9. Data-Driven Visiting Experiences

Steve Benford, Dimitri Darzentas, Edgar Bodiaj, Paul Tennent, Sarah Martindale, Harriet Cameron and Velvet Spors.

Abstract

Data is seen as the 'new oil' that drives the digital economy, and museums are no exception to this. We investigate how data captured from hybrid museum experiences can become a resource for designers, for museums, and for visitors in their understanding of a museum and a museum visit. We ground our discussion in three complementary case studies: Analysing visitors' movements in a touring virtual reality exhibition called *Thresholds*; analysing their gifting behaviours in the *Gift* app; and capturing data about how designers used our Visitor Box cards.

Keywords: Data visualization; Visitor behaviour; Data; Digital tools

Data is seen as the 'new oil' that drives the digital economy. This is most obviously true of digitally native products such as the social media platforms and search engines that we use every day which are fuelled by both the data we directly provide (our stories, comments, photos, videos and likes) as well as the data that is implicitly captured about our histories of searching, browsing and viewing. It is also true however of traditional physical products that are increasingly associated with data capture, from smart homes to software-controlled cars and many others. Such data provides rich opportunities to learn about, redesign and ultimately personalize the user experience, as well as to advertise further ones. It has also raised extensive ethical concerns about privacy, trust, bias and other potential misuses of personal data that we revisit below.

Museums are also interested in such data. They already routinely capture data about visitor numbers and ticketing and there have been various attempts to capture richer data about patterns of movement through the museum, dwell times and preferences. The spread of hybrid visiting

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experiences of the kinds described in this book raises the opportunity to capture far richer data about visitors' behaviours and, as it turns out, designers' thinking too.

In this chapter, we investigate how data captured from hybrid museum experiences can become a resource for designers, for museums, and for visitors in their understanding of a museum and a museum visit. We ground our discussion in three complementary case studies: Analysing visitors' movements in a touring virtual reality exhibition called *Thresholds*; analysing their gifting behaviours in the *Gift* app (see Chapter 3); and capturing data about how designers used our *Visitor Box* cards (see Chapter 8). Having introduced our case studies, we then reflect on the potential benefits of such data to museum designers, developers, curators but also visitors themselves, as well as the challenges they raise.

Visualizing Visitor Behaviour in Thresholds

For our first case study, we turn to a museum installation that was created by the artist Mat Collishaw in collaboration with the Mixed Reality Laboratory at the University of Nottingham. Technically, *Thresholds* is an example of so-called 'substitutional reality' in which a 3D virtual model is overlaid on a corresponding physical set to deliver the experience of passive haptics in which sensations of physical touch appear to be aligned to digital visual and audio stimuli.[1] We include *Thresholds* here because it provides an interesting first example of analysing data about visitor behaviour at scale as a way of gaining insights into museum experience design. A detailed account of the design and evaluation of *Thresholds* can be found in a journal paper by Tennent and colleagues;[2] the following is a brief summary.[3]

Thresholds recreates the 'Model Room', an exhibition that was staged at King Edward's School (Birmingham, UK) in August 1839 at which Henry Fox Talbot presented a display of 93 'Photogenic Drawings' (photographs). *Thresholds* is an artwork that explores how technology changes our relationship with the world. It comments on how a technical innovation

1 Simeone, Velloso, and Gellersen, 'Substitutional Reality'; Hoffman, 'Physically Touching Virtual Objects Using Tactile Augmentation Enhances the Realism of Virtual Environments'; Insko, 'Passive Haptics Significantly Enhances Virtual Environments'.

2 Tennent and others, 'Thresholds'.

3 Please see this video for an overview of Thresholds: https://www.youtube.com/watch?v=acktp-Wy8Nw.

of photography has led to today's visual culture and simulated realities. Substitutional reality is used to give contemporary audiences access to the previously radical technology of photography. By doing this Collishaw draws a parallel between past and present, both in terms of the thrill of new mediated experiences and in terms of the tensions they provoke. There are historical records of Fox Talbot's concerns about Chartist demonstrations in the Birmingham area at the time of the original exhibition, and in the virtual world of *Thresholds* this rioting can be witnessed taking place outside.

To experience *Thresholds*, each visitor dons a backpack PC and wireless head-mounted display that enables them to explore a room-size virtual reality recreation of the Model Room with up to five other visitors at a time. They are guided into an all-white physical room containing model vitrines and whose walls feature blank outlines of windows, picture frames and other details. Through the headset they see a virtual recreation of the model room as it might have been. This appears to be overlaid onto the physical room so that vision, sound and touch work in synchrony. As a result, they can see and hear Collishaw's recreation of the Model Room but also feel it whenever they reach out to touch a vitrine, lean against a wall or otherwise physically encounter the environment. Walking around, they can directly touch nearly everything, from the vitrines, to the frames of paintings, and can peer out of windows to see and hear angry protesters outside. The one exception is the photographs in the vitrines which cannot be touched; however, they can lift them up in the virtual space by hovering their hand above a vitrine in order to inspect them closely. The fire burning in the grate feels warm, while moths flit around the gaslights, and mice scuttle around the recesses of the room. The other visitors appear as ghostlike auras, conveying a sense of presence but without identifying them or encouraging closer engagement, leading to a shared but still isolated experience. A clock slowly ticks and when six minutes have elapsed, chimes, and they are asked to remove their headset, to find themselves once more in the bright white reality of the physical exhibit.

Thresholds toured widely, and has been exhibited at: Somerset House, London; Birmingham Museum and Art Gallery; Lacock Abbey, Wiltshire, UK; and the National Science and Media Museum Bradford, UK among others. The experience achieved an average throughput of 54 visitors per day across these deployments, peaking at an average of 200 at Somerset House.

Evaluation of the visitor experience drew on the conventional forms of observations and interviews with selected participants, comments captured by museums in visitor books and the like, and also on reviews in the press and on blogs. However, what was more novel and interesting here was the visualization of system logs of visitors' movements in the virtual world which shed additional light onto their behaviours.

We collected 5271 complete data logs of visitors' movements and actions in the virtual world including head position and orientation, hand positions and orientations, and interactions with the virtual photographs. Figure 9.1 (top) presents a heat map of the horizontal positions of all visitors' headsets as seen from above, set against the virtual model. Red shows the most popular locations, orange and yellow the next, green less so, while areas that are not coloured were not visited at all.

This reveals clustering around the door as we might expect as this is the entry and exit point for all visitors. It also shows the vitrines to be popular locations and that visitors tended to stand at their sides rather than their ends, reflecting the orientation of the photographs. They also avoided the relatively busy corridors around the outside of the room and through its centre. Windows were popular locations with many pausing to look out at the riot. The notable gap at the top left is where a static ghost avatar was placed so that invigilators had somewhere to stand safely in the physical room, a tactic that evidently worked well.

41% of these visitors picked up images at least once and visitors spent 2.5% of their time holding objects in total. The heatmap in Figure 9.1 (middle) conveys the relative popularity of images in terms of being picked up suggesting that larger images are more likely to be picked up, perhaps because they are easier to grasp, but also suggesting the images further away from the entrance appeared to be more popular than those near to it. This may be because it takes visitors a few minutes to become familiar with the experience, after which many move to the windows to watch the riot, after which they move along to the end vitrines.

Finally, Figure 9.1 (bottom) provides estimates of the spatial distribution of tracking errors, defined as being reported positions that were either outside the physical constraints of the space or more than 50cm away from the previous recorded point (unlikely to occur with logging at 90 Hz). The visualization shows the last reported 'good' position just before the tracking error occurred. We see the most errors around the entrance – this is to be expected as this was a popular location, is effectively outside the tracking space and we observed visitors adjusting the headset for comfort, or simply grabbing it when the tracking was first established which typically

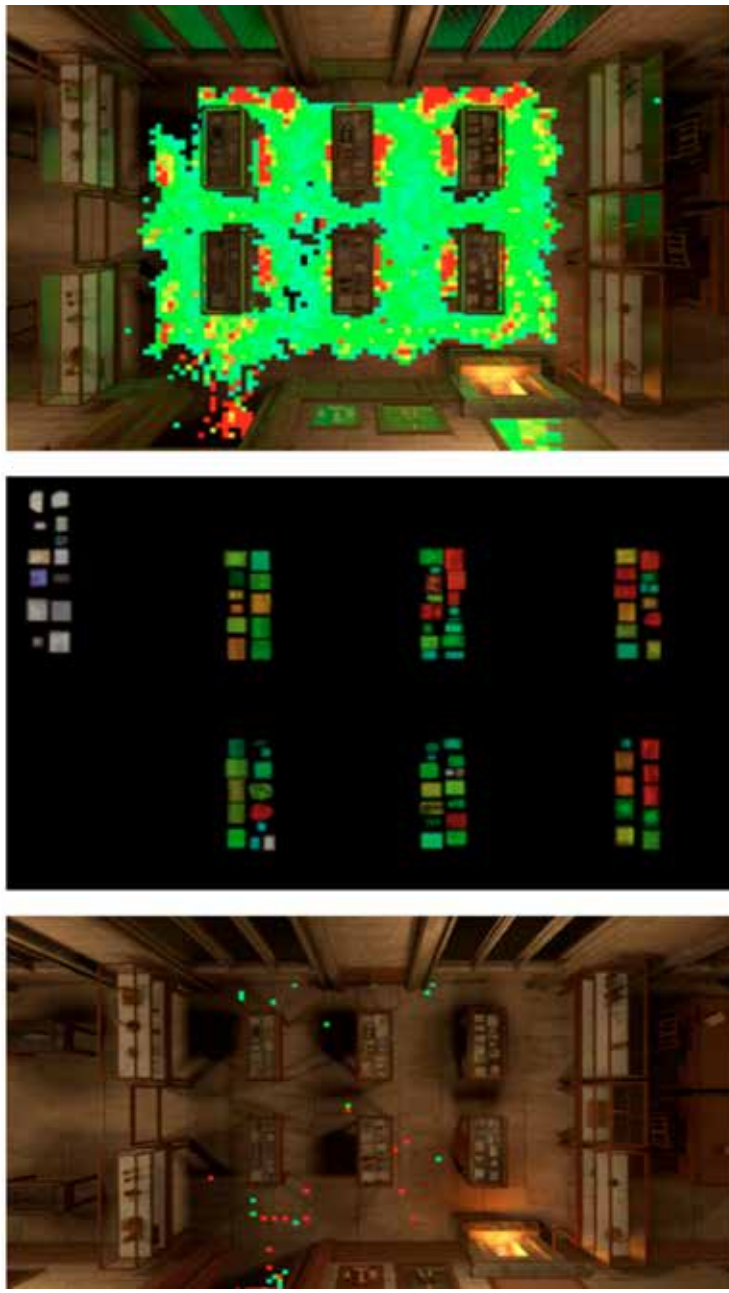

Figure 9.1. Visualizing visitor behaviour in Thresholds. Top: Heatmap of horizontal headset positions in Thresholds. Middle: Relative popularities of photographs for picking up. Bottom: Spatial visualization of estimated tracking errors.

results in their hands covering the sensors. We see several errors around the windows where the mouldings may have obscured the sensors and where we observed users to often physically grab onto and adjust their headphones that might further obscure the sensors. There are also some towards the centre of the room that is consistent with being on the edge of the maximum range of the sensors which we physically placed in its corners.

Visiting Gifting Behaviours

Our second case study turns to the *Gift* app that was described in detail in Chapter 3. As a reminder, this enables visitors to compose personalized museum tours as gifts for others by selecting up to three objects from a museum, taking photos of them and then recording personal messages about why they have chosen each for that person. Initial deployments of the app at the Brighton Museum and Art Gallery and the Munch Museum enabled us to capture data logs about who had sent gifts to whom and what these gifts had contained. In respect of ethical concerns about revealing sensitive personal information, the identities of individuals were anonymized as far as possible and we refrained from any analysis of the contents of their personal messages. In terms of figuring out what they had sent, we needed to manually inspect their photographs in order to determine what they were of; often museum exhibits (though perhaps shot from unusual perspectives), but also sometimes other objects such as selfies, pictures from the cafe, gift shop or even outside.

We developed a series of visualizations of the resulting dataset which comprised several hundred participants and objects with a view to providing insights into visitors' behaviours. The first (Figure 9.2, top) shows what proportions of people who use the app progress through the different stages of the gift-giving workflow. In other words, it shows how many users drop out of using the app at each key touch point of the visitor experience. In this case, we can see that many visitors are lost during the first introductory stage, after which most are retained, though not everyone goes on to include two or even three objects in their gifts (as expected). This is useful for identifying key weaknesses in the overall app or ways in which it is deployed in a particular museum (e.g., are there some aspects of operation that require greater scaffolding from museum staff). It also sets a benchmark as to expected behaviour with the app which might help museums plan deployments and likely uptakes in future deployments.

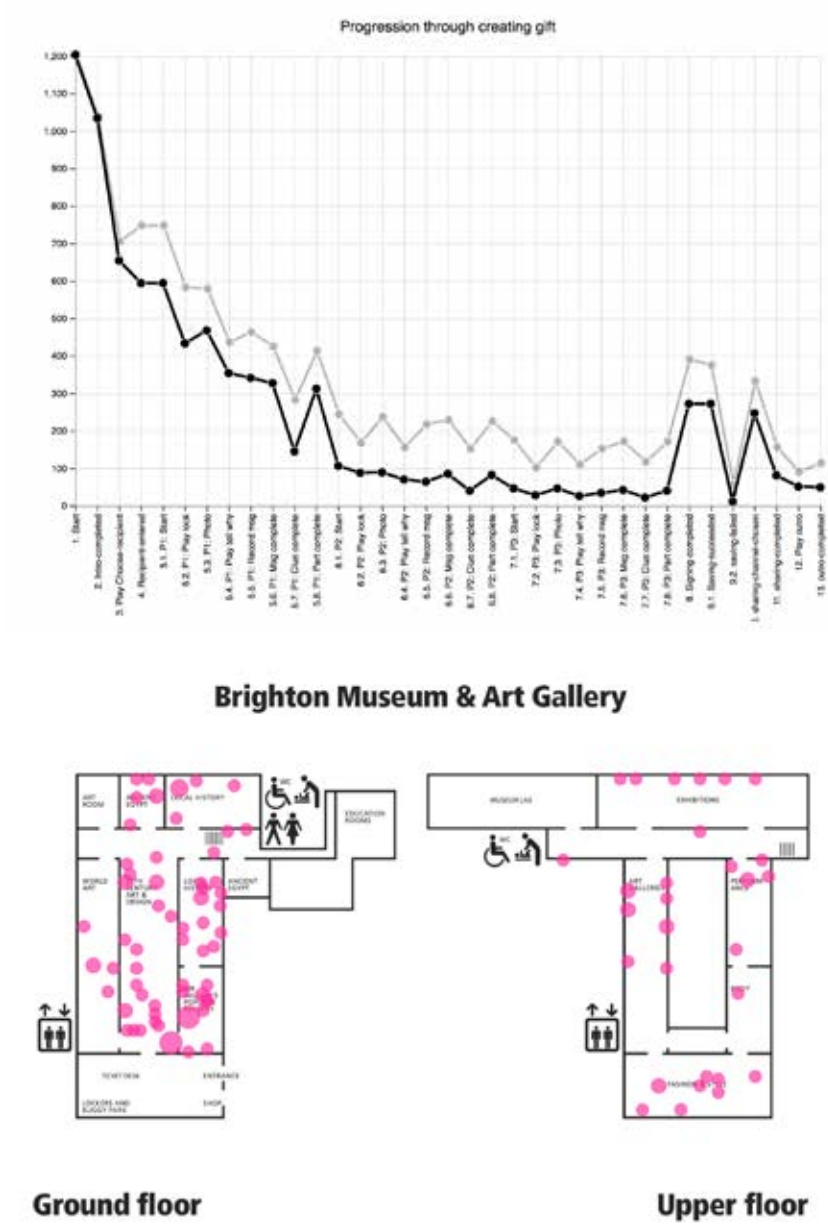

Figure 9.2. Visualizing interactions with the *Gift* app. Top: Visualizing progression through the *Gift* app experience (Green line for Brighton museum data and Pink line for Munch Museum data). Bottom: Map showing the popularity of chosen exhibits for gifting at Brighton Museum and Art Gallery

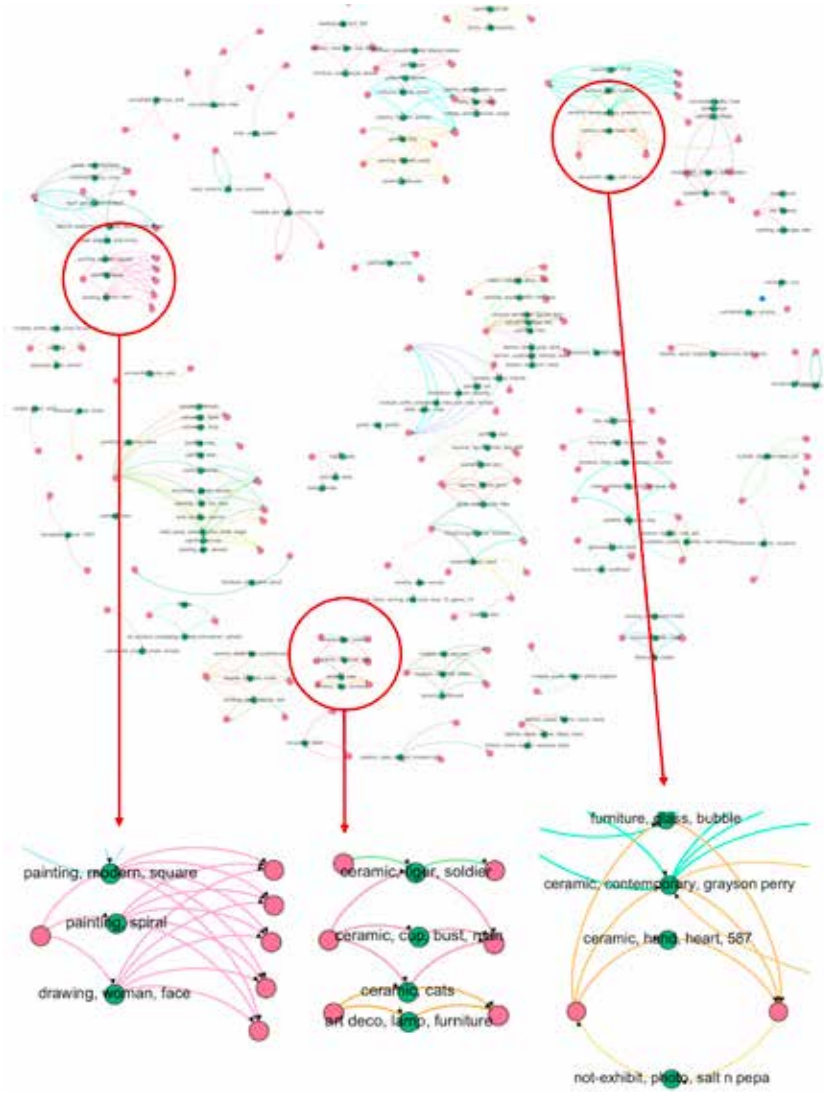

Figure 9.3. Visualizing patterns of gift exchange. Top: Overview of the entire dataset from the Brighton Museum deployment as a Network Graph. Bottom: Zooming in to identify three examples of gifting behaviours.

Our second kind of visualization shows the relative popularity of those museum exhibits that were chosen as gifts, overlaid on a map of the museum. Generating this currently requires further human processing of the data to map the photographs taken by visitors when using the app onto actual exhibits within the museum. Figure 9.2 (bottom) shows this for the Brighton Museum and Art Gallery, revealing how visitors explored the museum

widely, often venturing into some of its less frequently visited galleries in search of unusual gifts, which perhaps reflects the relatively non-linear and eclectic nature of its collection.

Our third visualization is an extended form of social network graph. The visualization generates network-style visualizations of gift giving between people, showing who gave which objects to whom. Technically, the visualizations show which devices generated and opened gifts, which is an approximation for people as there is the possibility that some people used multiple devices, or some devices were shared among people. Links from devices to things show whenever the former included the latter in a gift. Links from things to people show whenever the latter opened the former as part of viewing a gift. Figure 9.3 shows an example of such a visualization generated from the Brighton museum data. Figure 9.3 (top) gives an overview of the entire dataset, revealing clusters of gift exchange involving discrete subgroups of participants, and that these appear to involve different patterns of gift giving behaviour in terms of the choice and numbers of museum objects given, how they are combined into gifts, and also the extent to which these are reused (e.g., given to multiple recipients).

Zooming in for a more detailed inspection (Figure 9.3, bottom) reveals several interesting kinds of gift behaviour. Left, we see one person who has made a gift containing three exhibits and then shared it with five others who opened it. Middle, we see three people have made gifts for three others, where their gifts contain several exhibits in common. Right, we see an example of reciprocation between two individuals. Such images suggest the potential to inform our understanding of the social dynamics of gifting museum visits – do some individuals act as 'influencers' perhaps, and is reciprocation a key driver of gifting?

Visualizing the Use of Visitor Box Cards

Our third case study turns to using data to reflect on the design process behind museum experiences rather than on visitors' behaviours. Chapter 8 introduced the Visitor Box deck of cards as a tool for engaging diverse stakeholders in the design of interactive museum experiences. Here we report on a tool called *Cardographer* that was developed to capture data about how cards are used – which are used most often in what combinations by whom – to enable people to reflect in their design processes. This builds on previous work that explored the potential of capturing and analysing data

from a deck of Mixed Reality Game ideation cards.[4] The first function of *Cardographer* is to help capture data by using augmented reality technology to identify the presence of the cards during design sessions, and especially on design artefacts.

The second function is then to visualize the resulting data. For example, we captured data from ten design workshops which collectively employed the cards to work up 59 different documented designs. The average number of cards used in a design was 15. The smallest design included 3 cards and the largest design featured 43 individual cards. 3 of the workshops were to train students while the remaining 7 were targeted at museum professionals and accounted for 38 of the designs. An initial analysis revealed considerable variety between the various workshops and hence individual designs with regard to whether they followed and documented all of the stages of the Visitor Box process – only eleven design has all five stages fully documented while some covered only a few stages. This reflects the complexity of the overall Visitor Box process and the time it takes to fully complete it (which may not always fit a short workshop format) as well as the interests of the participants (some may wish to quickly proceed to ideation while others may wish to take their time setting the scene first).

Simply counting the popularity of cards as used can yield some preliminary insights as to their stakeholders' attitudes towards interactive technologies in museums. In this regard, the Visitor Box deck acts as a kind of survey tool to help reveal how the sector is currently thinking. Our data reveals which cards were used most. The following cards were used more than once:

Goals cards reveal overall priorities as: New demographics 12 cards, Use assets in new ways 9, Visitor participation 9, Change visitor attitudes of beliefs 8, Educational activities 4, Visitor numbers 3, Digitize more assets 3, Visitor spend 2, Visitor satisfaction 2, Brand awareness 2, Greater proportion of assets 2.

Motivations cards reveal how they see visitors' motivations for engaging: Curiosity 13, Stimulation 9, Social interaction 7, Academic interest 5, Aesthetic pleasure 5, To make and do 5, Cultural identity 4, Entertainment 3, Time travel 3, Inclusion 3, Wonder 3, Personal relevance 3, Nostalgia 2, Escapism 2, Stimulate the children 2.

4 Darzentas and others, 'Card Mapper: Enabling Data-Driven Reflections on Ideation Cards'.

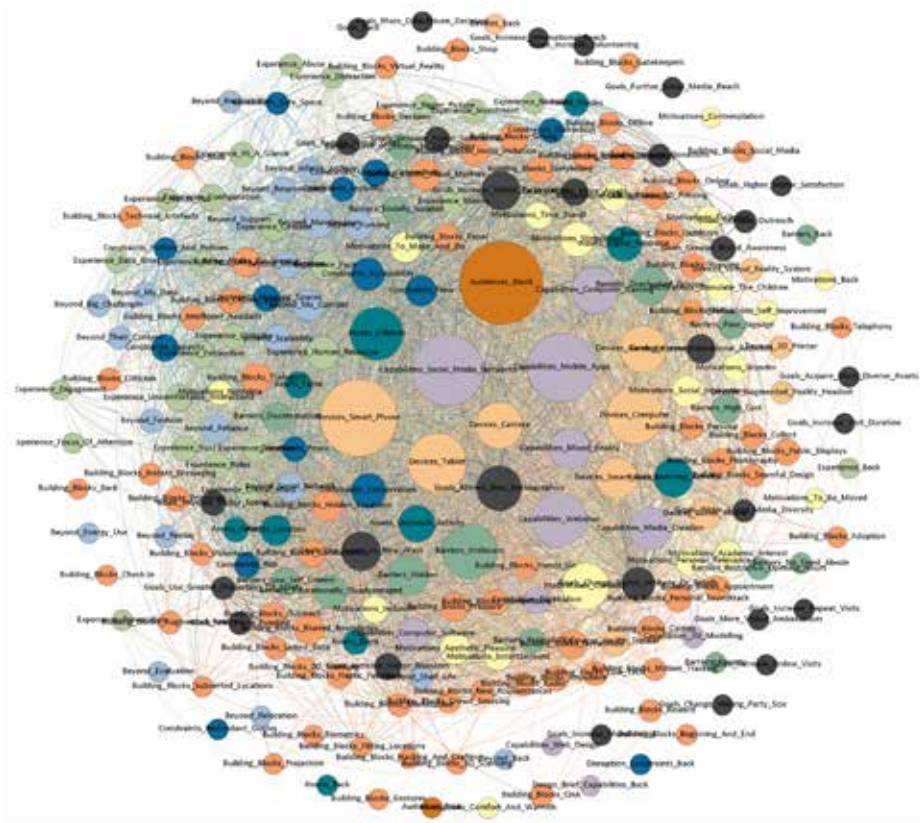

Figure 9.4. The cards perspective

Barriers cards reveal major barriers to digital technology adoption as being: Irrelevant 17, Hidden 10, Overlooked groups 9, Educationally disadvantaged 6, Flow 5, Discrimination 4, High cost 4, Unstable connectivity 3, Low self-esteem 3, Socially isolated 3, Poor signage 3, Accessibility 2, Peace 2, Risk 2, Lack of access to technology 2.

It strikes us that some cards are notable by their absence, not having been used even once. Notable omissions (in our view) include: Visitor Satisfaction, Increase Volunteering, International Reach, To be Moved, and Poverty.

We also explored how our dataset could be further inspected through two complementary visualizations. The first is the Cards Perspective, which gives an overview of all of the cards in the deck and how they have been used as shown in Figure 9.4. This takes the form of a network graph, with each node representing an individual card, the size of which represents the total of how many times this card has been used across all the designs in the

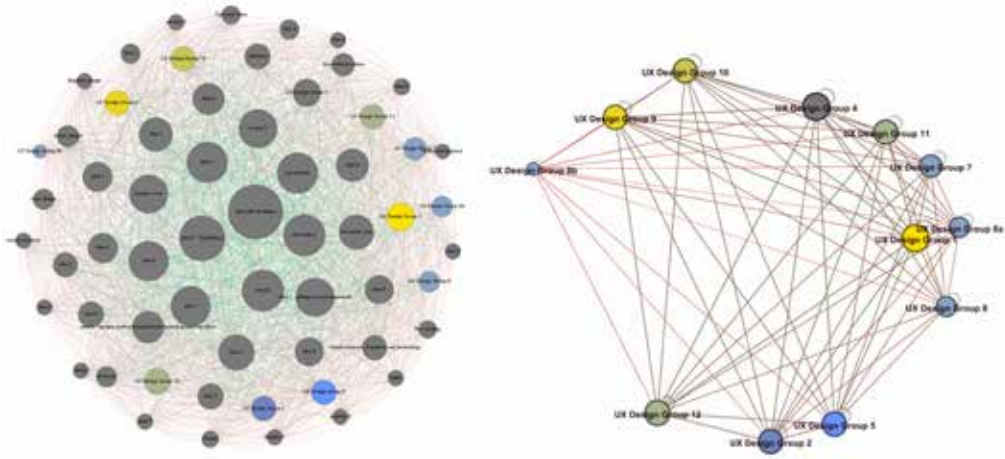

Figure 9.5. The Designs perspective

dataset. The colours match those of the physical cards and convey the theme to which they belong in the deck. Each link between two card nodes denotes the number of times that they have co-occurred in the database of designs (i.e., how often have they appeared together in the same design), with the thickness of the link representing the frequency of these co-occurrences. The card nodes are positioned according to the density of these links. As a result, frequently used and co-occurring cards tend to appear near each other in the centre of the visualization while less frequently used ones appear towards the edge. Cards that are not often used together tend to be positioned far apart. Our visualization is interactive, supporting zooming and panning and also selecting individual cards to show their strength of connection to other cards and data about their use.

The second related visualization is the Designs Perspective as shown in Figure 9.5 left. This shows all of the (currently over 50) designs in the dataset. This is also a network-style graph. Each design that was generated using the cards is shown as a node, with the size representing the number of cards that was involved in generating this design – which can be an early indicator of their complexity. The placement and proximity of the nodes is an indicator of the similarity of the designs in terms of the number of cards they share in common. Two designs are linked if they share at least one card in common. The thickness of the link denotes the number of such shared cards. Again, the placement reveals the centrality or otherwise of designs, at least in terms of the cards they use. Those that use many cards and/or share many in common tend to appear near the centre. Those that

just employed a relatively few distinct combinations of cards – which might be a clue as to potentially distinctive thinking – tend to lie towards the edge.

Subsets of these designs will have been generated by a particular organization and/or as part of a particular design process, and it can be illuminating to compare their particular designs to the whole to see how this organization is positioned in terms of its use of the cards. The most detailed case we have of this to date is the use of the cards to teach Masters students at the IT University of Copenhagen (ITU), especially as each was graded by both the course convenor and an independent museum professional. Figure 9.5 right pulls out the ITU students' designs from within all of the designs we captured to help understand their thinking relative to other designers we had encountered. In being shown the visualization, the course convenor was able to reflect that:

> Groups 7, 8, 11 were variations over the same concept, Tinder-style, the user swipes left/right on a bunch of artwork to indicate preferences to be matched with personalized content [...] Groups 2, 5 and 12 were all somewhat conventional designs (in my opinion), and not very original (though different from one another) [...] Groups 4 and 9 were also very similar designs (learning games about interpreting artworks for school students)

Opportunities and Challenges

We now reflect across our three case studies to consider how they highlight various opportunities and challenges for the data-driven design of interactive museum experiences. We consider this topic from three distinct perspectives: Opportunities and challenges for the designers of such experiences, for the curators that host them in museums, and ultimately for the visitors that engage in them.

For Designers

The main opportunity for designers lies in the richer evaluation of experiences, either to inform new ones in the future (i.e., inter-experience evaluation) or to shape an ongoing one as part of an iterative design process (intra-experience evaluation). We saw how in *Thresholds* visualization of fine-grained interactions across thousands of visitors allowed the testing of key design assumptions: Where do people tend to go, look and dwell within an interactive experience and can they be steered to or away from certain areas (e.g., where invigilators stand or areas of poor sensor coverage).

We saw how in *Gift*, one can get a detailed view of the bottlenecks in an experience: At what 'touch points' (to use a term from service design) in the visitor journey do they disengage, which allows for the refinement of the experience so as to deliver more sustained engagement. We also saw how data visualization can reveal unexpected behaviours that suggest new design opportunities. The social graph of gifting behaviours showed that visitors do not always gift museum artefacts as expected but sometimes take photos of other things; might we build on such behaviours to encourage people to share aspects of the visit beyond only the exhibits as part of a gift?

In turn, the data generated by the *Cardographer* tool enables designers to reflect on their own thinking and potentially to compare themselves to others. Are they drawing on the same ideas time and time again, or perhaps ignoring emerging concepts that might help expand their thinking? In more formal terms, are they suffering from 'design fixation'?[5] At a meta-level, the data can also inform the designers of the Visitor Box cards themselves: Are very popular cards conceptually overloaded and could they be split up into sub-concepts? Are little-used cards redundant or perhaps instead interesting outliers? And can the rules of using cards in design sessions be adapted (e.g., insisting that people choose at least one 'rare' card so as to encourage them to think more laterally)?

A key challenge facing designers lies in harvesting data in the first place. Technically, can they reliably capture it remotely from different museums where an experience is deployed (both *Thresholds* and *Gift* toured to multiple museums), and do they have the infrastructure to manage it? Legally and ethically, what are the appropriate terms under which this might be done, and how are museums and visitors involved?

For Curators

The kinds of data we have presented above suggest opportunities for curators and other museum staff to learn more about their museum and visitors. The *Gift* data, for example, highlights which objects were popular as gifted items and where they were in the museum with potential implications for physical curation: What kinds of objects should be displayed and where? They might also guide the curation of online digital collections: One could prioritize digitizing and recommending on a website objects that people want to gift to each other. There are also obvious commercial implications for refining souvenirs that are available in the gift shop.

5 Crilly and Cardoso, 'Where Next for Research on Fixation, Inspiration and Creativity in Design?'

Another opportunity is to learn more about visitors' behaviours. There have been previous attempts to develop algorithms to identify visiting behaviours from movement data, for example classifying visitors who browse galleries of paintings as being ants, butterflies, fish or grasshoppers and then producing exhibit recommendations based on this approach.[6] The kind of data captured from *Thresholds* might further reveal whether these styles are similarly exhibited in virtual worlds and/or more narrative-driven experiences. We might also be able to segment visitors according to other kinds of behaviour. For example, could further analysis of our gifting graphs reveal the presence of 'super-givers' who enjoy making and giving museum visits as gifts for others and if so, how might the museum support or reward them for being influencers in the network? It might even be possible to profile individual visitors with a view to providing them with personalized experiences. The individual stories associated with gifting might shed light into both givers' and receivers' personal associations with artefacts. However, ethically accessing such data might be extremely challenging as we discuss in the following section.

For Visitors

All too often, personal data appears to be something that is gathered and mined by service providers without the direct involvement of consumers themselves. Even where we understand that data is being captured and can consent to or otherwise control this, it is rarely fed back to us in a way that stimulates reflections and insights into who we are and how we behave. And yet the museum is a place of personal reflection and insight in which engagement with exhibits allows us to understand ourselves better or see ourselves in new ways. How then might visitors engage with their own data?

One option is through souvenirs, using data to generate personalized mementoes of the experience. Indeed, previous research has explored both the generation of tangible data souvenirs from museums as well as co-created photostories from theme parks to which both visitors and the park contributed materials.[7] The kinds of data captured from experiences such as *Threshold* and the *Gift* app might generate souvenirs of various kinds from postcards to tangible gifts.

6 Lykourentzou and others, 'Improving Museum Visitors' Quality of Experience through Intelligent Recommendations'; Sookhanaphibarn and Thawonmas, 'A Movement Data Analysis and Synthesis Tool for Museum Visitors' Behaviors'.

7 Durrant and others, 'Automics: Souvenir Generating Photoware for Theme Parks'; Petrelli and others, 'Tangible Data Souvenirs as a Bridge between a Physical Museum Visit and Online Digital Experience'.

An alternative approach is to directly display the data as labels and signage within the museum to complement traditional exhibit labels and provoke further interpretation. Visitors might be interested in the popularity or otherwise of different exhibits as gifts and also in the personal stories that others have told about them. However, this once again leads us back to issues of data ethics involving both ownership and privacy. The multi-faceted nature of some of our data makes this a challenging question. In the *Gift* app, for example, it is one thing to visualize patterns of gifting among anonymized visitors, but quite another to reveal sensitive details of their highly personal stories. A museum might request a visitor's permission to share, but who would they ask, the giver or the receiver? Who owns the gift and controls how and where it is displayed? Even our apparently anonymized data is fraught with challenges. Consider the case of an individual who makes several distinct gifts for different people where each gift involves unique objects that no one else had given or received. In this case, any of the recipients could spot themselves in the picture by knowing that they had received a particular object. From this, they could then identify the giver and also realise that this person had given many other gifts to other people, which in some circumstances might prove to be an embarrassing revelation. In short, anonymizing this kind of behavioural data is rarely as simple as changing names to numbers, as individuals may be revealed by their distinctive behaviours or connections to others, especially if they are in a minority of some kind. In summary, while this chapter has shown there are great opportunities in data-driven museum design, there are also significant challenges and risks that need to be addressed in tandem before these can be unlocked.

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About the Authors

Steve Benford, Dimitri Darzentas, Edgar Bodiaj, Paul Tennent, Sarah Martindale, Harriet Cameron, and Velvet Spors.

Steve Benford is the Dunford professor of Computer Science at the Mixed Reality Laboratory at the University of Nottingham where he directs the Horizon 'My Life in Data' Centre for Doctoral Training and the 'Smart Products' beacon. He previously held an EPSRC Dream Fellowship, has been a Visiting Professor at the BBC and was elected to the CHI Academy in 2012. He has collaborated with many artists over the past thirty years to create, tour and study interactive performances and installations with a view to gaining new insights into how humans can experience computers.

Dimitrios Darzentas is a multidisciplinary Research Fellow in the Mixed Reality Lab at the University of Nottingham's school of Computer Science. His background is broadly positioned around *Cultural Informatics*, *Game Design and Technology*, *Mixed Reality Storytelling*, and the *Design of Meaningful Things*. He is currently working on several EU and EPSRC funded projects involving the use of technologies such as Virtual and Augmented reality and 3D Scanning in interactive museum experiences. These explore how such technologies can enable end-to-end capture of meaningful content, whether tangible or intangible in nature, and their use through the creation of engaging experiences and exhibits. Beyond these he is also working on projects and evolving fronts involving Future Foods, Circular Economies, Experience and Game Design, and Hybrid Physical-Digital Artefacts.

Edgar Bodiaj is a research associate and developer at the Mixed Reality Lab. He has a background in Computer Science and is currently involved with projects focusing on user interaction and engagement inside Virtual Reality. His research interest includes VR experiences, Data Visualisation, and Novel Online Communication.

Paul Tennent is an assistant professor of mixed reality at the University of Nottingham. He has been working with artists and institutions round the world to deliver and study 'in the wild' experiences for more than a decade. His research is around sensing, sensation and sensitivities, often involving deployments that are physically and/or psychologically uncomfortable.

Sarah Martindale is an audience researcher with an interest in how people attach meaning and value to digital interactions and new media; she is a Nottingham Research Fellow in the Department of Cultural, Media and Visual Studies at the University of Nottingham.

Harriet Cameron is an interdisciplinary PhD researcher at the Mixed Reality Lab, University of Nottingham, based within the Horizon CDT. Her research explores identity, power, space/place, and how technologies interact with and configure these experiential concepts, particularly in galleries and museums.

Velvet Spors is a creative technologist and doctoral researcher at the Mixed Reality Lab, University of Nottingham, based within the Horizon CDT. They are currently investigating digital self-care technologies in a public setting (in partnership with the National Videogame Museum). Their research foci are empathy and care in/with/through technology, games and (implicit) interconnectedness between people.