is suitable for low vision users [13]. With CLEVR, an interaction concept was introduced to enable the efficient use of specially designed assistive tools for visually impaired people within VR environments. Additionally, more than 70% of the participants successfully completed the office tasks studied, highlighting the effectiveness of VR for low vision users in office work. SeeingVR also offers a collection of tools aimed at improving VR experiences for visually impaired people [52]. In addition, these tools are made available to VR developers for integration into their own applications, thus simplifying the implementation of visual accessibility.

Since reading information is a key activity that presents numerous challenges in VR [19], Wu et al. [49] investigate news reading in VR for low vision users. They identified principles that support this task, including adjustable font size and text layout, adequate text contrast, and the provision of an accessibility menu offering customization options. Furthermore, Wu et al. [49] analyzed existing VR news reading applications and discovered that these principles are seldom applied. Instead, most apps largely imitate physical or conventional digital newsreader solutions, leaving much of the potential of VR unused.

Similar principles were also derived as requirements from existing guidelines by Killough et al. [19]. In addition to text resizing, they explicitly mention the provision of a magnification feature. Additionally, Killough et al. [19] conducted a study with professional XR developers on barriers to XR accessibility and found that only a subset of developers currently follow these guidelines and implement corresponding solutions in their applications. These findings are consistent with a study by Naikar et al. [30], who examined the accessibility of free VR applications for Meta Quest 2. In that work, 36.8% of the applications did not offer any accessibility features. Regarding the magnification feature discussed by Killough et al. [19], Naikar et al. [30] report that only 10% of the applications included magnification and none of the applications provided options to adjust colors.

In a literature review on existing VR/AR accessibility research, Dudley et al. [8] identify the broad spectrum of diverse user needs as one of the main challenges in achieving VR accessibility. To address this, they propose concrete accessibility strategies tailored to different access needs, aiming to support practical implementation. Beyond these strategies, there is a broader body of XR accessibility guidelines, including the XR Accessibility User Requirements (XAUR) [45] and VR game accessibility guidelines from

Heilemann et al. [15]. Platform vendors also publish their own guidelines, for example, Meta Platforms, Inc. provides accessibility guidelines for Meta Horizon OS [27] and Virtual Reality Checks (VRCs) for accessibility [28].

Efforts are being made to develop dedicated tools that facilitate access to XR for visually impaired users and to formulate guidelines for accessible XR solutions. However, these measures do not inherently ensure that applications are accessible, as evidenced by the lack of corresponding implementations in many existing systems. Consequently, Dudley et al. [8] underscore the crucial role of engaging disabled people throughout the entire development process.

Previous work demonstrates that participatory methods can successfully engage blind and low vision people in shaping XR experiences, e.g., in the field of social interaction [51], avatar gaze behavior [6] or musical performance [7]. However, much of this work focuses on specific applications, and we found limited evidence of XR being used as a design medium to iteratively refine the visual complexity of a general-purpose productivity workspace. This motivates our approach, which uses VR scenes as the primary design material and supports the rapid in-situ exploration of VR office environments.

3 Co-Design of VR Office Environments with Low Vision Participants

As outlined in the previous section, there is currently no VR office environment explicitly tailored for low vision users. Our goal is therefore to explore the specific needs and requirements of this target group within a VR office environment. To achieve this, we selected a co-design approach conducted directly in VR. Co-design and participatory methods go beyond conventional user-centered design by actively engaging participants as co-creators and equal partners in the design process. In doing so, we aimed to gain deeper insight into the needs of low vision users and the design strategies for addressing them.

3.1 Preparation of VR Office Environments

We created four pre-built office scenes as starting points for the co-design sessions, drawing on prior work on VR office environments for sighted users. First, we varied the level of realism, particularly with respect to the amount and type of furniture, following Kiluk et al. [20]. Second, informed by research on well-being and stress reduction in virtual environments [5, 22], we incorporated more realistic skyboxes and elements such as plants. Third, based on the findings of Pavanatto et al. [33] and with the goal of maximizing customizability, we implemented freely arrangeable monitors. For the initial configurations, this was simplified to a single pre-defined monitor to provide an easier starting point.

3.1.1 System Architecture. We implemented the prototype environments in Unity 2022.3.45 [43] and assembled the scenes using prefabs and freely available assets from the Unity Asset Store [42]. In addition, we used free 3D models from Sketchfab [39]. During study sessions, we ran the prototype directly from the Unity Editor using Play Mode, with an HP Reverb G2 head-mounted display connected to the study computer.

We chose the Reverb G2 over a standalone headset because our prototype required a controlled, computer-based VR pipeline and rapid iteration during preparation. Using a tethered headset allowed us to (i) run the scenes directly from the Unity Editor (without packaging and deploying builds to a device), (ii) avoid battery-life constraints and charging dependency issues typical of standalone headsets [2], and (iii) simplify experiment operation for the facilitator (e.g. stable launch/reset between conditions and straightforward observation/debugging on the connected PC).

3.1.2 Pre-built Office Environments. The pre-built environments shown in Figure 1 were intended to illustrate a range of customization options that can serve as inspiration for the later design process. Across the four scenes, we varied (1) ambient lighting (light vs. dark), (2) monitor UI appearance (light vs. dark/inverted), and (3) the level of abstraction (abstract vs. more detailed/realistic). These options were selected because low vision participants often differ in their preferences for contrast and brightness (e.g., light vs. inverted color schemes) and in their choice for visually complex backgrounds. All four scenes also included a baseline set of accessibility tools to ensure that participants could immediately explore and compare environments without first configuring assistive features. In particular, we integrated a magnifier that follows the user's head movement as a persistent adjustable aid, allowing participants to change magnification strength and the size and position of the magnified region as needed. This magnification tool was inspired by Zhao et al. [52].

Space. As shown in Figure 1a, the *Space* environment places the user in a dark space skybox, standing on a crescent moon that serves as the floor. In front of the user is a transparent glass desk with a virtual mouse and keyboard, paired with an office chair. A super-large monitor is positioned close to the user and features a slightly curved display with a dark blue frame and shows a PowerPoint editing view in light mode.

VR World. Figure 1b displays the *VR World* environment, which is set against a bright sky filled with clouds. A large floating monitor displays a PowerPoint slide in an inverted (dark) color scheme. The surrounding landscape consists of stylized clouds and sky, with a small red-and-yellow hot air balloon visible in the distance. The workspace is placed on a large, flat, gray platform that includes a black desk with a virtual keyboard and mouse.

Toon World. In Figure 1c, the *Toon World* environment uses a comic-style visual design, with a simple, roofless room box floating against a background of stylized dark clouds. Inside the room, a door is placed on the left outer wall and a window on the right wall. A floating monitor displays a PowerPoint slide with a light-colored design, while a small central table holds a virtual keyboard and mouse, paired with an office chair.

Open Office. Figure 1d shows the *Open Office* environment, which resembles a conventional office interior with light wood flooring and ceiling and green walls. A very large floating monitor on the right displays a PowerPoint slide in a light (white) design. The wall behind the display is opened to reveal an outdoor view of a rocky

[2] In our experience, even when connected via cable, the battery of standalone headsets like the Meta Quest 3 can drain faster than it charges during extended sessions



(a) Space (dark, abstract environment)

(b) VR World (light, abstract environment)

(c) Toon World (dark, realistic environment)

(d) Open Office (light, realistic environment)

Figure 1: Pre-built VR office environments used as starting points for the Co-Design sessions, spanning levels of environment abstraction and different lighting conditions, including light monitor UI schemes (a, c, d) and dark/inverted monitor UI (b)

landscape [3] with a stone arch and vegetation under a bright sky. The room also includes a desk with an office chair and a virtual keyboard and mouse, as well as a plant. There are two virtual colleagues in the room, sitting at separate desks. The desks face the adjacent wall, which is positioned at a 90-degree angle to the co-designer's own desk with its large monitor.

3.2 Participants

We recruited 11 low vision participants with various onset conditions through email lists and posts in relevant institutions. Four participants reported having visual impairments, six having severe visual impairments[4], and one participant reported being blind with light perception. Four participants stated that they had never used VR before, while the other seven participants described usages ranging from private to educational purposes, or work to participating in a study. More detailed participant information can be found in Table 1. To participate in the study, participants were required to have visual impairment and work visually on work related tasks. In addition, we only recruited participants over 18 years old. Overall, we employed a volunteer-based recruitment strategy. They received a compensation of 30€. The overall project was approved by the university's ethics committee. The data protection statement and information was provided and informed consent was obtained from all participants prior to participation.

3.3 Procedure

In general, the study consisted of two parts: (i) an online questionnaire and (ii) an on-site Co-design session.

3.3.1 Online questionnaire. We administered an online questionnaire through SoSciSurvey [10] to gather demographic information and details about each participant's visual impairment and the assistive tools they employ for work-related tasks such as reading. In addition, previous experience with VR technologies was recorded along with potential prior usage scenarios. The online questionnaire was sent to the participants prior to the on-site session in our lab.

3.3.2 Laboratory set-up and personnel. Two researchers assisted the low vision co-designer throughout the session with the following tasks:

[3] 3D Model is based on Terrain Dristibute GN by Node_λrt on Sketchfab [39]
[4] The categories for the degrees of visual impairments (VI) are applied according to German law defining visual impairments (VI) as visual acuity less than or equal to 30%, severe VI less than or equal to 5% and blindness less than or equal to 2%

Table 1: Demographic data on study participants P01-P11 regarding type and onset of visual impairment (VI), affected visual field, glare sensitivity, and the usage of assistive technologies (magnification, screen reader and inverted color scheme)

Code	VI	Onset of VI	Visual Field affected	Glare Sensitivity	Magnification	Screen Reader	Inverted Colors
P01	VI	Birth	no	yes, severe degree	yes	no	no
P02	Severe VI	Birth	yes, entire	yes, severe degree	yes	yes	no
P03	Blindness	age 21-60	yes, central	yes, severe degree	yes	yes	yes
P04	VI	Birth	no	yes, severe degree	yes	yes	no
P05	Severe VI	under age 6	no	yes, severe degree	yes	yes	yes
P06	Severe VI	age 6-20	yes, peripheral	yes, severe degree	yes	yes	yes
P07	VI	Birth	no	yes, severe degree	yes	no	no
P08	Severe VI	age 21-60	yes, entire	yes, severe degree	yes	no	no
P09	VI	age 6-20	yes, central	no	no	no	no
P10	Severe VI	under age 6	yes, peripheral	yes, mild degree	yes	no	yes
P11	Severe VI	Birth	yes, peripheral	yes, mild degree	yes	yes	yes

- **Implementer:** This person operated the Unity editor and immediately enacted every spoken request (e.g., adding, removing, or recoloring objects).
- **Facilitator:** This person provided verbal instructions, answered questions from the participants, and took detailed notes. The facilitator also reminded the participants to adopt a think-aloud protocol.

A schematic diagram of the laboratory layout is shown in Figure 2.

3.3.3 Session structure. Each on-site session consisted of three consecutive parts and lasted between two and three hours per participant. Individual breaks were taken throughout this session as needed.

(1) **Part 1: Introduction.** The facilitator explained the overall agenda, instructions, and the operation of the VR hardware (HP Reverb G2). Participants were asked to continuously verbalize their thoughts, following a think-aloud methodology.
(2) **Part 2: Exploration.**
   (a) **Scene introduction and familiarization.** Participants put on the VR headset and were guided through the four pre-prepared office scenes (see Section 3.1). For each scene, the facilitator gave a brief overview of the visible elements. Participants were then free to explore and comment aloud. When the participant signaled readiness, the implementer loaded the next scene.
   (b) **Selection of a base scene.** After all four scenes had been explored, participants chose the one they wished to customize further. They could request a replay of any scene before making their decision.
   (c) **Co-Design adaptation.** Working in the selected scene, participants issued voice-command style instructions (e.g., "remove the object"). The implementer applied each change immediately while participants observed the result and refined their request. When a requested modification could not be performed on the spot, the facilitator noted the request for later analysis.
(3) **Part 3: Post-session debrief.** At the end of the study session, participants were asked to provide a concise summary of their experience, highlighting (i) what they liked, (ii) what hindered their work, and (iii) any additional features they would like to see in a low-vision-friendly VR office.

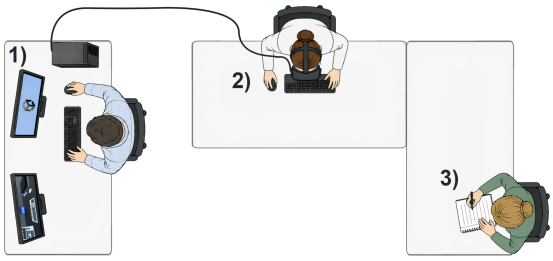


Figure 2: Laboratory layout: (1) implementer's workstation (left), (2) low vision co-designer's area with the HP Reverb G2 (middle), (3) facilitator's desk (right).

3.4 Data Collection and Analysis

The workshop facilitator recorded the comments of the participants. The notes were taken closely to the wording of the participants and also included reactions in order to function as a summarizing transcript. The changes made in the VR environments were documented in the notes as well as through screenshots of the scenes and note hints in the Unity scene. One researcher conducted a qualitative analysis of the data using the structured qualitative analysis approach proposed by Kuckartz and Rädiker[21]. This approach suited best our research interest and study design as it allowed us to focus on predefined central topics through deductive analysis of the qualitative data while also staying open to new analysis directions and supporting novel interpretations through subsequent inductive analysis. First, broad categories were developed according to the session guide and after the initial reading of the first two note transcripts. These general categories were subsequently used for the initial coding of the data. In the next step, several subcategories were developed inductively in the process of engagement with the data. During and after the coding of the entire data set with subcategories, memo writing was used to reflect on some general tendencies of the participants' experience in the VR environment

and some potential connections between analysis categories that appeared from the data.

3.5 Results

In this section, we first report on the quantitative results of the resulting scenes over all participants. The qualitative results are then described by the main themes identified through structured qualitative analysis.

3.5.1 Quantitative Results. To contextualize the results, we first summarize the typical (non-VR) reading setups of the participants from the questionnaire. Regarding color schemes, five participants reported adjusting the color scheme (all by inverting colors), while six reported no color adjustments. Participant P03 reported using different color schemes depending on task and daily form, including white on black and yellow on black, but mainly using inverted colors.

Regarding screen readers, six reported using one and five reported not using a screen reader. The tools reported included NVDA (2), OS-built-in screen readers on macOS/Windows (3), Supernova (1), and ZoomText (1). Finally, ten reported using magnification and one not using magnification. Eight reported magnification tools including Windows Magnifier, four Apple magnification features, two ZoomText, one Android magnification, and one Supernova (multiple tools could be reported per participant). The results show that the participants use various color schemes, different tools for magnification, and some of them additionally use speech output.

Starting Scene. The participants could choose between the four starting scenes: *Space*, *VR World*, *Open Office*, *Toon World*. Among participants, the most frequently selected starting scenes were *Space* and *VR World* (each chosen by four), followed by *Open Office* (3). *Toon World* was not selected and was predominantly described as visually "too gray" and "dull" (see Figure 4 in Appendix B for more details).

Skybox. For the skybox, participants largely preferred darker backgrounds. A dark abstract skybox was chosen the most (5), followed by a dark realistic skybox (3). Light abstract variants were less common (2), while a light realistic skybox was not chosen at all. One participant completely removed the skybox. Considering skybox and monitor color settings jointly, most participants selected combinations that matched their typical desktop preference. Overall, seven of the 11 participants used a "matching" combination of skybox brightness and monitor color scheme consistent with their usual (inverted vs. non-inverted) reading setup (see Table 3 in Appendix A for more details).

Room Layout. For the overall geometry of the room, minimal setups dominated. A pure void environment (4) and a "floor-only" setup (4) were equally common, whereas only a few opted for partial (1, no ceiling) or fully enclosed rooms (2).

The Room-setup choices appeared to relate to the visual profiles of the participants and typical reading tools. Table 2 shows the per participant overview of visual profiles and scene configurations. Void setups were chosen by one participant with blindness and two participants with severe visual impairment. All three reported using both a screen reader and magnification in their typical setup. The remaining participant who chose a void setup had a visual impairment and explained that environmental elements were not necessary for the task and could therefore be removed. Floor-only setups were created mainly by participants with severe visual impairment (four participants) and one participant with visual impairment. Among them, two typically used a screen reader, and four used magnification. All participants in this group reported an impaired visual field that included peripheral, central, or whole-field defects. By contrast, the fully enclosed room setup was selected by two participants with visual impairment who did not report visual-field impairments. Both typically use magnification, and one additionally uses a screen reader.

Office Layout. Office layout preferences were also predominantly minimalistic. Desk-only setup was the most frequent choice (4), followed by void offices (2) and setups without a chair (2). Single-office (1) and fully furnished offices (2) were selected less often. The selection of the Office layout was dependent on the geometry of the chosen room. Void office configurations occurred only together with either a void environment (1) or the "no ceiling" room setup (1). Desk-only offices were chosen only in minimal rooms, namely void environments (3) or floor-only setups (1). The single-office layout was selected in combination with a floor-only room setup (1). No-chair offices occurred together with floor-only and full-room setups, while fully furnished offices were combined with either full-room or floor-only environments. Across these combinations, we did not observe an apparent correlation between office layout choices and the type of visual impairment of the participants. Similarly, prior VR experience did not appear to influence the selection of room or office setup.

Tools and Decorations. The use of tools was heterogeneous, but many participants did not add any tools (5). When tools were added, they covered (i) interaction/input devices (Braille keyboard, joystick control ball, touchpad, and button; (4) in total), (ii) productivity tools (calculator and stopwatch; (2) in total), (iii) information displays (clock, including two instances, and weather; (3) in total) and (iv) integrations of real-world content (document scanner and tracked smartphone; (2) in total). Additional elements included a pen/notebook and a whiteboard (2).

Decorations were used to varying degrees, ranging from no decorations (3) to common additions such as plants (4) and cups/glasses (3), including one time as a tracked object). Less frequently, participants added hot air balloons (2), mountains (2), a co-working area (2), and single instances of a lamp (1) or a cat for emotional support (1)[5].

Monitor Setup. Finally, participants configured between one and five monitors (mean = 2.9), with three participants using a single monitor. Most participants included at least one very large ("colossal") display (9), while others preferred multiple smaller monitors. In VR scenes, seven participants included at least one monitor with an inverted/dark color scheme, and four participants at least one curved monitor. We further explored whether participants replicated their typical desktop color-scheme preference (inverted vs.

[5]This 3D Model is based on "Cat" by Fyrokid licensed under CC-BY-4.0

Table 2: Per-participant overview of visual impairment profiles and VR scene configuration ($N = 11$). Abbreviations: VI status (Blindness, severe VI = severe visual impairment, VI = visual impairment), Room (Void, Floor, Partial, Full), Office (Void, Desk, No Chair, Single, Full), Monitors Inverted (All/Some/None).

Code	VI	Visual Field	Glare Sensitivity	Skybox	Room	Office	#Monitors	Monitors inverted
P01	VI	no	yes, severe degree	Dark Real	Full	Full	5	All (100%)
P02	Severe VI	yes, entire	yes, severe degree	Light Abstract	Floor	Full	1	None (0%)
P03	Blindness	yes, central	yes, severe degree	Dark Abstract	Void	Desk	4	All (100%)
P04	VI	no	yes, severe degree	Dark Real	Full	No Chair	4	None (0%)
P05	Severe VI	no	yes, severe degree	Dark Abstract	Void	Desk	2	Some (50%)
P06	Severe VI	yes, peripheral	yes, severe degree	Dark Abstract	Floor	Desk	4	All (100%)
P07	VI	no	yes, severe degree	Dark Abstract	Void	Void	2	None (0%)
P08	Severe VI	yes, entire	yes, severe degree	Light Abstract	Partial	Void	5	None (0%)
P09	VI	yes, central	no	Dark Abstract	Floor	Single	1	All (100%)
P10	Severe VI	yes, peripheral	yes, mild degree	None	Floor	No Chair	1	All (100%)
P11	Severe VI	yes, peripheral	yes, mild degree	Dark Real	Void	Desk	3	All (100%)

non-inverted) in VR. Among those who typically did not use inverted colors (6), four also did not invert colors in VR, while two opted to invert all monitors in VR. Among those who typically use inverted colors (5), four also used inverted colors in VR, while one inverted only 50% of their monitors. In general, eight out of 11 participants fully adhered to their typical desktop preference and one partially followed it.

To complement these aggregate counts, Appendix A summarizes the final per-participant scene configurations as well as their usual assistive technologies used for working.

3.5.2 Qualitative Results. We report qualitative findings as themes identified through the structured qualitative analysis of facilitator notes, complemented by cross-sectional patterns observed in the final workspace configurations (Appendix A).

Cross-cutting configuration patterns. Building on the per-participant overview in Table 2, we observed three recurring configuration strategies. First, many participants leaned toward minimal geometries (e.g., void or floor-only rooms) and minimal office layouts (e.g., desk-only), suggesting that removing environmental structure was often used as a way to reduce visual load and maintain orientation. Second, participants frequently carried over familiar accessibility settings from their everyday desktop setups into VR (notably for color inversion and magnification), while a smaller number deliberately deviated (e.g., inverting all monitors despite typically not using inversion) to probe what worked best in VR. Third, monitor setups reflected different approaches to managing information. While most participants used at least one very large display, others preferred multiple smaller monitors, sometimes mixing inverted and non-inverted screens.

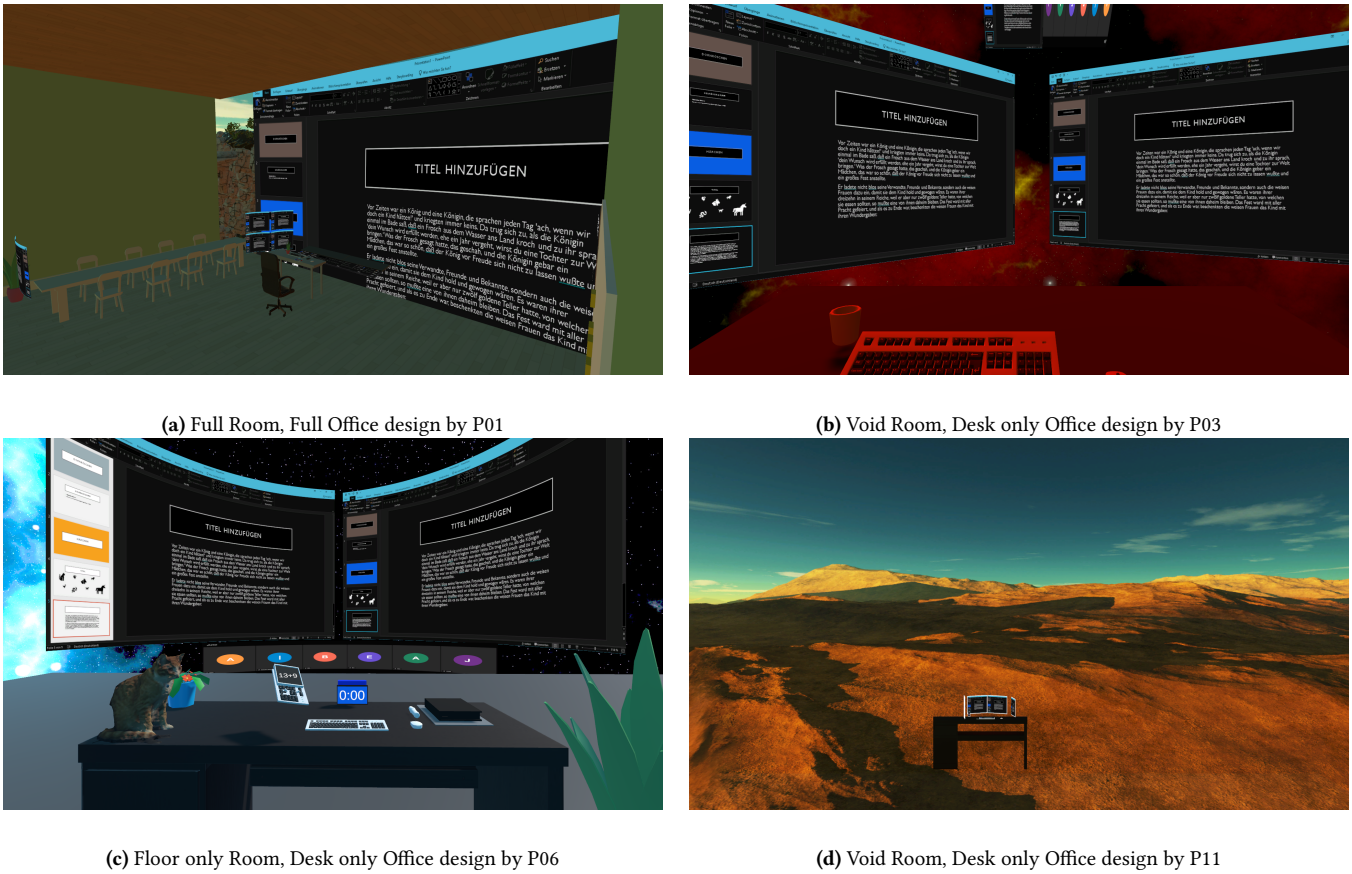
To make these strategies more tangible, Figure 3 shows four example workspaces created by participants. Rather than representing a single "best" configuration, the examples illustrate how different combinations of minimalism, display adaptation, and environmental context were used to negotiate legibility, orientation, and comfort.

Theme 1: Autonomy through fine-grained control. Theme 1 describes the need for autonomy of the participants at the level of individual interactions. They wanted precise control over the tools and objects they use so they could complete tasks on their own, without relying on the assistance of others. Participants highlighted that they found it great and fascinating to directly design, immediately see the changes, and carry out the process on their own. Thus, they appreciated being able to adjust the form, size, and position of objects such as the monitors or the magnified region and therefore iteratively configure their workspace. Referring to the use of a head-controlled magnifier, P11 remarked that it is *"better to be in control of when it's zooming in/out and when it's on/off"*[6]. The participants particularly emphasized the importance of being able to consistently locate and follow relevant objects and content. As relevant objects, participants mentioned PC-mouse and keyboard as the most important interaction devices as well as the mouse and text cursor pendents on the monitor.

Theme 2: Supporting residual vision through adaptable displays and multimodal feedback. Participants discussed compensating for impaired vision through large and configurable displays and, where relevant, by combining visual adjustments with additional sensory channels such as touch or audio feedback. This was especially mentioned with respect to receiving notifications. It was discussed as a current challenge and therefore the demand that they need to be clearly perceivable, preferably through multiple modalities.

Color was characterized both as a matter of aesthetic taste and as a necessary requirement. When trying different environments, participants frequently took into account whether a setting felt pleasant or unpleasant when choosing or rejecting a particular environment or skybox. To illustrate this, P03 expressed regarding the color choice of a virtual PC-mouse on the virtual desk: *"If the entire mouse has the same color, it is easy to recognize. It is shining, and [...] can also see it from the corner of [the] eye.* Participants wanted to choose colors that were easy to perceive, noted that very bright colors could be disturbing or even pain-inducing, and used inverted color schemes to make reading easier. Brightness was framed similarly as a key factor in shaping work capacity, with some participants describing unpleasant or painful brightness levels that could induce stress. Contrast was discussed as essential

[6]Translation by the authors as the study was conducted in German.



(a) Full Room, Full Office design by P01

(b) Void Room, Desk only Office design by P03

(c) Floor only Room, Desk only Office design by P06

(d) Void Room, Desk only Office design by P11

Figure 3: Four example VR office designs created by participants P01, P03, P06, and P11, illustrating different strategies for minimizing visual load while maintaining task-relevant information and orientation.

not only for reading, but also for orientation in VR and for autonomously locating objects (e.g. PC-mouse). Finally, participants highlighted magnification options that are difficult or impossible in physical workplaces, such as a head-tracked magnifier that enlarges whatever they are looking at, the ability to bring elements closer or moving themselves within the virtual scene.

Theme 3: Managing visual load through minimalism and negotiating realism. In contrast to the emphasis of Theme 1 on interaction-level control, Theme 3 concerns environment-level curation to manage visual load and maintain orientation. Participants frequently described the need to reduce visual overload through minimal room and office setups, few essential objects on the virtual desk, and stable environments without sudden changes. This preference for minimalism was closely related to the way participants negotiated realism. Some wanted the environment to be "realistic enough" to support familiarity and orientation, e.g. by placing copies of real-world objects such as a mug or glass at the exact same spot as in reality. In contrast, others were interested in making the virtual workplace "better than real" by simplifying the space, removing barriers, or adding helpful elements not available in physical offices. P04 therefore mentioned that it is *"convenient that the desk is tidier than in reality"*.

More broadly, the participants described a complex relationship with reality, balancing the desire to rebuild familiar environments, including their drawbacks, with opportunities to overcome those barriers through VR. An example was the option of including a virtual keyboard model or having a passthrough camera image of the real keyboard. P07 argued that the *"virtual keyboard is rather better visible."*. With respect to familiarity, P07 stated *"Nothing else on the desk except water bottle (otherwise grab "blindly" because [...] know where it stands)"*. They stressed the importance of actively managing distractions by keeping the office setup itself as free from disturbance as possible, while deliberately using the surrounding scenery as a visual "resting" space or as a playful setting for taking breaks. P10 specifically arranged mountains and a lamp in the nearby environment to support rest and relaxation. Others, including P08 and P11, expressed a desire for a moving hot air balloon in the environment that they could search for and track during an in-VR break.

Theme 4: Collaboration. Several participants reported that communication and co-working tasks can be stressful, particularly when social cues like facial expressions are hard to perceive and when attention must be split between content and communication. At the same time, participants raised the idea of having co-workers

present in the VR environment. Four participants expressed interest in including colleagues, either as representations of their real co-workers or simply to feel less alone while working, noting that it is common to have co-workers around. Taken together, participants described a tension between the comfort of co-presence and the added stress of communication and non-verbal communication.

Theme 5: Learning curve and physical comfort. Participants also highlighted practical challenges, such as the need for time to get used to VR interaction and experiencing physical discomfort from extended headset use, including the weight of the device and the associated head movements. P01 mentioned losing track of time during the co-design session and commented that he is *"not used to the weight on the head. In the long run ok, seems possible"*. P07 even noticed benefits of using a VR headset, stating: *"I usually get headaches without my glasses, but I've never noticed that in VR"*. The participants further reported an emotional dimension to using the system, with responses ranging from positive (e.g., "cool," "funny," "pleasant") to feelings of uncertainty and unfamiliar work practices, and, in some situations such as with the pre-built *Toon World*, perceiving the environment as unengaging or boring.

Across these themes, participants repeatedly reflected on how the virtual and real worlds relate, using their designs to selectively reproduce familiar office conventions while also embracing VR-specific opportunities. Several comments highlighted that VR can make certain activities feel easier or more natural than expected, as P11 expressed: *"Funny, getting up and walking around is no problem [...] feels like I'm really there"*. Additionally, elements with limited value in a physical setup can become useful or enjoyable in VR like P03 noted: *"Two screens don't really add anything in the real world, but in VR"*. P11 added *"Hot air balloons are so cool (closer and bigger) [...] best feature right now, I never see anything like that in real life, totally cool"*. Taken together, the results show that participants did not simply want a direct copy of a real office, but rather an adaptable environment that supports task work, comfort, and restorative breaks by leveraging what VR affords. In general, our particpants were extremely enthusiatic about designing their individual working environments and could readily envison using such environment in practice.

4 Discussion

In the following section, we discuss the findings obtained through our in-VR co-design approach. After identifying a gap in both academic literature and commercial solutions that there is an absence of VR work environments explicitly designed for low vision users, we first wanted to understand what users expect and require from such environments. To this end, we conducted a co-design study with low vision participants, in which each participant customized and shaped their own ideal VR office environment based on a set of pre-built environments. From these results, we now synthesize the insights and outline the design implications for future accessible VR work environments.

4.1 Co-Designing VR Office Environments with and for Low Vision Users

To address our first research question, we explored which configurations, concepts, and spatial layouts of VR office environments low vision participants considered desirable.

4.1.1 No single solution. Consistent with findings in other technology domains, we observed that there is no single solution that works for all low vision users. The ways in which tools are used and configured are strongly influenced by individual preferences, specific tasks, and situational context. This observation aligns with extensive prior research on assistive technologies [3, 11] as well as on VR office environments more broadly [1, 31]. Reflecting this participants described a range of strategies for setting up their VR workspaces and pointed to both professional and everyday scenarios in which VR tools could be advantageous. Beyond our main focus on office-related tasks, orientation and mobility were frequently highlighted as additional promising XR application areas, which is consistent with previous work on supporting travel through VR [35].

4.1.2 Spatial Setup. Our participants' various monitor configurations (Section 3.5.2) mirror the flexibility of people without visual impairments reported by Pavanatto et al. [33]. This indicates that there is no single optimal information display configuration in VR also for low vision users. Instead, each option offers distinct advantages reinforcing Theme 2 of our findings about the need for customization controls per-display.

Regarding room configurations, we observed effects similar to those reported by Kiluk et al. [20], where some participants chose dark and sparsely furnished rooms to simplify their workspace. In contrast, others replicated familiar room layouts, as also noted by Ofek et al. [31] for users without visual impairments. Most of the participants indicated that their aim was to design an environment superior to their physical office, but their approaches and requirements differed considerably, resulting in highly individual virtual workspace designs in general.

Overall, we found that participants with visual impairments generally favored more enclosed room layouts, while those with severe visual impairments or blindness more frequently selected void room layouts. Furthermore, participants without visual field loss were more likely to retain fully furnished room layouts, whereas those with central or peripheral visual field impairments often preferred nearly empty (void) or floor-only setups to reduce visual clutter. We did not observe any consistent preference for particular office layouts (e.g., desk-only, no-chair, etc.) across different impairment profiles. Rather, participants mainly explained their selections in terms of personal comfort or aesthetic taste.

4.1.3 Color, contrast, and magnification. Features such as color, contrast, and magnification were frequently mentioned during the co-design sessions by most participants, underscoring how crucial these options are, which aligns with [19, 30]. An additional aspect that emerged was the role of color as an aesthetic component of the surrounding scene and the skybox. For one participant who is legally blind, experiencing the color red in VR felt novel and enjoyable compared to real life, leading him to set the entire skybox lighting to red. This illustrates that customization options are not

solely aimed at accessibility but also serve to enhance comfort and aesthetic self-expression for low vision users.

4.1.4 Distractions. Distractions emerged as a salient theme in both the co-design sessions and the existing literature. Participants deliberately shaped their environments by choosing skybox styles, adding or omitting decorative items such as plants or a floating hot-air balloon to manage visual load. These choices echo prior work highlighting the restorative value of outward views [5] and the positive impact of virtual greenery [22]. Rather than perceiving these elements as disruptive, users viewed them as controllable cues that facilitate relaxation and brief restorative breaks, a strategy that aligns with findings on distraction management and cognitive overload in immersive workspaces [24, 40]. This behavior substantiates Theme 3 of our findings, highlighting the importance of providing users with explicit mechanisms for managing visual distractions.

4.1.5 Co-design approach. Co-design proved to be essential in this context, as it enabled the emergence of unexpected strategies such as combining inverted and non-inverted monitors, using object placement as a scaffold for spatial orientation, and establishing "resting" zones for the eyes. Providing participants with autonomy within the co-design process allowed them to adapt the system ad hoc to their needs and preferences. This autonomy is also highlighted by Bittenbinder et al. [4]. Furthermore, prior acclimatization to VR interactions appeared beneficial, particularly in end-to-end workflows where VR is used not only to experience the workspace but also to design it. That means, designing VR offices directly in VR. Nevertheless, an important consideration remains the ergonomics and weight of the headset, which can significantly influence comfort and sustained use.

4.2 Design Implications

Based on our observations and findings from the co-design study, we derive design implications for minimalist, adaptable VR office environments to answer our second research question. The three themes are grounded in the specific needs and requirements articulated by low vision co-designers while configuring VR office settings. Across all three themes, visual overload and clutter were not simply understood as "too much content," but rather as a loss of control over interface elements, displays, and the broader surrounding environment which aligns with general work on clutter [36, 44].

4.2.1 Autonomy through reliable, fine-grained control.

- 1.1 Provide brightness and color control, including color inversion, as core customization features that can be applied consistently to individual interface elements rather than being limited to selected elements or the entire environment.
- 1.2 Support rapid switching between user-defined presets (e.g., "reading", "writing") to accommodate short-term changes in user needs and task contexts.
- 1.3 Offer aesthetic personalization options (e.g., skybox color/lighting, selectable palettes) alongside accessibility features, while incorporating safeguards against extreme brightness and glare.

4.2.2 Adaptable displays and mixed configurations.

- 2.1 Enable per-display customization of size, distance, curvature, brightness and color, explicitly supporting mixed display configurations.
- 2.2 Provide clutter-reduction mechanisms that extend beyond conventional multi-monitor layouts (e.g., canvas-style placement combined with temporary "focus" modes that hide non-essential elements but provide options for secondary windows).
- 2.3 Provide optional, configurable multimodal cues (e.g. audio/haptic feedback) for critical events such as focus changes, errors, and notifications to support interaction when relevant visual elements are out of the user's Field of View (FoV).

4.2.3 Minimalism and negotiable realism at the environment level.

- 3.1 Allow users to customize the level of environment abstraction, from minimal to realistic, by adjusting background detail, motion, lighting, and skybox settings rather than selecting from fixed presets.
- 3.2 Preserve orientation within minimal scenes through stable landmarks and a consistent spatial structure, while allowing users to remove or simplify non-essential decor.
- 3.3 Support deliberate recovery strategies, such as calm, low-detail regions and optional slow ambient motion (e.g. drifting distant balloons), without requiring a uniformly minimal workspace.

5 Limitations and Future Work

The participating users reported heterogeneous levels of prior experience with VR technologies. However, none of them were familiar with VR-based office environments, nor had previous experience with VR-based design activities. Furthermore, the time available for participants to familiarize themselves with the VR technology itself was limited. As this study focused on the design of a single workplace in an office environment, future research will examine how visual environment requirements may vary across different office tasks and work modes and investigate the dimensions of immersion and presence as central promises of VR. Collaboration and interactions with colleagues emerged as a relevant theme in discussions with the low vision co-designers, yet this aspect was outside the scope of our prototype-based co-design study. Future work should examine collaboration requirements in more depth and evaluate how well contemporary VR office applications support them. In addition, the study did not address the long-term effects or real-world use of the designed VR office environments. Future studies with longer work sessions are needed to confirm whether our design implications support long-term productivity in real-work settings, as they focus on user needs and design rationales.

6 Conclusion

In this work, we investigated how VR office environments can be designed to support low vision users in everyday productivity tasks. We conducted a VR-based co-design study in which 11 participants created and refined their own workspaces. This revealed highly individualized strategies for managing visual load, including selective visual simplification like minimal room setups, mixed display

configurations (e.g., combining inverted and non-inverted monitors), strong reliance on magnification and contrast tuning, and the use of stable spatial anchors and "resting zones" for recovery.

Based on these findings, we derive design implications for VR offices that treat accessibility as end-to-end controllability: provide reliable, fine-grained settings, enable per-display adaptation including heterogeneous setups, and offer a continuum of environment abstractions with tunable parameters. Importantly, customization should not be limited to addressing accessibility needs, but should also enable comfort and personal aesthetic expression. Future work should evaluate how well contemporary VR office applications implement these capabilities and where additional platform-level support is required.

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A Appendix A

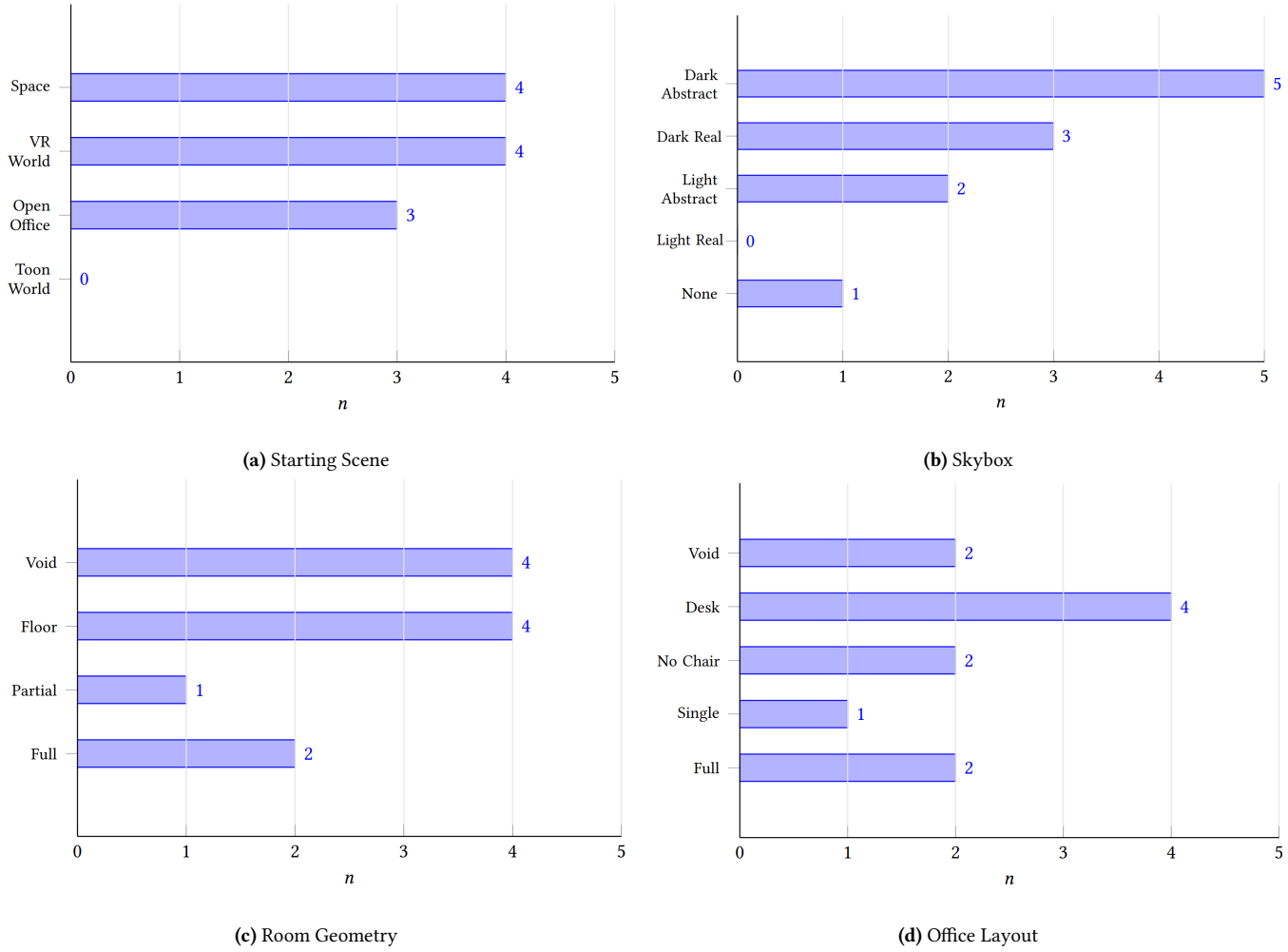
Table 3 provides a per-participant overview of self-reported non-VR reading setups and VR scene configurations.

Table 3: Per-participant overview of self-reported non-VR reading setup and VR scene configuration ($N = 11$). Abbreviations: VI status (Blindness, severe VI = severe visual impairment, VI = visual impairment), Mag = Magnification, SR = Screen Reader, Room (Void, Floor, Partial, Full), Office (Void, Desk, No Chair, Single, Full), Monitors Inverted (All/Some/None).

Code	VI	Color Inversion	Mag	SR	Skybox	Room	Office	#Monitors	Monitors Inverted
P01	VI	no	yes	no	Dark Real	Full	Full	5	All (100%)
P02	Severe VI	no	yes	yes	Light Abstract	Floor	Full	1	None (0%)
P03	Blindness	yes	yes	yes	Dark Abstract	Void	Desk	4	All (100%)
P04	VI	no	yes	yes	Dark Real	Full	No Chair	4	None (0%)
P05	Severe VI	yes	yes	yes	Dark Abstract	Void	Desk	2	Some (50%)
P06	Severe VI	yes	yes	yes	Dark Abstract	Floor	Desk	4	All (100%)
P07	VI	no	yes	no	Dark Abstract	Void	Void	2	None (0%)
P08	Severe VI	no	yes	no	Light Abstract	Partial	Void	5	None (0%)
P09	VI	no	no	no	Dark Abstract	Floor	Single	1	All (100%)
P10	Severe VI	yes	yes	no	None	Floor	No Chair	1	All (100%)
P11	Severe VI	yes	yes	yes	Dark Real	Void	Desk	3	All (100%)

B Appendix B

Figure 4 in this appendix summarizes participants' scene configuration choices.



(a) Starting Scene

(b) Skybox

(c) Room Geometry

(d) Office Layout

Figure 4: Overview over the quantitative results on the selected starting scene and environment configurations like the chosen skybox, room geometry and office layout over all 11 participants.