Seeing Art Differently: Design Considerations to Improve Visual Art Engagement for People with Low Vision

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ABSTRACT

Most people with a visual impairment retain some residual vision, yet accessibility strategies and research for visual art focus on non-visual aids and strategies. Little is known about how image enhancements may benefit people with low vision in art settings. Our study explored the challenges of people with visual impairments in museums and art galleries and the potential of visual enhancements to improve accessibility. Through online focus groups with 18 participants, we uncovered multifaceted visual challenges. Participants emphasised the role of non-visual senses to reduce visual ambiguities. Subsequently, we presented participants with the concept of image enhancements on Head-Mounted Displays (HMDs) as a potential approach to enhance visual accessibility. Participants expressed nuanced perspectives, advocating for this technology to improve visual art. The findings provide valuable insights for enhancing the visual experience of people with low vision in museums and galleries through design.

CCS CONCEPTS

• **Human-centered computing → Accessibility design and evaluation methods**.

KEYWORDS

Visual Accessibility, Visual Art, Museum, HMD, Head Mounted Display, Image Enhancements, Low Vision, Sight Loss

ACM Reference Format:

Paul Goddard, Nervo Verdezoto, Tom H. Margrain, Yu-Kun Lai, and Parisa Eslambolchilar. 2024. Seeing Art Differently: Design Considerations to Improve Visual Art Engagement for People with Low Vision. In ,. ACM, New York, NY, USA, 13 pages. https://doi.org/TBC

TBC, TBC

ACM ISBN TBC
https://doi.org/TBC

1 INTRODUCTION

Visual impairment affects approximately 1.7 million people in the UK, with 87% retaining some residual vision [41] and represent an important target audience for museums to achieve their major vision to become more inclusive and participatory [35, 36]. People who are blind or have low vision value their physical presence in museums, fulfilling their cultural and social needs [21, 28]. The physical proximity to art helps convey the artwork's authenticity and allows them to experience other sensory information such as the smells, sounds and conversations of other visitors [21, 28]. Although these non-visual senses add value to their visit, blind and low vision visitors have an overriding desire to gain more visual information. For example, many of the questions asked on staff-led tours focus on the aesthetic qualities of visual art [21]. Crucially, "a loss of vision is not connected with a loss of interest in art and museums" [30, p221].

Although 21st-century museums are working towards being more inclusive, the implemented accessibility strategies for people with visual impairments are often inconsistent and poorly executed [33]. Adding to the challenge are vague agreements for human rights and legislation. For example, the UN's Universal Declaration of Human Rights (1948) asserts that "everyone has the right to rest and leisure" [54] and in the UK, current legislation requires reasonable adjustments for people with disabilities [53]. Neither provides clear guidelines for accessibility in museum settings. Common strategies to make museums more accessible are guided tours, audio headsets, large prints, and tactile replicas [33], and suggestions to improve accessibility primarily revolve around the use of sound, touch, smell, and taste [9, 57]. As these strategies cater to non-visual interpretations of visual art, they neglect to improve the visual aspects of art. Moreover, creating content bears a financial and time cost, meaning the strategies are typically only available for a predefined collection of items and so offer a limited choice of what to view [12, 18]. In addition, tours can be infrequent or require booking, restricting the ability to be spontaneous [12]. These limitations leave few people with low vision visiting such places [31, 33].

The inaccessibility of visual art and the resulting lack of independence act as discouraging factors for people who are blind or have low vision, deterring them from visiting museums [2, 30, 42].

Without a means to engage with the content available in museums, the act of visiting becomes somewhat pointless [18]. These challenges severely impact the lived experiences of people with low vision as well as the priority of making museums more accessible and inclusive, and perhaps represent a self-fulfilling prophecy as only 5.5% of blind people visit museums [15].

The perception held by people with visual impairments is often that they should not visit museums due to their limited ability to perceive exhibits [42]. In addition, art is highly visual and, therefore, "it is important to keep looking for possibilities to allow blind persons to access visual art" [14, p333]. Initiatives should enable individuals to "afford better use of the vision they do have", and visual accessibility strategies such as mixed reality for this demographic is still under-explored and could be a future direction [23, p7].

While visual enhancements have shown promise for other highly visual formats, such as TV [58], this hardware is not portable and could only work in predefined spaces within a museum, and might not be suitable for people with low vision as they prefer to be "physically next to the works of art" [20, p67]. In addition, image enhancements on a Head Mounted Display (HMD) could improve the visual elements of visiting museums to view visual art, yet little is known about the visual challenges of visual art within museums previously described.

In this paper, we report insights from three focus groups with 18 museum visitors with visual impairments aimed to understand further the visual challenges experienced by people with sight loss when they visit a museum or art gallery, understand and explore how they currently deal with these challenges and what their perspectives are of image enhancements as a potential method to enhance visual art.

Our study builds upon accessibility research in art settings [9, 21, 28, 30, 31] in several key ways. First, the challenges identified highlight the complexities inherent in existing accessibility strategies. Second, we proposed design considerations based on our findings, such as using computer vision for automatic art detection, introducing enhancements, and advocating for customisable zoom/magnification options. Third, our emphasis on the importance of natural-sounding audio descriptions, text-to-speech options, and the recommendation of optical see-through HMDs to address disorientation collectively advance the understanding of enhancing the user experience in art settings for people with low vision.

2 RELATED WORK

In this section, we explore both visual and non-visual accessibility strategies for people who are blind or have low vision.

2.1 Non-visual Accessibility Strategies

Conventional strategies to improve accessibility in museums and art galleries centre around alternate senses to sight. While these strategies provide more information and context to people with sight loss, they are often limited by the inability to customise the content, limited amount of detail, or provide limited visual information.

One common strategy is guided tours that can help provide historical and biographical details, but these are not always available or cover a subset of the overall museum collection [12]. Friends and family can provide alternatives to guided tours by offering descriptions of art and customised tours. However, their ability to provide useful descriptions is limited, and the person with low vision may also feel like they are being a burden [2]. In addition, people with visual impairments often want more visual details, with some reporting that "verbal imaging goes just so far" [21, p169]. Moreover, having someone interpret visual art reduces the experience and excitement [21]. People with visual impairments want to know more about colours, brushwork and where visual details are present concerning other parts of the artwork [21].

One current strategy to make museums more accessible is tactile replicas and prints. Visitors who are blind or have low vision appreciate the chance to get closer to a copy and therefore look closer. However, tactile options are rare, and the raised images are often simplified and give a drastically altered version of the original [9, 10]. When tactile options are used, it is often to construct a mental visual representation of the touched item [46]. However, tactile replicas are simplified to allow emphasised features to be presented and offer no enhancement of colours or details. The simplified features present something "which is radically translated and is lacking in many respects" [9, p104], leaving the visitor to make their own interpretations of what the original might look like or struggle to convey the meaning [2].

Another strategy for museums is using audio devices worn around a museum to provide limited descriptions of art or academic qualities (e.g. the artist's history and types of work). However, these devices often offer no way to customise the content to the wearer's preference or needs and no option to ask questions [2]. Newer multimodal strategies combine audio descriptions with tactile [34] but largely ignore the need for visual enhancements [31, 34]. Where technology is used, it primarily provides non-visual interpretations and further research is needed to identify the "user needs and expectations from integrating assistive technologies across the continuum of visits to museums" [57, p72].

Non-visual exploration of visual art can provide context for the artwork and help fill in visual ambiguities. However, people with some remaining vision or not congenitally blind still desire further visual information [14, 21]. Thus, studies of museum accessibility strategies have prompted people who are blind or have low vision to discuss their desire for further visual details in museums [20].

2.2 Visual Accessibility Strategies

Visual enhancements in museum settings are infrequent, and even the provision of magnifiers is uncommon [33]. In this section, we will explore the limited art and museum-based enhancements and the visual enhancement strategies from other mediums that could be applied to visual art in museums.

Smartphones and tablets contain large colour displays that could present their users with visual enhancements. Apps like ReBokeh [44] convert the live camera feed or photographs into black and white and provide zoom and colour swapping with the option to save the customised view as a preset for future quick access. Where such apps have been tested in art settings, participants found that

holding a phone to align the camera with the artwork on the wall was physically draining [19].

Websites allow all visitors to view pictures and understand more about artworks before visiting museums and during their visit. Low vision participants who used a website with high-resolution images, close-ups of artworks (i.e., zoomed in), high contrast and simplification in an art gallery found "the images were the most appreciated element of the web pages" [23, p10]. When the participants carried an iPad around the gallery to access the same website, the participants could see the images and text on the iPad "much clearer" than the gallery walls. However, participants struggled to match the physical artwork with the correct piece on the website. This appreciation for the image enhancements suggests that the visual data is useful and highlights the need to delve further into image enhancements in museums [23].

Image enhancements have been shown to improve the visual qualities of other highly visual mediums and have the potential to enhance visual art for people who have low vision or are blind. Enhancements on real-time television broadcasts [58], face recognition [37–39] and printed pictures [39] have received positive feedback from people with low vision. However, existing literature on image processing techniques is limited by a low number of participants with lived experience, e.g. [47], if any, e.g. [39, 40, 45].

In particular, mixed reality Head Mounted Displays (HMDs) allow for hands-free, visual enhancements to be presented to people with low vision in real-time and could combat the physical demands of holding a mobile phone or tablet or the static nature of printed images. HMDs for low vision enhancement have been used in various scenarios, including reading [52], navigation [24], shopping [5], and more [25]. However, HMD studies for people with low vision are often limited by the low number of participants with lived experience, e.g. [25, 47], if any, e.g. [13, 48, 51]. Moreover, little is known about the potential use and effectiveness of these devices for visual arts, especially in museum and gallery settings.

3 METHODS

We conducted three focus groups in April 2022 and asked participants to share their past experiences in museums and art galleries. We wanted to uncover the visual problems they have encountered, how they have responded to these problems, and whether image enhancements on a HMD could help further.

We recruited 18 participants (12 female and six male) with a wide range of visual impairments (Table 1) in response to advertisements through three sight loss charities. In line with Purposive Sampling [16], we purposely selected people with some residual vision and experience viewing art in museums. The focus groups were initially intended to run in person but changed to Zoom [59] video calls due to the growing prevalence of a new strain of COVID-19 and the uncertainty of its effects. We chose Zoom due to its video calling facility as it is one of the more accessible video calling technologies for people with low vision [29] and had the facility to join by a conventional phone call if participants wished. Others have previously conducted remote focus groups via conference phone calls with people with low or no vision [1], and recent research suggests that there is no clear advantage for running focus groups in-person or online [27]. Split equally into three hour-long focus groups; fourteen participants joined us from South Wales, three from South East England and one from the Midlands.

As we conducted the focus groups online, we had no facility to test participants' eyesight and therefore relied on the information that they could provide to us from previous sight tests. Before starting the focus group, we asked participants for their visual acuity, diagnosis, age group, and sex. Most participants provided their visual acuity; however, six participants could not locate this data. This information is noted in Table 1.

Participants were provided with a Participant Information Sheet and Consent Form via email or post with an option for the forms to be read verbally over the phone and consent taken verbally before the focus groups took place. The University's Ethics Committee granted a favourable ethical opinion.

3.1 Focus Group Procedure

Each of the three hour-long focus groups were split equally into two parts. In the first part, we asked our participants to consider their past experiences when visiting museums and art galleries. Each participant took turns explaining the problems they faced with visual art, how they overcame them, and any valuable strategies the centres offered to enhance the accessibility. In the second part, we described what image enhancements and HMDs are. We explained that these devices are wearable headsets with lenses that cover the eyes, so any digital content could be superimposed on the lens. We also explained that the headsets have sensors such as cameras, speakers, eye and hand tracking, and speech detection.

In addition, we displayed a picture of the Microsoft Hololens 2 as an example HMD which has been used in previous low vision studies [24, 49, 50, 52]. We audibly described this visual aid for participants who could not clearly see it. We then clarified the explanations for any participants who had questions.

We asked participants to consider if this technology is worth exploring in museums and galleries and whether there is anything they think could be advantageous and disadvantageous in this setting. Participants actively added their thoughts to those of other participants when relevant points were raised.

3.2 Data Analysis

The focus groups were recorded using Zoom's built-in recording feature. The automatically generated transcripts were reviewed by listening to the recording, and any automatically generated errors were manually fixed. This correction process was iterated three times to ensure all errors were appropriately addressed. We followed a six-phase approach to Reflexive Thematic Analysis [6] and subsequent developments [7], which we explain below.

The audio recordings of the focus groups were transcribed as quickly as possible after the focus groups and imported into NVivo v1.6.1. All participants were anonymised, and a transcript per participant was exported. A mind map per participant was created from the transcripts for Phase 1, Data familiarisation. The first author revisited and coded the focus group transcripts over several iterations as new codes were generated throughout the process. Following a break, we revisited codes, and further iterations were made (Phase 2: Coding).

Table 1: Participant Data

Focus Group	ID	Sex	Age Group	Location	Visual Acuity	Diagnosis
Group 1	P01	F	25-34	South Wales	6/60	Severe myopia, cone dystrophy, nystagmus
Group 1	P02	F	45-54	South East England	Not provided	Classic RP
Group 1	P03	F	65-74	South Wales	Not provided	Autosomal Recessive Retinopathy
Group 1	P04	F	65-74	South Wales	6/120	Childhood toxoplasmosis caused scarring in the back of the eye. Myopia.
Group 1	P05	M	50-54	South Wales	2/60	Cone dystrophy
Group 1	P06	F	35-44	South Wales	Not provided	Lebers Amerosis
Group 2	P07	F	65-74	South Wales	3/60	Glaucoma
Group 2	P08	M	25-34	South East England	1/10	Retinopathy
Group 2	P09	M	25-34	South Wales	6/48	albinism
Group 2	P10	F	55-64	South Wales	Not provided	Glaucoma, detached retinas. Myopic degeneration
Group 2	P11	M	65-74	South Wales	Not provided	Macular degeneration
Group 2	P12	M	65-74	South Wales	6/96	Nystagmus
Group 3	P13	F	65-74	South Wales	6/60	Retinopathy
Group 3	P14	F	45-54	Midlands	1/60	Stargardts
Group 3	P15	F	75-84	South Wales	Not provided	Uveitis to secondary glaucoma. High myopia. Macular degeneration
Group 3	P16	M	55-64	South Wales	2/60	Keratoconus and secondary Glaucoma
Group 3	P17	F	45-54	South East England	6/60	Myopic macular degeneration and atrophy
Group 3	P18	F	55-64	South Wales	20/200	Oculocutaneous albinism type II (OCA2)

All codes were printed on plain paper, cut out and placed on a large table. The codes were then grouped to generate candidate themes (Phase 3: Generating initial themes). Several iterations took place of the grouping over several days and locations to prompt new insights and reflections (Phase 4: Developing and reviewing themes). Figure 1 shows an early iteration of the grouping of some of the codes and themes. Candidate themes were reviewed and debated amongst the authors, which prompted further changes and reorganisation. A synopsis was provided for each theme, and further discussions amongst the authors prompted further changes (Phase 5: Refining, defining and naming themes). Finally, we proceeded to report the analysis and present the themes. Writing prompted further reflections and iterations of the themes as the themes evolved during the writing process (Phase 6: Writing up).

4 FINDINGS

The final analysis results in four major themes: The need for Bigger, Bolder, and Brighter; Clarity is provided by non-visual senses; Challenges of following the rules; and Perceived value of the potential use of HMD technology to enhance the visual art, that will be presented in the following subsections.

4.1 The need for Bigger, Bolder, and Brighter

The most common visual challenges viewing visual art for our participants centred around the size or the distance of the art, the colour and contrast, and lighting. Participants expressed that fine details in visual art were hard to see, and getting close to the picture enlarged it in their field of view, or they took photos and zoomed in. However, there is a need to stand further away or reduce the size of the image to gain further context of the overall picture. Participants described how low contrast art also caused issues as colours blended, reducing the ability to distinguish between parts of the picture. Finally, lighting can be too bright or too dim, causing reflections which were hard to see or prevented good quality photographs or blurring the final result. Inconsistent lighting also meant that participants' eyes took time to adjust or struggled to adjust at all.

4.1.1 Distance and size define the details and context. Participants (P1-5, P8-9, P11-13, and P15-18) provided insights into how distance and size are crucial in shaping their perception of visual art and its associated text descriptions. In addition, participants (P1-5, P8, P11-13, and P15) expressed the inclination to approach the artwork closely, which enlarges the image within their field of view. This proximity enabled them to discern intricate details, such as the nuanced texture of brush strokes. Additionally, some participants (P9, P12, P17-18) resort to capturing photographs of the visual art on their smartphones and subsequently zooming in to fulfil their

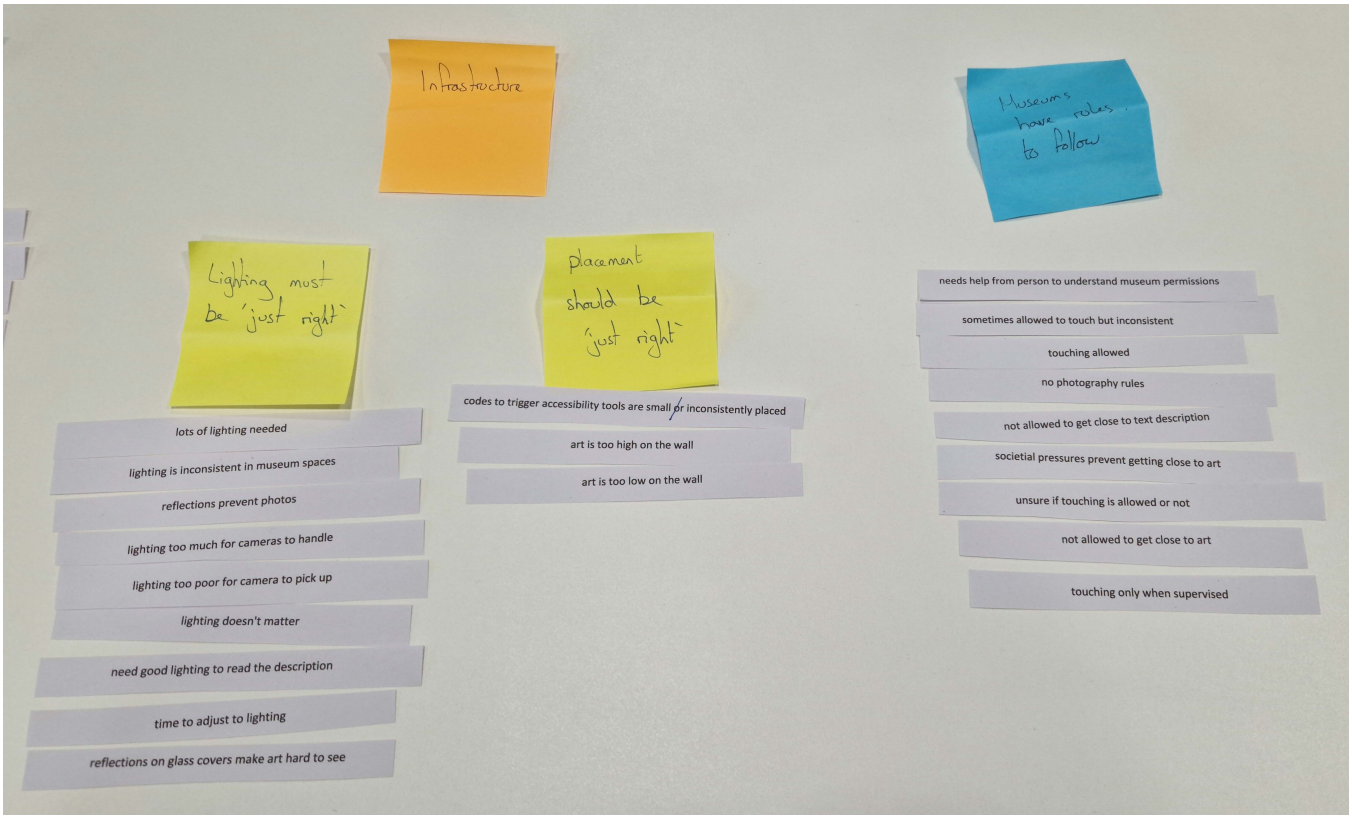

Figure 1: An early iteration showing some of the codes and theme groupings

desire for a bigger image. Another participant (P15) told us that they use a monocular telescope but it is time-consuming to find a suitable distance from the art and to adjust the device appropriately to see the art.

However, the desire for larger images via close proximity contradicts the need to maintain a certain distance to appreciate the broader perspective, especially when confronted with larger paintings (P2, P4, P11-12). Participants 2 and 12 noted instances where other visitors obstructed their view or posed problems navigating to a further distance. P12 also highlighted that it is hard to predict directional changes of moving children. These navigation and mobility issues impede their overall art-viewing experience:

> "*the bigger the picture, the further back I need to stand to actually understand what the whole thing is and then and* ***quite often you get people in the way***." (P2)

The placement of the art on the wall is also an important factor when considering the size (P3, 11, 13, 15, and 17), as the art can be either too high or too low for them to see. Ensuring an appropriate placement aligns with participants' tendencies to approach the artwork closely to enlarge it. This proximity allows them to discern subtle details, such as the texture of brush strokes, which are vital components of their art appreciation. A participant commented:

> "***I'd have to get so close****. So, you know,* ***I like to look at brush strokes and details like that****. I might have to be inches away. So* ***I'd only be able to see a little bit of the picture if it's higher****, maybe just a little bit at the bottom or something like that.*" (P11)

In addition, some participants (P4, P11-13, and P16) told us that the accompanying text descriptions were too small, and few of them (P4 and P11) told us that they needed to get close to make the text bigger. One participant stated:

> *"I can't see the writing underneath, and in fact it makes me envious when people are reading it, 'cause I wish I could see all that [. . .] I would like to know these things but just can't, because* ***you can't see the [small] print***." (P13)

While dealing with the challenges related to small text, participants adopted various strategies to enhance their access to visual art information. In particular, two participants (P12 and P18) noted the occasional availability of bigger, large print versions of text descriptions. On the other hand, one participant (P16) found the existing text size suitable to read, and another participant (P11) expressed reservations about the idea of permanent large print displays next to visual art, citing concerns about aesthetic appeal. Additionally, a participant (P12) shared a practice of extensively reading the museum website before visiting, serving as a proactive workaround for the limited availability of large print materials. In addition, smartphone apps played a significant role in compensating for the small print, with some participants (P8, P12, and P17-18)

utilising them for tasks such as scanning and reading text aloud or connecting with others for assistance.

> "*I use other apps on my phone [. . .] that will **capture the text and then read it back** for me, and there's another application called Be My Eyes and Aira. So with that, **a sighted person will be on the other end that will describe everything**. Either it's related to painting or if it's a text they have to read for me.*" (P8)

4.1.2 Colour and contrast are hard to see. Ten participants (P2, P4, P7, P8, P10, P11, P13, P15-17) highlighted that colour and contrast are hard to see for visual art. They state that colours blend, especially in older, darker paintings. Low-contrast art is hard to see and participants often cannot figure out where one colour ends and another begins. A participant commented:

> "***Older paintings that tend to be quite dark**, perhaps. Uhm, you know. [. . .] **it's just a mass of colours**.*" (P2)

4.1.3 Lighting must be 'just right'. Lighting was highlighted as an important part of museums' visual aspects by nine participants (P4, P8, P10-12, and P15-18), who raised lighting concerns. These participants stated that the lighting must be *'just right'* and varies between participants and from room to room, as it can be too bright or too dim. In addition, our participants report that it takes time for their eyes to adjust to changes in lighting. For example, P8 commented:

> "*If you're going from one section to another section, **the light is different and sometimes shining bright or sometimes too dull** or can't adjust. That's too difficult for me.*" (P8)

Reflections caused by lighting on protective covers can make visual art harder to see for some participants (P10, P11, P15, P17, and P18). One of these participants stated:

> "*Some of the pictures do have glass covers, and **the reflections on them do affect the way we see them**. [. . .] it does depend on what the work is and how it's being displayed.*" (P18)

Lighting is also important for participants' smartphone cameras to take good quality photos without reflections if there is a protective cover. P12 added that lighting can sometimes be specific to a piece of visual art and, therefore, can have an impact on the ability of a camera:

> *"I know some of the paintings have [. . .] **a lamp of some kind** and the rest of the places if it's dark or darker. Yeah, I'm not sure whether **that's messing up the camera** at all."* (P12)

4.2 Clarity is provided by non-visual senses

Our participants highlighted that they rely on their non-visual senses to help them understand visual art in museum settings. Our participants often need help from technology like audio headsets, or help from other people, such as a friend or family member. Commonly, visual art is audibly described or participants use tactile options, such as replicas. However, limited availability, ease using technology, or problems with visual descriptions restrict the art experience.

4.2.1 Reliance on Technology. All eighteen participants explained how non-visual aids help clarify any visual ambiguity when viewing visual art. On the one hand, some participants (P2, P3, P5, and P18) commented on how audio descriptions add clarity. For example, a participant explained *"You can physically see something, but **you can't tell what it is until you have an auditory association with it**"* (P18). On the other hand, another participant uses imagination to fill in the gaps in audio descriptions, explaining:

> "*You can use your imagination then, you know. I mean like anybody blind or partially sighted, **our imaginations are very good. We can visualize things and things like that**.*" (P4).

In addition, two participants (P11 and P17) explained that accessibility tools, like audio headsets or fixed computers enabling zoom facilities and guided tours, help them feel included in the exhibition. However, few participants (P10 and P17) told us that codes (e.g. numeric or QR codes) to trigger accessibility tools are small or inconsistently placed and other participants (P6 and P8) pointed out that accessibility tools are often complicated to use, as one participant elaborated stating that staff are not appropriately trained on how the accessibility tools work.

> "*... most of these things [are] not easy to use, it's not accessible. **They create these things, but it's very difficult to use them as a visually impaired [person]**. We don't know how to navigate, and even on the reception, **they don't really bother to explain in detail how you use these devices**, so I had so many different experiences. They just give you these devices and it's just useless because you don't know how to use them. And this is very important. I believe **if somebody is creating these things so this is very important to make it simple and easy**.*" (P8)

Furthermore, other participants (P7-9, P13, P18) said that accessibility tools are not always available, with a participant (P18), who has previously worked with museums to help with their accessibility strategies, advising that accessibility tools cost money for the museum, so there is limited availability. To work around the inconsistent availability, some participants (P11, P14, and P16-P18) bring their own smartphones and download the museum's app to guide them around the museum. One participant said:

> "*we should be linking in modern technology so **museums and art galleries having apps** that you can then plug in, which would then save this whole bit of having to provide headphones that **you could plug in your own headphones and talk your way around**.*" (P14).

Acknowledging that some people might not have access to smartphones, some participants (P13 and P18) suggested that museums should provide small tablets for those who do not have their own.

Apart from audio, four of our participants (P4-6, P17) explained that touching adds clarity and a participant (P6) said that they will only visit if they can touch. For example, a participant (P5) commented:

> "*[You can] get closer to some things and you can* ***appreciate the texture and the feel of them in the in the way that you can't visually****, but you might be able to do, you know, with touch.*" (P5)

4.2.2 Reliance on other people. Much of the clarity provided by non-visual senses comes from relying on others to identify and describe visual art and reading any text out loud. Participants (P1, P4-5, P7-9, P11-12, P14-18) explained the importance of other people when viewing visual art. While two participants (P5 and P15) rely on someone to identify art for them to look at, seven of our participants (P4, P7, P11-12, P15-16, P18) rely on someone else to describe the art to them. For example, a participant (P15) stated:

> "*I can't read the description under the paintings, it's quite small print.* ***[I need] somebody with me, asking them to describe that to me describe that to me****. [. . .] I have always visited gallery's or museums with a partner, or a you know a friend.*" (P15)

However, three participants (P1, P7, and P15) explained that fully sighted people are not the best at describing things and one of them (P7) pointed out that staff are available in some rooms but not others.

4.3 Challenges of following the rules

Twelve of our participants (P1, P3-7, P9, P12, P14, P16-18) highlighted that museums and galleries often have rules that limit their ability to implement accessibility strategies. For example, two participants (P9 and P17) explained that photography can be prohibited, and one of them commented:

> "*there will probably be a sign saying* ***photos are prohibited*** *and there's me taking them and then* ***I'll probably end up seeing the sign later on when it's too late****, when I've taken about 200 photos already*" (P17)

In addition, participants (P1, P2-5, P12, and P14) explained that they are not allowed to get close to art or text descriptions. While a participant (P1) feels self-conscious because of the "etiquette" of not getting close to art, two participants (P9 and P14) commented on the rude or poor attitude some staff have:

> "*there's also [something] about talking to room attendant [staff] and saying, for me personally,* ***I had some that were quite snotty about the fact that I actually wanted to stand closer*** *than they thought was appropriate I said, but I have no desire to touch it,* ***I just want to be able to actually see what you've got hung on the wall*** *here. And I recognize you can't have everybody there but* ***I'm standing here with a big, long white stick it kind of gives you an idea that I might not be able to see it from that distance****, from several feet away.*" (P14)

Although three participants (P3, P6, and P17) commented that touching is often allowed, one participant (P7) told us that the availability of tactile options is often limited. In particular, one participant (P3) was often unsure if touching is allowed or not in museums, explaining:

> "***I'm never sure what [. . .] pieces we're allowed to touch*** *because I want to touch things but not sure what we're allowed to touch sometimes because with art and pictures I can't see them*" (P3)

4.4 Perceived value of the potential use of HMD technology to enhance the visual art

In the second part of the focus groups, we explained what a HMD is and briefly how image enhancements works on them. We then asked our participants to share their thoughts on how HMDs could visually manipulate visual art or the environment to aid their viewing experience and address the above mentioned challenges. Our participants shared their suggestions and perceptions for visual enhancements, concerns about comfort, and the potential complexity that technology could bring.

4.4.1 Improving visual aspects. Participants described how HMDs might help improve the visual aspects of art by enhancing colour and contrast and digitally magnifying but without changing the art too much. The most commonly suggested option is the ability to increase the size by magnifying the art to see details. This suggestion was made by nine participants (P1-5, P9, P11, P13, and P17). For example, a participant commented:

> "*I would agree that what* ***one of the nicest things would be to be able to just get something much, much bigger*** *in your visual field [than] what you've got, so you've got much more of a chance of kind of appreciating what's in front of you.*" (P5)

In addition, other participants (P2-4, P8, P13, P15, and P17) suggested improving the colours and contrast of art or swapping one colour for another.

In particular, two participants (P1 and P2) told us that they wanted to see the visual art as close to how a fully sighted person would be able to do, and some participants (P2, P4-5, P9, P15) also pointed out that they would not want to change the art too much.

> "*[W]e went to the Escher at the Dulwich Gallery 8 years ago. [. . .] I mean,* ***you'd be changing what Escher did if you try to even enhance his staircases*** *and the like. [. . .] Is this me being a purist, the daughter of an artist, I'm not sure. But here I mean one of the most wonderful exhibitions I went to at the Royal Gallery again, not long before [a COVID-19] Lock Down, was with Monet. Now, yeah,* ***I wouldn't want you to change anything [that] Monet did****.*" (P15)

In addition, some participants (P4, P6, P11, P17-18) perceived the benefits of combining audio descriptions with any visual enhancements that can provide them with multimodal support. Audio can be essential to identify which areas of the art to look at and add some context. For example, a participant stated:

> "*they link together because* ***through audio if you know to look for*** *something like, for instance, that painting of Monet. Okay, there's one in the museum [where] there's a bit of a sunset and the colours.* ***Now it's only because I know they're there, I can sort of can visualize it*** *and focusing but by being told. If someone doesn't know that, say they had these glasses on and they knew they had to look for something in that*

> *painting,* ***they could then use the goggles to look in to it. If you don't know what you're looking for, if you don't know it's there to look for***" (P18)

Another participant (P6) highlighted the need for audio that has more natural-sounding voices:

> "*And if it could be* ***a proper person talking rather than like a by screen reader*** *that you know. I know that's really difficult to do, but if it kind of had some intonation in its voice and think let's say [in a robotic voice] "you are looking at a painting. It is black." You know that would be really good, right?*" (P6)

4.4.2 Physical and emotional comfort. Participants also highlighted the potential of technology, like HMDs, to provide both physical and emotional comfort as for example, HMDs could promote independence (P1, P15, P17). One participant commented:

> ***"if I was on my own and still wanted to go to galleries. Yeah, I'd be back to you like a shot****. [. . .] That could be very different.* ***What you're doing could be, you know, a life changer****."* (P15)

In contrast to the perceived independence that could be gained from HMDs, four participants (P1, P5, P10, P11) said that they are worried about the look of a HMD, with P11 saying that they would feel self-conscious about highlighted disability:

> "***[T]hey do look very much a visual aid device, and I'm a bit self-conscious about that****. [. . .] I don't ever use a signal stick, a white stick. Well, it's addictive, and I think lots of other people [are] like that.* ***They want to sort of try and pretend they're, you know, fully sighted and just do things as normally as possible***." (P11)

A participant (P5) also suggested that any HMD should not prevent interactions with other people:

> "*I don't know if this is possible, but 'cause sometimes* ***these sensory adaptations are great, but then they block out whoever you're with****, 'cause you are either in the goggles environment or you're not.*" (P5)

In addition, P9 explained that a visit to a museum could take several hours, so any HMD must be physically comfortable.

Furthermore, a participant (P10) is concerned about possible disorientation from such devices, and two participants (P2 and P5) expressed the desire to stop or pause the visual information, for example:

> "***My eyes can get a bit overwhelmed if there's too much information*** *so it would be nice to be able to put it down and go "Yeah, no, that's not helping, that's just giving me too much" and lift it up. Or those times when it is helpful and then you can go, "yeah, that's great.""* (P2)

4.4.3 Accessibility tools must be quick and easy to use. Our participants explained that accessibility tools must be quick and easy to use. Technology requires training and time (P4, P7, P10-11, P15) as one participant (P11) told us that it must be easy to use:

> "*[P]eople would probably like to go to museums, but* ***they might be that much older and be a bit wary of technology****. But I think that the vast majority of [older] people have got visual impairments, so if you just keep that in mind as well.*" (P11)

Two participants (P10, P18) suggested a QR code placed next to visual art to trigger relevant enhancement, but three participants (P5-6 and P9) suggested that devices should be triggered automatically.

4.4.4 Customisation allows for individual differences. Four participants (P4, P7, P15, P17) highlighted the importance of customising visual aids to each person's visual differences. For example, one participant said:

> "*[Y]ou're up against the fact that each of us will have our own idiosyncratic ways of seeing things. So, you know, that's just going to be something that I'm sure [. . .] you've taken [that] on board already. [. . .]* ***Some things that will help one person may not be of absolutely no use to another***." (P15)

A participant (P3) told us that one magnification strength may be too strong, and some participants (P3-4, P11, P15, and P17) stated that they would want the ability to customise the strength of any magnification. In addition, three participants (P3, P6, P11) wanted to customise audio descriptions based on interests, and other three participants (P2, P4, and P11) told us they would want to remove a HMD at times.

5 DISCUSSION

Our findings contribute to the limited research on visual accessibility in museums and art galleries, especially for people with visual impairments e.g. [23, 31]. We compare our findings with existing literature in the following subsections: Beyond Enlarging the Art or Text Descriptions: The Need to Make Museum Spaces More Accessible; Improving Art and Visual Perception: Dealing with or Balancing Visual Ambiguities in Art; and Improving Visual Features and Accessibility and the Potential of HMDs. We then propose some design considerations for future work on this topic. Finally, we discuss the study's limitations and suggest future work.

5.1 Beyond Enlarging the Art or Text Descriptions: The Need to Make Museum Spaces More Accessible

Our participants' most favoured visual strategy involved enlarging the art or accompanying text. However, they highlighted instances where restrictions prevented them from getting close to the artwork, with some being asked to maintain a distance. These challenges align with findings from previous studies [21, 22, 30]. Interestingly, our participants expanded on these observations, noting that even when allowed proximity, they faced the dilemma of needing to step back for a holistic view. This back-and-forth motion not only diverted their attention from the art but also introduced difficulties with navigation and mobility. Navigation inside museums is problematic for people with low vision, with reports of problems reading signs or concerns about walking into exhibits [26]. Our findings contribute to this work by outlining that other people moving about in museums, especially children, present navigation

challenges and distractions from appreciating the artwork from a distance.

Our participants also explained the size of visual art and the accompanying text descriptions are problematic for them. The placement on the wall causes issues because it is too high or too low, which increases the distance and provides a physical barrier for getting close. In addition, our participants advised us of issues seeing the small text descriptions often accompanying visual art. Existing literature focuses on non-visual accessibility strategies in museum spaces, e.g. [8, 10, 31, 33]. As such, there has been limited exploration of how the enlargement of art and its accompanying descriptions can benefit our target demographic. Our participants explained that large print descriptions are helpful but infrequently available, and larger text would ruin the aesthetics of the text and art. Additionally, some participants said they use the smartphone camera to take photos then zoom in to provide digital magnification of the art and accompanying descriptions, but this strategy is not always practical as photos are often prohibited and, in some cases, the photography policy is unclear. Others have suggested finger-worn cameras for magnifying text [52], but our participants stated that they often cannot get close enough to the wall to be able to touch the written descriptions. Beyond attempting to move closer or utilising photos as digital magnifiers, our participants also leverage smartphones for text-to-speech functionalities or connect remotely to receive real-time verbal descriptions of the art or to have accompanying text read aloud. Similar findings were reported by [31].

The other problem our participants told us they have experienced with smartphone photography is the lighting conditions, which cause poor quality photographs or reflections. While magnification serves as a prevalent low-vision strategy, opinions differ on whether museums should furnish magnifying equipment [33] or if people with low vision should rely on their personal magnification devices [12]. Our focus groups delve deeper than this research by reflecting on the potential utilisation of mobile devices as magnifiers in art settings.

Our participants also reported issues with lighting that changed from room to room in museums, causing their eyes to take time to adjust. Similar findings report that this causes temporary blindness [26].

These challenges highlight that museums still need further work to make their spaces more accessible. Items like magnifiers might not help as the art may be unreachable, and the magnifiers do not fix the issues we outlined with lighting. Special access programmes like dedicated days where lighting is consistent, or tours could be considered but these programmes limit the ability to be spontaneous and do not always appeal to people with low vision [28]. Museums could place their art in more accessible places, but it is unlikely that museums would remove protective covers or physical barriers or adjust their lighting due to the need to preserve their collections. These measures do not eliminate the need to move back and forth. Therefore, alternate accessibility strategies need to be considered.

5.2 Improving Art and Visual Perception: Dealing with or Balancing Visual Ambiguities in Art

Another visual challenge highlighted by our participants is the limited perception of colours and contrast in visual art. Our participants elaborated further than previous findings of appreciation for vivid colours and struggles with subtle colours [21] with a discussion of how older paintings darken over time, which causes the colours to blend, thus making the details more challenging to see. In agreement with a previous report [21], our participants want to see textures, including brushstrokes but find their vision limits their ability to do so. Low vision participants of a navigation study found that the OpenCV Edge and Comic overlays enhanced the contrast and allowed them to see brushstrokes on a picture on the wall, but no further exploration of these methods for art was explored [24].

To address visual ambiguity in art, audio, either through descriptive devices or assistance from another person, is a commonly adopted strategy [21, 31]. Our participants emphasised that audio aids clarify their understanding of the artwork, allowing them to use their imagination to fill gaps in visual information. Building a mental image of art is a shared experience described by others, particularly for individuals who lose sight after birth [14, 31]. However, our participants raised concerns about the use of headsets, which, while enhancing personal engagement, may isolate them from the community aspects emphasised by others [21, 23] within this demographic. Additionally, headsets can obstruct people with low vision from hearing nearby conversations and the sounds of footsteps, which is critical for full immersion [21]. Furthermore, prerecorded audio descriptions limit the ability of people with low vision to seek clarifications or ask questions. Regarding audio devices, our participants highlighted small and inconsistently placed codes (e.g. QR codes), contributing to cognitive load. Participants preferred natural-sounding voices over computer-generated ones, often used in prerecorded audio [3].

Echoing the sentiments of others [12], our participants highlighted the usefulness and inclusive nature of guided tours. However, they noted a drawback – sighted guides often struggle to provide accurate descriptions of visual art, aligning with findings by a recent study covering audio and tactile art viewing [31]. The benefits of having a sighted guide to seek clarifications are at odds with the desire to go around at least part of the museum independently, expressed by our participants. Additionally, guided tours remove the ability to choose what to look at, the order, and for how long [23].

Our research reaffirms the complexity of accessibility tools in museum settings, often compounded by insufficient staff training. Similar findings report that each art gallery (or museum) can have a different accessibility aid [31], which means people with low vision must learn a new system for each place they visit.

Tactile art emerged as another valuable strategy for enhancing clarity, a sentiment widely shared by our enthusiastic participants. The benefits of tactile versions of visual art and its lack of availability in museums are widely reported [10, 20, 21, 23, 28, 33]. Our participants were particularly enthusiastic about tactile opportunities. Touching presents a chance to get physically close to an item, providing a better opportunity to see the details [10]. This

proximity may be a key reason why people with low vision like tactile options. Previous reports indicate that individuals who once had good vision could translate tactile interpretations into visual mental images [46]. However, the simplified and radically different nature of tactile versions compared to the original artwork [10], and introduces the potential for a loss of quality or misinterpretation. Additionally, touch tours generate little interest [10]. Previous work provides guidance to avoid misrepresenting the art when making an accessible translation and ideally involving the artist in any translation [11, 23]. Involving the artist in creating accessible versions can help avoid subjective information, but this is not possible for artworks where the artist is deceased. In addition, there is no agreement on whether any subjective information should be provided [23]. Even if the translation is as accurate as possible, art is subjective, and everyone viewing it will understand it differently [14], so there will always be a degree of interpretation. This complexity underscores the occasional need for a narrative to supplement the tactile experience [56] and the need to control how much the art is changed.

People with low vision engage in interpreting the two primary non-visual accessibility strategies: converting information to an accessible format and constructing a visual image. This process, akin to a game of telephone where the original detail is lost in translation, prompts reflection on whether to persist with these methods or explore strategies directly enhancing the visual qualities of art.

5.3 Improving Visual Features and Accessibility and the Potential of HMDs

Our investigation sheds light on the perceived advantages and drawbacks of visual enhancements within museum contexts. Participants voiced apprehensions that using a HMD might inadvertently draw attention to their disability, echoing concerns regarding the aesthetics of such devices [24, 47]. Our participants also acknowledged the potential for disorientation, a common issue associated with HMDs. To address these concerns, participants suggested the need for features allowing them to halt or pause visual information, particularly when navigating between artworks.

5.4 Design Considerations

Following the challenges we identified through our study, and those of others, we propose design considerations for visual arts. Here, we outline the importance of visual aspects such as colours and contrast, and magnification. We highlight the need for customisation to balance artist integrity with accessibility needs and to maximise the enhancements across the large range of sight conditions. Automatically detecting art can remove the need for QR codes or similar trigger mechanisms, reducing the learning curve for its users. Audio descriptions serve as a prompt for visual details and should be included in new devices, but following audio description best practices. Allowing all visitors access reduces any extra attention to individual's disabilities and could benefit others. Finally, we present ways to reduce disorientation if wearing a HMD.

Provide magnification. Magnification enables people with low vision to see detail in visual art and helps them read the accompanying printed text. Using a magnification device that does not require a close physical proximity to the art avoids the need to keep getting close then returning back to a distance, which we previously describe. However, the magnification needs to be easy to configure and align with the desired art or text. Consideration should also be made to avoid physical challenges of aligning hand-held devices with wall-placed items [19].

Enhance colour and contrast. Our participants outlined how colour and contrast are hard to see, especially with older paintings. Contrast enhancements increase the ability for people with low vision to see detail and textures (i.e. brushstrokes) [24]. Additionally, colour improvements can help differentiate between parts of the image.

Customise enhancements. Our participants wanted to see the art as close to how others do and not to change the art too much. Despite efforts for accuracy, interpretations of art remain subjective, leading to varied understandings among viewers [23]. We recommend allowing users to tailor the strength of any enhancements, controlling the degree of manipulation while respecting the artist's intent and allowing the device to work around different sight conditions and stages of sight loss. Additionally, giving the user a facility to limit, pause or stop visual data could help minimise visual overload, which was requested by our participants.

Automatically detect art. Our participants highlighted issues with the size and inconsistent placement of visual art, often within the same museum. Digital accessibility tools commonly rely on physical triggers like numerical codes or QR codes and can increase cognitive load on the visitor. Detecting the art automatically could help reduce the cognitive load, and increase usability of accessibility aids. We recommend using computer vision methods to detect the art, e.g. a camera mounted to an audio headset, where artworks are automatically detected [55].

Provide audio descriptions. Our participants told us they appreciate text descriptions being read to them as they help identify what to look for in visual art. We recommend providing a text-to-speech option to automatically read text descriptions, reducing the need for a sighted guide. However, efforts must be made to use natural-sounding voices. In addition, when using audio to describe visual art, it should follow best practice guidelines for people with low vision, e.g. Art Beyond Sight's Guidelines for Verbal Description [4].

Cater to all visitors. Our participants raised concerns that use of HMDs would highlight their disability to others. Universal Design in art settings is called for by others, e.g. [17, 43] and could help unintended audiences, enhancing the experiences in museums for everyone [23, 30]. Allowing all visitors to use enhancement tools would help avoid this problem, and allow others to benefit from any enhancements the technology could provide.

Use optical see-through HMDs. Our participants raised concerns over potential disorientation from wearing a HMD. Disorientation is widely reported for all users of these devices. If HMDs are used to improve visual accessibility, we recommend using optical see-through HMDs (instead of video

pass-through) for people with low vision, in agreement with [5].

5.5 Limitations and Future Work

Our study has the following limitations. First, it was hoped that an option to join our focus groups via phone call would address potential participants' technological concerns about using online video calling. However, there is a need to improve the accessibility of video conferencing tools further [29], and potential participants might not have realised the relative ease of connecting to Zoom via a phone call if they have not used this method before. Therefore, using Zoom may have prevented some potential participants from joining, leaving the more technically experienced to join us. Future research should clearly label multiple modalities to join online video calling studies.

Second, as we conducted our focus groups remotely, there was no facility to test participants' eyesight. Instead, we relied on participants to provide information about their eyesight. As such, some participants could not provide their visual acuity, and we could not verify the information they provided about their sight conditions.

Third, as is common for accessibility research [32], we recruited participants through sight loss charities to maximise our advertisement reach. However, some people with low vision may not be registered with sight loss charities. While we were able to recruit significantly more participants than some previous studies to identify what this community wants from HMD-based low vision aids, e.g. [47], future research could advertise through visual health services as well as support groups or charities. In addition, as Purposive Sampling is designed to concentrate on particular characteristics [16], it allowed us to find participants who have both experience in museums and some residual vision. However, this method presented participants who are collectively not representative of the UK sight loss population. In a topic as subjective as art experiences, we encourage others to explore new insights to add to ours and that of others to ensure a more diverse collection of research.

Fourth, due to the online nature of the study, there was no example HMD to demonstrate to participants, which may have limited the participants' understanding of the potential of this technology. Instead, we described HMDs and image enhancements alongside a visual aid. Through our study, we realise that audio descriptions of visual images can be limited, and therefore, suggest that future video calling research for people with low vision considers sending visual aids to participants in advance. Consideration should be made as to whether the printed medium is enhanced using the methods we discuss in this paper.

Finally, some participants had not visited a museum since the pandemic started, so their memory was not fresh. This was unavoidable and allowed participants to reflect on all their prior museum experiences rather than be biased from visiting a specific museum at the time of the study.

To address the limitations we describe above, and to further add to the research in this under-explored topic, we intend to conduct follow-up studies in-person to explore the visual needs of people with low vision in art settings, and to allow people with low vision to try image enhancements on a HMD.

6 CONCLUSION

This paper describes the findings of three focus groups involving 18 low vision art patrons. The focus groups explored the lived experience of participants' visits to museums and art galleries, specifically on the visual challenges and accessibility strategies to overcome these challenges. We also explored whether participants think visual enhancements on HMDs could help deal with the visual issues they reported. The aim was to contribute to the small volume of existing research of this topic. Four overarching themes were discovered 1- The need for Bigger, Bolder, and Brighter; 2- Clarity is provided by non-visual senses; 3- Challenges of following the rules; and 4- Perceived value of the potential use of HMD technology to enhance the visual art. We argue that visual enhancements on HMD technology could benefit people with low vision whilst viewing visual art and advocate for the further exploration of such technology for this purpose. Our participants desired to prolong their museum visits if the environment were more visually accessible. They highlighted the potential transformative impact of image enhancements in enhancing the visual aspects of art. Describing it as a possible "life changer", participants see image enhancements as a promising avenue for improving the museum experience.

ACKNOWLEDGMENTS

We thank our research participants for their time and insights which helped us develop this work. With thanks to Amgueddfa Cymru – National Museum Wales for their support throughout the study. We would also like to thank Sight Life Wales, Sight Cymru and Royal National Institute of Blind People (RNIB) for their help recruiting participants.

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