Beyond Data Visualisations

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How would we respond if we could feel data?
What influence does representation modality have on our experience of data?

Although it is not the purpose of this piece to answer these question we do aim to present an approach that is focused on discovering the answers to these and other questions related to peoples' experience of data represented beyond the visual senses. Before we explore this issue let us begin by drawing comparisons between our approach and that of a data-evangelist from the mid-1850s.

Florence Nightingale, widely known for her pioneering work in nursing during the Crimean war, is also commonly acknowledged as one of the first to utilise the perceptive power data visualisations to draw people's attention to socially relevant issues. She recognised that by presenting data using modalities other than text and numbers that this would help lay non-expert people to better understand and empathise with the implications of the presented data. Nightingale is widely credited with developing the "coxcomb", known today as the polar area diagram, or occasionally the Nightingale Rose Diagram to lay out the causes of mortality on soldiers, highlighting the death toll resulting from preventable diseases (e.g. caused by malnutrition, poor sanitation etc). She used this extensively in 200 books, reports and pamphlets that she published. It could be said that by using such representations Nightingale posed the question "Can people gain a deeper understanding of statistical data by representing it using graphical imagery?"

Our work extends this question by asking "What do people experience when they touch, feel or listen to data?" and "How is touching, feeling or listening to data different from experiencing traditional representations?" We believe that such novel data representations can support a deeper engagement and more intuitive or emotional understanding, as they address/involve more sensory modalities and thus different aspects of human cognition than purely visual representations do. This is inspired by some of our past research that has shown that tangible installations can engage a broad range of people (age groups, interest areas) with e.g. museum installations, and by recent research on the role of embodied interaction for cognition and experience [1]. Although we have as yet to fully answer these questions, we are in the process of doing so by creating a range of unique data-driven artefacts and carrying out studies that explore people's interpretation of the data represented in these objects. We have illustrated some of these developments here to shed light on our present line of enquiry. It is Nightingales' motivation and use of alternative modalities that first drew us to her work and it is also what connects our approaches even though we are separated by over 160 years.

During the intervening century and a half very little happened in regards to the development of techniques that were pioneered by Nightingale and others, in particular William Playfair. Techniques such as the Bar and Pie Chart, or the Line and Circle Graph, have remained unchanged and are still in common use today. They have been shown to be effective if used appropriately. For example, diagrams can reduce the cognitive effort involved in making inferences, exploiting spatial perception and allowing us to see several items of information simultaneously.

From our perspective we however want to point to two key moments that breathe new life into the world of data representation. These were the publications of the eminent scholar and pamphletist Edward Tufte and the heralding of the era of personal computers. When Tufte's book "The Visual Display of Quantitative Information" was first published in 1983 it revitalized interest in the representation of data using visual elements and also revived interest in the 18th century pioneers of this field. Alongside these publications came the widespread proliferation of the personal computer. This device offered new opportunities for non-expert people to engage with new and novel ways of representing data, this was further enhanced with the release of the World Wide Web and more recently the easy availability of big datasets via APIs.

These theoretical and technological developments paved the way for new fields of research in the 1990's, the most notable being Information Visualisation (InfoVis). Shortly after its creation, InfoVis was defined by some as "the use of computer-supported, interactive, visual representations of abstract data to amplify cognition." [2] More recently, with the advancement of various sub-fields such as Information Design, Scientific Visualization, Data Visualization and Information Aesthetics we are starting to see Information Visualisation being labelled as a medium in its own right. Eric

Rodenbeck remarked at his keynote lecture at Emerging Technologies 2008 that “Information visualization is becoming more than a set of tools, technologies and techniques for large data sets. It is emerging as a medium in its own right, with a wide range of expressive potential.” Today we are immersed in what are commonly called information visualisations, from WebPages to TV and Newspapers to Blogs these data objects all compete for our perception and cognitive engagement. The characteristic that connects these is the complete reliance on our visual sense to reveal information from the data. The approach we take to our work is to offer people alternative ways of interacting with data, such as touching, felling or listening.

We are interested in questions such as whether it makes a difference if we can touch and hold a data representation in our hands, instead of seeing it on paper or on a screen from a distance. Does this create a more emotional experience? Could we use non-traditional non-visual representations to support an emphatic understanding of data?

Capturing direct human experience is notoriously difficult. To achieve this we take a phenomenological approach to our research. This involves observing, recording and listening to peoples’ immediate responses as they perceive, sense, and engage with data-driven artefacts. We use these to build a descriptive framework to better understand the range of experiences people have with data.

We place our approach in the field of New Media Art but at the intersection of Interactive Design, Human Computer Interaction and Information Systems. For obvious reasons we do not see our work placed under the umbrella of Information Visualisation although it builds upon theoretical and practical developments that have occurred in this field over the past two decades. We also exploit more recent developments, which aim to democratize the access to data for large cohorts of lay, or non-expert, people. These recent movements represent a significant step away from the traditional focus on developing data representations for well-defined, narrow, expert tasks, and data mining tools for professionally trained experts. Although the exploration and use of alternative modalities to represent data began with the emergence of Ambient Displays this has also been further developed through work in Data Sculpture and Data Art.

While we aim to create data-driven artefacts that possess artistic qualities we also explore peoples’ responses while interacting with these artefacts. For us, data-driven artefacts are physical objects whose movement, shape, sound or texture is controlled and driven by the input of raw data. Once we have created these data-driven artefacts we give them to people or groups of people to use. We then observe and extract personal responses from these people when they are using the artefacts, and ask them to describe this experience. It is this research-through-design and phenomenological approach that we hope will assist us in answering one of our main research questions “What influence does representation modality have on our experience of data?”

Beyond Theory

Over the past year we have created a number of data-driven artefacts that possess a range of physical and interactive qualities. The initial artefacts were stationary sculptural pieces that represented data through their form. “Vessels of Ireland’s National Debt (1910-2010)” (figure 1) is made up of a group of hollow vessels produced by inputting data collected from the national debt of Ireland over the period 1910 to 2010. The data was put into a software program sequentially and processed to produce a number of 3D models whose profile was mapped to that of the data stream. These models were then printed using a 3D-Printer. The purpose of creating these vessels was to encourage people to reflect on the economic, social and cultural implications that surround the conceived dataset in an interesting and unique manner. It was also intended that the vessels themselves would be the immediate object of interest, however, as the audience touch and caress the uneven and pointed edge of the vessels they would think beyond these to the topic of national debt.

Figure 1. Vessels of Ireland's National Debt (1910-2010), Trevor Hogan 2010.

This project utilised peoples' perceptive capabilities through their visual and tactile senses. Following this we began to investigate the use of multiple modalities that represent the same dataset. This study involved the design and creation of physical objects that were also dynamic and responsive to the data driving them. The main criteria for selecting a data source for this and all of our projects is that it must be socially relevant and from a trust-worthy source. We selected a dataset collected by the United Nations that represents the latest global urban outdoor air pollution figures from 91 countries. For our study, the annual mean reading for six countries (Greece: 44, Ireland: 15, India: 109, Egypt: 138, United Kingdom: 23 and Turkey: 66) was used. As we were interested in how the modality affects the experience of the user we utilised the same data for all the artefacts created for this study. In designing the artefacts we explored many modalities, and also wanted some of the artefacts to represent the data using more than one modality (i.e. haptic *and* auditory). Collaboration with peers while using the artefacts was also an important characteristic that we sought to facilitate for in the design process.

SonicData and DataBox were two of the data-driven artefacts that were produced for this study. SonicData represents the dataset by playing sonic tones at certain frequencies through a tactile interface. Users of SonicData are presented with a labelled surface and a small coloured wooden cube. Placing the cube over each label plays a tone in a frequency representing the urban air pollution of that country. The tones' frequency is mapped to the level of air pollution; high pollution results in a high frequency sound and low pollution will result in a low sound. DataBox is a wireless cube-shaped object (10x10x10cm), which represents the dataset through haptic and auditory feedback. The six faces of the box represent the six countries of the dataset. When the user hovers each face over a scanning station DataBox immediately responds by knocking on the internal walls. The rate of knocks corresponds to the level of air pollution, high rate means high pollution and visa versa.

Beyond Design

As important as the design and production of these artefacts was to us, investigating peoples' experience when using them was always going to be the key part of this study. Taking a phenomenological approach, we gathered a group of people together and presented the artefacts to them. We let them use the artefacts for a time while observing and recording their interactions and conversations. A short time later we conducted a group discussion to come up with quality-dimensions for each of the artefacts. It was to be expected that the unfamiliar mapping utilised by the artefacts would cause some difficulties, but this was offset with what we observed when reviewing the transcribed sessions.

We found that the language used by participants while interacting with the Databox and Sonicdata was, in general, more emotive than when around traditional visualisations such as a Bar Chart. There was frequent use of expressive descriptions such as; annoying, hurts, beautiful, healthy, alarming, relaxing, dead, urgent, fun, torture, irritating and intense, used in relation to the Databox and Sonicdata. At one point a participant, when using the DataBox, remarked that some of the countries feel very unhealthy and some of them felt dead, associating the knocking of the box to

the heartbeat of a country. The conversations also focused on the consequences of air pollution and participants spoke very candidly about how they would feel if they were living with such high pollution, mentally transporting themselves into the environment. The visceral and emotive nature of these conversations tell us that people seem to respond to data, represented beyond the visual sense, in a way that is not present when it is represented through familiar visual metaphors.

But our work continues, we strive for more clarity regarding the description of peoples' experience of data represented through touch and sound. To date we have created a number of sculptural pieces as well as responsive tangible devices, all of which represented socially relevant archived data. The next stage of our research will involve streaming live data into handheld objects. The data will be mapped to the objects movement, vibration and sounds that are emitted from the object.

Beyond Us

Although the topic of our research is still somewhat in its infancy we do not claim to be alone in this investigation. Many people, from many differing fields, are engaged in similar lines of enquiry, all of whom inspire us in many ways. Andrew Vande Moere publishes widely on the topic of data visualisation and was instrumental in drawing academic interest to discrete fields such as data sculpture. Lev Manovich has addressed many issues related to data representation. His essay "Data Visualisation as New Abstraction and Anti-Sublime" is widely cited and clarifies many issues related to the artistic representation of data. In his publications Mitchell Whitelaw explores a wide range of data issues but also applies this theory to the creation of artistic pieces that are exhibited widely. As well as these theorists there are also many practising artists and designers who stimulate us by using data not only as their source of inspiration but also as their medium. These include the dramatic and awe-inspiring photography of Chris Jordon, the stunning virtual objects by Alex Dragulescu, Etienne Cliquets data origami, Nathalie Miebachs complex and intriguing sculptures and Adrien Segals data inspired furniture [3].

Beyond Now

The work by these and others confirm that representing data beyond the traditional formats is an exciting place at present. This is also assisted by emerging technologies that enable us to capture and represent data in ways that were not afforded to our predecessors. There are now many web services available that let us utilise vast amounts of archived data and also tap-into live data streams. Making use of this data beyond the printed page or LCD displays is now much more accessible with a plethora of off-the-shelf actuators driven by easy-to-use microcontrollers. The future also looks bright, it has been said that data will be the black gold of the 21st century. While many are exploring new ways of drilling, storing and piping this commodity into our computers, mobile phones and other digital devise, we seek out new and engaging ways of representing it beyond the screen. To conclude, when some seek to explicate the virtues of information visualisations, they often resort to the age old saying "a picture paints a thousand words". Without disagreeing with this, the purpose of our research is not to compare the amount of words other modalities paint but to explore the differences in the painted words.

Endnotes

[1] Hornecker, E., Let's Get Physical: The Role of Physicality in Tangible and Embodied Interactions. ACM interactions magazine vol 18, iss.2 (March/April), pp. 19-23

[2] Card, S. and Mackinlay, J. and Shneiderman, B., Readings in Information Visualization: Using Vision to Think, Morgan Kaufmann Publishers, 1999.

[3] Contact details for those mentioned in this section: Andrew Vande Moere (http://web.arch.usyd.edu.au/~andrew/), Mitchell Whitelaw (http://teemingvoid.blogspot.com/), Lev Manovich (http://manovich.net/), Chris Jordan (http://www.chrisjordan.com/), Alex Dragulescu (http://www.sq.ro/), Etienne Cliquet (http://www.ordigami.net/), Nathalie Miebach (http://nathaliemiebach.com/), Adrien Segal (http://adriensegalfurniture.blogspot.com/).