Making Sense of Art: Access for Gallery Visitors with Vision Impairments

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ABSTRACT

While there is widespread recognition of the need to provide people with vision impairments (PVI) equitable access to cultural institutions such as art galleries, this is not easy. We present the results of a collaboration with a regional art gallery who wished to open their collection to PVIs in the local community. We describe a novel model that provides three different ways of accessing the gallery, depending upon visual acuity and mobility: virtual tours, self-guided tours and guided tours. As far as possible the model supports autonomous exploration by PVIs. It was informed by a value sensitive design exploration of the values and value conflicts of the primary stakeholders. We report a preliminary evaluation and examine the role IT technologies play in supporting the model and underlying stakeholder values.

CCS CONCEPTS

• **Human-centered computing → Empirical studies in accessibility**; Accessibility technologies.

KEYWORDS

3D printing; Accessibility; Art; Blindness; Value Sensitive Design; Vision Impairment.

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1 INTRODUCTION

In the last three decades there has been increasing recognition of the importance of providing equitable access to cultural institutions such as art galleries to everyone in the community, including people with disabilities [20]. In 2006 the UN formally recognised the right of people with disabilities to take part in cultural life and enjoy access to cultural materials in accessible formats [38, Article 30]. One group that has long been excluded from galleries are people who are blind or with severe vision impairments. Fortunately, there is now recognition that people with vision impairments (PVIs) can and do enjoy visiting galleries when provided with adequate access. Nonetheless, providing PVIs with access to gallery collections is difficult. It involves issues ranging from effective ways to provide an accessible representation of an artwork to questions such as whether blind people should be able to touch works even if this has the potential to slightly harm them and determining the role (if any) of the artists in translating their work to different modalities.

Questions of human values such as fairness, artistic integrity, and ownership lie at the core of many of these issues. We therefore turned to value sensitive design [24, 25] to guide our work. Over the last 18 months we have collaborated with Bendigo Art Gallery (BAG), a regional Australian art gallery that has built a strong national reputation through its permanent collection and popular exhibitions of loan items from major international institutions. As a result, BAG is central to the local community and economy. We describe a values-based model developed with PVIs, gallery staff and artists

to provide PVIs with access to BAG, as well as the studies informing its design. Our main contributions are:

(1) The first comprehensive exploration of stakeholder values and value conflicts in this field. We used value sensitive design to explore these fundamental questions in our main study, a workshop with representatives of the major stakeholders, including PVIs, gallery staff, artists and local community members (Section 4).

(2) A novel model for providing access to galleries by PVIs that draws on key stakeholder values. For example, autonomy was identified as a core value by many PVIs, which we seek to support by facilitating independent exploration. Reflecting the wide variance in visual acuity and mobility among PVIs, the model provides three complementary ways of accessing the gallery: virtual tours, self-guided tours and guided tours. We discuss how IT can be used to support the model and the role of new technologies such as digital fabrication and scanning or augmented reality (Section 5).

(3) In collaboration with BAG, we have implemented pilot versions of the model's main components and conducted a trial with seven blind and low-vision visitors to the gallery. User-evaluation was extremely positive, and BAG is now planning to deploy the model more widely (Section 6).

An additional contribution was a formative study comparing 3D printed models, laser cut stepped reliefs and raised line drawings (often called tactile graphics) for the presentation of sculptures and paintings. This informed the main study and pilot evaluation of the model.

Our main study demonstrates that accessible access to artworks is a value-laden domain. Existing accessibility guidelines focus on only one aspect: how to present artworks for PVIs. The significance and novelty of our research is that it provides a values-driven framework for positioning guidelines and research that takes account of the full breadth of stakeholders, in particular the artists, and makes explicit underlying stakeholder values, such as independence and artistic integrity, and the tensions/tradeoffs between these. Our research is of significance to the HCI community because it provides a values-based framework and model for accessibility in cultural institutions. While there has been significant prior work in the area (see e.g. [45]), it has primarily focused on the technology. By clarifying stakeholder values and conflicts, our research helps ground future research into the use of IT technologies for such access.

2 RELATED WORK

Inclusiveness of galleries and museums

Throughout the world, art galleries and other cultural institutions such as museums are investigating and trialling ways of making their collections more accessible to PVIs. For instance, in the UK the British Museum has provided tactile exhibitions and tours since 1983, while in the USA, Art Beyond Sight (ABS) has partnered with cultural institutions such as the Metropolitan Museum of Art since 1987 to make art and visual culture accessible to PVIs.

One issue this has raised is the role of touch. Art galleries typically do not allow visitors to touch their exhibits, both to preserve them and also to reflect the primacy of vision [14]. Yet touch is one of the main ways that PVIs experience the world. As Candlin [13] notes, "Handling is one area where the right of the individual to learn from and enjoy public collections is in tension with the duty of the museum [or gallery] to care for its objects in perpetuity." The importance of touch is not limited to those with a vision impairment: evidence from museums is that hands-on access provides a more engaging and memorable experience for most visitors [35]. This conflict between accessibility and conservation is instructive as it suggests that providing accessibility may involve conflicts among different stakeholder values. Yet to date, there has been no systematic attempt to identify stakeholder values and value conflicts.

Accessible artworks

One way to resolve the conflict between access and conservation is to create replicas of 3-dimensional artworks for touching by the general public. Museums have long used this process, casting or sculpting highly accurate models, often using similar materials [7]. However, manual replication can be prohibitively expensive for all but a few artifacts.

For this reason, cultural institutions are very interested in the use of digital scanning and digital fabrication methods such as 3D printing, e.g. [37, 47, 48], sometimes augmented with touch controlled audio description [1]. 3D printing can dramatically reduce the cost of manufacturing, though with some loss of verisimilitude. While such replicas are of considerable benefit to blind visitors, they also provide a more engaging, multimodal experience for all visitors: in a recent survey of sighted museum visitors [52], most agreed that being able to handle 3D printed replicas would enhance their experience. 3D prints have also been used to present tactile pictures to children with vision impairment [49].

The most common method for providing access to cultural collections is audio description, usually by a trained guide. ABS have produced guidelines for audio description of artworks [5]. There has also been research into sonification of images, e.g. [17, 36, 39, 55]. While sonification can be successful for line graphs and similar information graphics [10, 18], understanding sonification of more complex graphics or the environment requires considerable training [17, 40] and it can only convey very basic information [55]. Rector *et al.* [41] prototyped and evaluated an audio interface for blind and low-vision gallery visitors that gives differing audio feedback based on distance from the artwork: audio description, sound

effects, sonification and music. We will use audio description alongside other formats and explore stakeholder suggestions regarding further audio options.

A number of more specialised tactile presentation methods are also used. Accessibility guidelines recommend the use of raised line drawings (tactile graphics) for graphics in which spatial relationships are important [9] and for artworks [6]. ABS has released a multisensory art history book series [4] utilising tactile graphics and research supports the claim that tactile graphics aid in understanding artworks [29]. Refreshable tactile displays have also been used for drawings [8].

Hand sculpted bas-reliefs are also used [51], though much less commonly than tactile graphics due to the high cost of production. A number of researchers have looked at digital production methods [26, 43, 44, 51]. Automated image processing techniques are used to identify different regions in the painting along with their relative height, and then a bas-relief is digitally fabricated using CDC routing or other techniques. Alternatively, flat layered bas-relief diagrams, in which the relief is made up of distinct layers, can be fabricated using laser cutters [43, 51]. A related example of automated production is given in [16], using image processing to create a tactile graphic with braille key and legend.

We are aware of only one study comparing tactile presentation mediums for artworks. This compared tactile outline, textured tactile, flat-layered bas-relief and (smooth) bas-relief representations of two still life paintings [51]. The smooth bas-relief was preferred followed by the flat-layered bas-relief because it was easier to perceive shapes. Our formative study extends this by considering a wider variety of artworks.

Case studies

There are several case studies aimed at professionals in the sector that describe how particular institutions have made part of their collection accessible to PVIs, e.g. [20, 21, 28] while Kleege [33] presents a personal reflection on art, vision impairment and cultural access. A number of surveys of visitors with visual impairments to cultural institutions investigate barriers to access [2, 3, 12, 27, 42]. These identify reasons for visiting a museum or gallery, diversity of knowledge, need for multimodal presentation (audio guides and tactile), targeted tours, accessible websites, better lighting, large print and braille labels, the need for staff training, and difficulty in navigation within the institution. Our model and evaluation add to this body of knowledge by helping clarify stakeholder values and conflicts as well as the role IT technologies can play.

3 FORMATIVE STUDY: ACCESSIBLE PRESENTATION

As a first step in providing access to BAG's collection we conducted a formative study investigating digital design and fabrication techniques for provision of accessible artworks. This examined a broader range of artworks than [51].

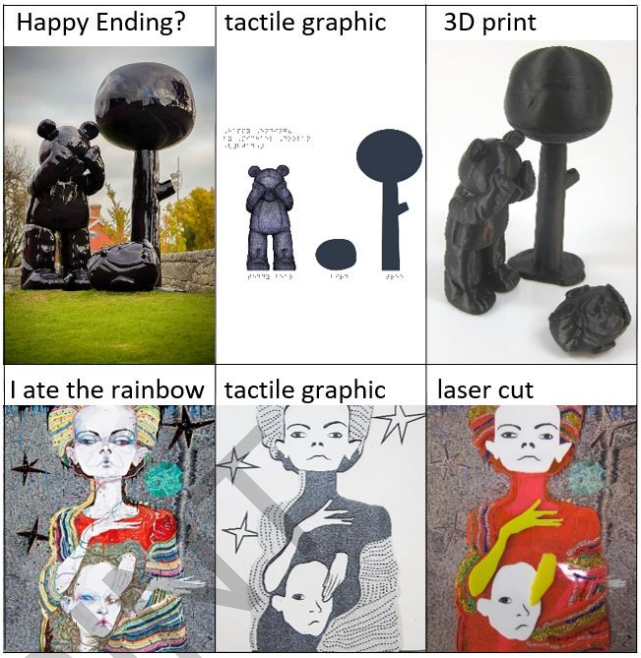

Figure 1: Two of the original artworks and accessible formats produced for the formative study and also presented in the main study: *Happy Ending?* (2014) ©Michael Doolan and *i ate the rainbow up... ... ...* (2008) ©Del Kathryn Barton. Collection Bendigo Art Gallery. Images courtesy the artists.

Materials

Accessible materials were created for five artworks selected for their importance in the gallery collection and their diversity in medium and style. The artworks were: *Circe* (c1920) by Bertram Mackennal, a bronze statuette of a woman; *Conjurer III* (2012) by Benjamin Armstrong, a tall wood sculpture of an imagined creature; *Happy Ending?* (2014) by Michael Doolan, an outdoor fiberglass sculpture of a cartoon-like tree, teddy and bird; *i ate the rainbow up... ... ...* (2008) by Del Kathryn Barton, a modern painting of two women; and *The Young Family* (2003) by Patricia Piccinini, a lifelike latex sculpture of a hybrid human/pig mother and babies.

Various techniques were used, with design decisions made to optimise the usability of each format. Laser cut graphics were constructed from 3mm acrylic sheets in contrasting colours for two of the artworks. *I ate the rainbow up... ... ...* used separate layers of acrylic for the background, body, faces and hands, with etching for details on the faces and background. High profile glitter glue was applied to represent the rainbow. *Circe* proved extremely difficult to 3D scan due

its dark reflective surface, and was instead represented using a single layer of acrylic for the figure's side profile, mounted on cardboard for a textural contrast.

3D printing was trialled for the three sculptures. The artist provided the 3D files for *Happy Ending?*. *The Young Family* was 3D scanned. The whole sculpture was 3D printed in one piece and details were also printed separately of the mother's face and one of the babies. As it is simple in form, *Conjurer III* was able to be quickly computer modelled. All printing was via FDM using PLA except for *The Young Family*, which was SLA printed using photopolymer resin to better represent the high level of detail in the model.

As a point of comparison, tactile graphics were created using microcapsule paper, as this is the most common method used for tactile graphics in Australia and provides high contrast for use with low vision. A4 size clear colour prints of the artworks were also provided.

Procedure

Materials were presented to PVIs attending a regular Day Centre Program at Vision Australia Bendigo. A total of 39 PVIs consented to answer questions as part of the study: 21 men and 16 women. They were aged from 42 to 99, with an average age of 78 years. Ten participants were legally blind and the remainder had low vision. Only three had congenital vision impairment, with the remainder having acquired vision loss, usually later in life.

Two or three artworks were presented at each session. Volunteer guides from BAG gave a verbal description of the artwork to the whole group, then tactile and visual representations of the artworks were shown individually to the participants.

Results

When provided, the laser cut and 3D print were the most popular formats, with more than half of the participants preferring them over all other formats. Some participants commented that they preferred the laser cut format because they were using touch in combination with their residual vision. The laser cut was the clearest format to see with simplified forms and high contrasts. In the case of *Circe*, some participants also commented that they preferred the laser cut because it was the smoothest, giving the best impression of the sculpture's hard texture and fluid curves—it was "pleasing to touch" and "more feminine". Nonetheless, the tactile graphic or clear print were preferred by some others. Preference was dictated by the type and degree of vision impairment. Further, some participants liked the option of having multiple complementary formats.

4 MAIN STUDY: VALUES IDENTIFICATION & INITIAL MODEL DESIGN

When preparing materials for the formative study, it became clear that stakeholders had differing values. Although not required for copyright purposes, the gallery had been careful to obtain permission from living creators of the artworks before translating them into other media. One artist refused permission and so this artwork was not used. To investigate this and other value conflicts, we conducted a four-hour workshop with major stakeholders. It had two parts. The first was to identify stakeholder values and value conflicts using value sensitive design. In the second part, we explored ways in which BAG could provide access to PVIs in accord with these values.

Participants

Initial planning identified the following major stakeholder groups in the provision of accessible art: (a) vision impaired visitors to the gallery; (b) the gallery and its staff who would need to implement accessibility measures; and (c) artists whose works were being made accessible. Invitations to a workshop were extended to people who represented at least one stakeholder group, recruited through researcher and gallery networks. Participant profiles are shown in Table 1. Two of the five PVIs had acquired vision loss (both low vision). Ages ranged from 20 to 85 years of age.

Table 1: Workshop participant profiles

	participant id											
category	1	2	3	4	5	6	7	8	9	10	11	12
resident	*			*	*		*	*	*	*	*	*
artist	*	*	*			*		*		*	*	
educator		*	*		*							
BAG staff/vol	*			*	*				*			
low vision						*			*	*		
blind							*				*	

Procedure

Prior to the workshop, participants completed a 10-minute semi-structured interview to gather their initial thoughts on the values associated with accessible art. Their ideas were then presented as part of the workshop to help ensure that a full range of diverse viewpoints were raised.

The workshop was held in the gallery space at BAG. It began with an explanation of the project so far, with exposure to the accessible versions created for *I ate the rainbow up... ... ...* and *Happy Ending?* and touch access to the latter in the gallery gardens (See Figure 1).

A discussion was then facilitated on the topic of stakeholders and values, prompted by the summary of points raised in the pre-workshop interviews. We asked: Who are the people interested in accessibility? What are their reasons? Are there

any tensions between the interests of the different stakeholders? Should the artists be involved in the process of making an artwork accessible and, if so, what should their role be?

In the second half of the workshop a Future Workshop [31] methodology was applied to explore strategies for a realistic model for access to art by PVIs. As part of the critique phase, participants examined (with the aid of verbal description) the painting *Gentlemen, "the Queen"* (1894) by Albert Chevallier Tayler and a response to the artwork, an installation titled *I forgot to remember (The most organised violence in the world)* (2018) by Denis Chapman. In the fantasy phase, we asked the workshop participants to suggest how they would like artworks in the gallery to be made accessible if there were no constraints in terms of money, resources, time and technology. The workshop ended with an implementation phase, when participants were asked to suggest what BAG could do in practice to improve the experience of PVIs.

After the workshops, a questionnaire was sent to the attendees to assess their individual views about the values and strategies discussed. Nine responses were received, covering PVIs, gallery guides, artists and educators.

Values and value conflicts

Participants identified many additional stakeholders who could be affected by making BAG's collection accessible to PVIs: friends and family of PVIs who may be able to enjoy a more shared experience of the gallery; the vision impaired community who could benefit from increased awareness of the need for inclusion and participation in all aspects of life; the wider disability community, many of whom may also be able to benefit from some of the accessible formats and increased awareness; other artists whose exposure to accessible art could expand their thinking about art and how to convey ideas; sighted visitors and the Bendigo Community who will be exposed to new ideas about access and inclusion; and the Bendigo City Council, which funds the gallery and wishes to attract more visitors to the city.

Many values were explicitly and implicitly raised during the workshop. Two researchers independently coded the responses then compared results, discussing and resolving conflicts. The analysis was informed by Schwartz's Theory of Basic Values [46] and by values identified in other value sensitive design investigations. Values identified were:

Inclusion: This is about ensuring the gallery experience is available to everyone and that PVIs have access to the artworks. It is closely related to fairness and equity.

> From my perspective of being totally blind. I have been to art galleries and I've felt myself being dragged along … They might describe something to you and say "this painting is red" and I will think, "well, so what?". It doesn't mean anything to me … the descriptions just get scrambled in my brain. Because of that, I don't frequent art galleries as it stands at the moment. It has diminished my interest in it [visual art].

Respect: This is about due regard for all people regardless of difference or disability. Participants discussed the importance of raising awareness of PVI's needs by gallery staff and in the wider community.

> I think that having works that are accessible is also important for the general community as well because having those works there increases their understanding about what those things are. It's a two way education process between what the people with needs are getting as well as the wider community.

Stimulation: This includes intellectual stimulation, aesthetic pleasure, emotional response, entertainment and sensory engagement with artworks in the gallery by PVIs. Artists also said that they were creatively stimulated by thinking about how their art could be made accessible to PVIs.

Social connection: This includes connection by PVIs to friends through shared visits/experiences with the gallery, connection to the local community through shared knowledge and pride in the gallery and its events as well connection between the artist and audience, which includes PVIs.

> I'm thinking about Bendigo being a small community. Out there, they're talking about exhibitions on here and you really aren't able to contribute unless you've been up to the exhibition. I think if it's made accessible to all, it certainly would be of benefit in our community.

Autonomy: PVIs wished to have the same level of independence and control as sighted visitors. For instance, it was very important to them to be able to visit when they like, have a choice of exhibits, and be able to safely and independently explore the gallery.

> I could happily do that by myself. It would give me more autonomy. I would stop and look at each work and take my time.

(Artistic) Integrity: Audio descriptions and presentation of artworks in alternative formats should be non-misleading and true to the artistic vision.

> What is the essence of the concept they are trying to relate? How do we communicate this in a non-visual way that can also be easily understood by anyone with vision or no vision and make it relevant?

Ownership & property: This includes copyright, physical ownership, IP, moral and cultural ownership of the artworks

by the gallery, artist and community, or entities lending artworks to the gallery.

Fiscal responsibility: Gallery staff have a responsibility to ensure the gallery remains financially viable and makes fair use of limited resources.

> It's an issue of resources, time, practicalities.

Stewardship: This is about ensuring the gallery preserves its artworks for future generations.

> As a policy we have to say no touching because if it breaks then we have a very large cost.
>
> You can't damage the artworks.

Self-Achievement: This includes job satisfaction by gallery staff, self-expression by artists, reaching a wider audience by artists and learning about art and art history by PVIs.

> It is great for us to be able to empower people then see their response.

Workshop participants identified several value conflicts.

Inclusion-Fiscal responsibility: The most obvious value conflict arises because BAG has limited budget and resources, and so cannot, for instance, afford to pay for hand-crafted high quality replicas of all of its artworks. Gallery guides expressed concern that resources used to support PVIs could reduce available support for other visitors, including those from other disadvantaged groups.

> Our art education department is fairly small. It is just myself part time and another part time. We don't have a full time position so we juggle quite a lot. ... It's just a matter of balance.

On the other hand, there was also agreement that making the artwork accessible through touch and other sensory channels would benefit all visitors to the gallery, not only those with visual impairments.

> Universal design can be good for those with a disability or vision impairments but what is good for those people or specific to those people is helpful for everybody else as well.

Inclusion-Stewardship: The next obvious value conflict is between artwork conservation and access. Touch and bright light can harm most artworks but potentially allow much better access by PVIs to sculptures and paintings. This conflict has been extensively studied by Candlin [12], who has also examined the changing attitude to touch in museums [15]. BAG uses dim lighting and has a no touching policy. Paid gallery staff agreed that for some artworks, supervised touch and use of torches might be permitted by PVIs, although the three volunteer guides participating in the workshop had reservations about loosening rules for conservation.

Inclusion-Ownership & property: Gallery staff expressed concern about infringing copyright by artists or their estates, or other galleries for works on loan, and also moral ownership of artworks by living artists or their estates when creating reproductions or providing images in a public website. Aboriginal artworks posed further complex questions about moral and cultural ownership. The gallery's concerns were not only due to legal obligations, but also to maintain a respectful relationship with the artists and their culture. On the other hand, they did not want to give control to artists in dictating how accessible or educational materials relating to the works are produced and used by the gallery. This is a clear conflict of values and its resolution depends upon values of the gallery, artists, local community and legal framework the gallery is operating in.

Inclusion-Integrity: A fundamental value conflict raised in the workshop was between inclusion, which requires translating an artwork to other modalities, and artistic integrity, which requires that these new representations do not misrepresent the artwork. Gallery guides indicated that they were uncomfortable with interpreting the work as part of an audio description. They felt that it was their role to present objective facts about the artwork: its title and year of creation, a description of the main elements, as well as contextual information about the artist and style. This accords with ABS audio description guidelines [5] and [28], who reports the "importance of just describing the piece of art without a philosophical or conceptual critique". On the other hand, in our workshop some PVIs clearly wanted more to aid their understanding and engagement.

> If we can understand the work, we can see it. It has nothing to do with the retina. It's understanding. Seeing is understanding. To understand the work, whether you approached it tactilely, if you had limited vision, if it has been explained to you, if you are coming with your own ideas about the work, once you understand the drive that created the work, the meaning, the message, the essence, you will see it.

Kleege [33, pg 121] also feels that adequately explaining artworks requires subjective interpretation. She recommends that we "abandon the pretext of objectivity [in audio descriptions]. It is impossible and beside the point."

One artist at the workshop suggested obtaining a statement from (living) artists about their artistic intent, though said that only some artists would be comfortable providing this as others wanted the artwork to speak for itself.

> I think you always have to go back to the artist and what they were intending to get a faithful representation. And then that's difficult because it depends on what level of detail you need to go into. … It's important to always bring it back to the artist.

> Some artists would be alarmed at being restricted to an interpretation, rather than a whole suite of interpretations. The understanding [is] that they are handing the artwork over to their audience and each person in the audience's interpretation is equally valid. There is that dilemma.

There was no agreement on this issue, with post-workshop questionnaire responses ranging from "disagree" to "strongly agree" for the statement "When providing a description of an artwork for a person with a vision impairment, it is important only to describe what can be seen, without any subjective statements or assumptions."

To overcome questions of subjectivity, some participants suggested that the audio description could include a conversation about the artwork. This could explore possible meanings but, by its format, would clarify that these were individual views open for discussion.

An even deeper conflict concerned the extent to which tactile translations can remain faithful to the original visual artwork. This was not so much an issue for presentation of sculptures, though it was observed that 3D printed models could be misleading because size, weight and texture might not match that of the artwork. One participant felt that the 25cm high 3D print of the 3.5m high sculpture *Happy Ending?* did not adequately capture the impact of the original artwork and also that the texture was not as smooth as the original. Previously, De Coster and Loots [19] questioned the inherent integrity of any tactile presentation, stating "this emphasis on touch carries the danger of denying the importance of art's visual character." Caro Howell (quoted in [15, pg. 136]) highlighted that touch can only play a small part in understanding the vast majority of artworks and that for artworks such as Marcel Duchamp's *Fountain* (a ready-made urinal) "It is not about touch, it is about ideas." Nonetheless blind participants at the workshop emphasized the importance of touch and how useful they found the combination of audio description and tactile presentation. Remarking on the general issue, one artist said

> The thing to remember with those sorts of interpretations of an artwork, is that it's the same as having a diagram in an art text book that's explaining the perspective of a particular painting or the compositional arrangement of a particular painting. It is not the painting, but it is explaining the painting or certain facets of the work.

Stimulation-Integrity: A closely related conflict is between the desire of PVIs for tactile and audio translations to engage and delight their senses and artistic integrity, as achieving this may require a departure from that which was conveyed visually in the original artwork.

> There has to be interpretation at some point to encapsulate the other senses that are heightened. Somebody who has a sensory disability like blindness or deafness … the other senses are heightened. So you have to experience the world in a different way anyway. At some point there has to be interpretation.

Initial Design Ideas

The vision impaired participants called for techniques to engage their other senses, such as tactile models or graphics, a soundscape or a recreation of the scene being represented. There was a strong desire for engagement using the senses rather than relying just on descriptions. PVIs wanted to touch the artworks, smell the oil paintings, smell the frames, and listen to associated sounds and music.

There was some conflict between the needs of people who have low vision versus those who are blind. One participant with low-vision highlighted the fact that most PVIs had some vision, yet galleries and the researchers appeared to be focussing on access by the fully blind, ignoring the needs of the larger group. Visitors with low vision wanted brighter lighting to afford better use of the vision they do have, and measures to allow them to navigate the gallery independently. Blind visitors acknowledged that they would not be likely to walk through the gallery independently but wanted more information to be able to plan their visit.

After the workshop, participants were asked to rate all of the strategies that had been suggested. As seen in Table 2, strategies enabling independent access to the gallery (autonomy) rated most highly. While some strategies, such as enlarged images, were clearly of use to only a subgroup (people with low vision but not those who are blind), many were considered to have cross-over and also be helpful to general gallery visitors. As discovered in the formative study, a combination of approaches seems most appropriate.

5 VALUES-BASED MODEL

Guiding principles

Based on the previous studies and a critical review of the literature, we identified the following guiding principles for our values-based model for equitable access by PVIs to gallery collections. The brackets indicate relevant values.

(1) *Develop and maintain a respectful, informed ongoing partnership between all stakeholders.* Stakeholders at the workshop provided feedback about how important and empowering it was to be involved. Surveys indicate that respect and knowledge of disability (or lack of these) by gallery

Table 2: Strategies for access suggested at the second workshop. Median rating by participants (n=9) on a 3-point scale of "not helpful" ( ), "somewhat helpful" (*) or "very helpful" (**) for people who are blind, have low vision or are sighted.

	target group		
method of access	blind	low vision	sighted
signage for navigation	**	**	**
accessible labels	**	**	*
group tours for PVIs	**	**	*
description of visual elements	**	**	*
map of gallery	**	**	*
accessibility feedback	**	**	*
description in writing	**	**	*
touch access to materials	**	**	*
additional information	**	**	*
gallery staff training	**	**	
supplementary objects	**	**	
touch access to artworks	**	**	
tactile representation	**	** / *	
models of 3D artworks	**	*	
images on iPad		**	*
improved lighting		**	*
artist's statement of intent	*	*	*
soundscape	*	*	
scents	*	*	
touch access to painting frames	*	*	

staff significantly affects enjoyment of a gallery visit by PVIs [2, 27, 28, 42]. (Inclusion, Respect)

(2) *Support independent, autonomous access.* The workshop highlighted the importance of independence and autonomy to PVIs. Supported by [3, 28, 42] (Autonomy, Respect)

(3) *Cater for individual PVI differences in reasons for visiting the gallery and background knowledge.* The workshop, in accord with other studies [12, 28], makes it clear that PVIs visit the gallery for diverse reasons and with a broad range of background knowledge of the visual arts. (Stimulation, Social Connection, Self-Achievement (Learning))

(4) *Cater for individual PVI differences in visual acuity and other sensory, physical and mental abilities.* Both studies make it very clear that the needs of fully blind and low-vision visitors differ dramatically. This difference is also discussed in [12, 42, 50]. Furthermore, vision impairments frequently occur with other disabilities, in part because vision loss is most often age-related. (Inclusion)

(5) *Accessible translations of an artwork should not be misleading, but should provide sufficient information for the work to be enjoyed and understood.* Our studies identified that some PVIs wanted contextual information including technical information about the artwork itself and information about artistic intent. Where practical, the artist should be asked to provide this and perhaps also advise on how the work might be translated to different sensory modalities. (Inclusion, Integrity, Stimulation, Self-Achievement (Learning))

Note that Principles 3 and 4 are in accord with inclusive access and ability-based design [53].

Model

In collaboration with gallery staff, we developed the following general model for providing PVIs with access to BAG and its collection. The first step in implementing the model will involve institutional change: Awareness training for all staff including focus group with PVIs [34] and creation of an advisory group including members of relevant stakeholder groups (staff, PVI, artists) to advise and monitor gallery progress (Principle 1). The model provides three complementary ways of accessing the gallery to cater for different levels of vision impairment and mobility (Principle 4).

Accessible website: Providing accessible online information about the gallery and its collection is one of the most effective strategies for inclusion. Regardless of accessibility of the gallery space, many PVIs will rarely visit the gallery itself because of mobility issues. Allowing access through a website allows PVIs in the local community to easily keep up to date with the latest exhibits, communicate access options and help PVIs prepare for a visit. The need for accessible websites to help preparation has been previously noted in [2, 27, 42].

Guided gallery tour: For people with severe vision impairments, the most practical option is to provide organised guided tours in which an individual or small group is shown three or four artworks using a mix of accessible representations, and supervised touch of selected artworks. A small group size allows the guide to tailor the choice of artworks and discussion to the group (Principle 3).

Self-guided gallery tour: The most novel aspect of the model is to support autonomous self-guided tours (Principle 3) by PVIs with low-vision or a companion.

Principles 4 and 5 require that the gallery provides a mix of multisensory presentations [11] of artworks that are tailored to the artwork. The formative and main study made it clear that a variety of presentation methods are needed when presenting artworks to PVIs, and that the best combination depends upon the artwork, level of vision and viewer preferences. The mix includes audio description, tactile presentations (3D models, bas-reliefs, layered bas-reliefs, tactile graphics), enhanced images of the artwork designed for people with low-vision, soundscapes, and role-play (i.e., taking the position of an actor in the artwork).

Role of IT

Various kinds of IT play a central role in this values-based model. Most obviously, accessible presentation of the gallery

collection through a website involves accessible website design and digitally enhanced images suitable for people with low vision. Social media integration would benefit social connection. In the future this might also include immersive technologies such as virtual reality (VR) so that viewers are transported to the gallery and can better prepare for their visits. VR for PVIs is currently an under-explored area.

The second major role is for the production of tactile representations. Semi-automated translation, 3D scanning, 3D printing and laser cutting offer a relatively cheap way of constructing accessible models and bas-reliefs of artworks, thereby partially alleviating the *Inclusion-Fiscal responsibility* values conflict. One might also imagine the use of computer generated soundscapes and the use of augmented reality (AR) in the gallery to enhance artworks when they are being viewed by people with low vision.

The third role for IT is to support independent wayfinding within a gallery or public space through 3D printed maps [30], beacon-based user tracking with smartphones [1, 32] or custom wearable devices [23], computer vision with audio feedback [22], and social media integration [54].

6 PILOT EVALUATION

In our final study we ran a pilot evaluation of the values-based model. We implemented and evaluated a prototype of each of the three different access methods.

Guided gallery tour

Based on suggestions from the workshop, the tour was limited to a small number of artworks and participants so that each artwork could be examined thoroughly and on a personal basis. Participants had taken part in the previous studies or were recruited through social media.

Four visitors took part. Two were blind and two had low vision. Vision loss was acquired for two of the participants and congenital for the other two. All had a keen interest in art. Their ages ranged from 20 to 85, and all but one had attended the workshop.

The tour was run by one of the gallery's education officers, who gave a verbal description of the artwork's appearance as well as providing interesting facts to encourage discussion. The researchers were present to audio record the session and provided assistance only in moving from one artwork to another and guiding touch access to the materials.

Four artworks were chosen in consultation between the researchers and gallery staff to explore a range of artworks and practical strategies for their accessibility. Most differed from those shown in the previous studies to provide a novel experience for returning participants. *Sometimes the Dead Are More Alive Than the Living* (2017) by Alex Seton is a five tonne marble sculpture of a human skull. Guided touch access to the original artwork was provided. *Girl with Cigarette* (c1925) by Agnes Goodsir is a painting of a girl seated in a cafe. Props were provided to recreate the scene with the participant sitting on a chair in the same pose as the girl in the painting, along with a laser cut tactile representation. *The Drover* (1916) by Walter Withers is a painting of a drover herding sheep with his dog. Touch access was given to a frame of similar style, some sheep's wool and a simplified 3D printed raised bas-relief, along with a soundscape of sheep bleating, a drover's whistle and a dog barking. *Happy Ending?* (2014) by Michael Doolan was again presented with touch access to the original artwork and a 3D printed tableau, now placed on a base to indicate relative positions.

Table 3: Evaluation of pilot guided tour and web pages at accessed at home. Median response on a five-point Likert scale from strongly disagree (-2) to strongly agree (2).

	tour (n=4)	*web* (n=4)
I was able to access the artworks (inclusion)	*1*	*2*
I was able to access the artworks independently (autonomy)	*0.5*	*2*
I felt included in BAG's community (social connection)	*1.5*	*1.5*
I enjoyed the (virtual) tour as a social activity (social connection)	*1.5*	*0*
I enjoyed my (virtual) trip to the gallery (stimulation)	*1.5*	*2*
I would recommend this method of visiting the art gallery to people with vision impairments	*1.5*	*1.5*

Immediately after the tour, the guide and participants took part in individual semi-structured interviews to gather feedback about their experience. Using a five-point Likert scale from strongly disagree (-2) to strongly agree (2) to rate the usefulness of each mode of presentation, those preferred were: touching the artwork and role play (median = 2); touching the frame and the 3D model (median = 1.5); and the guide's description and touching related objects (median = 1). Interestingly, two of the participants strongly agreed that the laser cut graphic was useful while the other three respondents were neutral.

Using the same Likert scale, the tour was evaluated by the participants in terms of general satisfaction and meeting some of the key values. As seen in Table 3, the tour was successful in providing an enjoyable experience that people would like to repeat and would recommend to others. However, it did not rate highly in terms of enabling autonomy. Two participants suggested that they would prefer to be able to choose the artworks they were shown from a selection on a web page before the tour.

Accessible web site

Sample web pages were created to trial remote access to the gallery's collection. The landing page included a high-contrast plan of the gallery with links to representative artworks. Each page included basic information about the artwork; a series of high-resolution images of the artwork with close-ups, high contrast and simplification for people with low vision; a visual description for people who are blind; supplementary information such as context, information about the artist and an artist's statement; a soundscape of related music or environmental noises; and a conversation about the artwork. Heading structure and links were provided for user-friendly accessible navigation.

Seven paintings and two sculptures were selected: *A Primrose from England* (1855) by Edward Hopley; *The Golden Wedding* (1883) by Carl Hoff; *The Drover* (1912) by Walter Withers; *Red Vine Structure* (2006), *Red Space* (2014), *Dialogue* (2014) and *Structured Space* (2017) by Craig Gough; *Venus Tying her Sandal* (1913) by Ettore Cadorin; and *Folly* (2008) by Sebastian di Mauro. Copyright concerns affected the choice of artworks, with the gallery wanting to select artworks out of copyright or with direct permission from the artist.

The web pages were tested remotely by four people: One with low vision and three who are legally blind. Vision loss was acquired for two of the participants and congenital for the other two. Their ages ranged from 32 to 54. All but one had also been present either at the workshop or tour. The website was evaluated after the tour, on a different day.

After viewing as many of the artworks as desired, participants were interviewed using the same questions as for the pilot tour. As seen in Table 3, general satisfaction was high and, unlike the guided tour, participants were able to gain a high sense of autonomy.

> Being totally blind, I've always found art galleries to be boring until … this virtual tour. Having the soundscape and the visual descriptions made it a meaningful experience.

The usefulness of each element of the web pages was assessed using a five-point Likert scale from strongly disagree (-2) to strongly agree (2). The images were the most appreciated element of the web pages, with both testers with low vision strongly agreeing that they were useful. The next most helpful elements were the visual description, contextual information, interpretation and information about the artist (median = 1). There was disagreement about the soundscapes, which were loved by some but disliked by others, who complained that they were too loud, too quiet or too distracting and suggested that they need to be easier to use and adjust.

Self-guided gallery tour

In a final component of the pilot, we evaluated the usefulness of the same web pages for self-guided tours of the actual gallery. The pages could be accessed on an iPad provided by the gallery or the participant's own mobile device.

Testing was conducted with one additional person with low vision, who used a borrowed iPad in the gallery after being given brief instructions on how to use it. The images and text were "much clearer" on the iPad than the gallery walls and the participant enjoyed the social aspect of being in the gallery. The main difficulty experienced was in finding the matching artwork and web page. We plan to address this problem and then conduct evaluations with multiple participants in the future.

7 CONCLUSION

In this paper we have presented a values-based model for providing people with vision impairments equitable access to art galleries. The model was developed in collaboration with a regional gallery using value sensitive design. We conducted a formative study comparing different tactile presentation methods, then our main study which explored stakeholder values and initial ideas for the model. Finally, we conducted a pilot evaluation. User evaluation was extremely positive, and BAG is now planning to deploy the model more widely.

Our research provides the first values-based framework and model for accessible access to cultural institutions. In particular, it highlights the importance of supporting independence and autonomy of visitors with visual impairments, and involving the artists when developing audio descriptions and translating their work into other sensory modalities. By clarifying stakeholder values and conflicts, our research helps ground future research into the use of IT technologies for this purpose. For example, it demonstrates the importance of providing online access both for PVIs with limited mobility and to prepare more mobile PVIs for a physical visit. Further, it motivates the use of digital design and manufacturing techniques such as 3D printing and laser cutting in the production of tactile presentations as well as research into wayfinding technologies for use in the gallery and supporting access with emerging virtual and augmented reality systems.

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