

Tangible Data, a Phenomenology of Human-Data Relations

Trevor Hogan

Bauhaus-Universität Weimar, Fak. Medien,
Bauhausstr. 11, D-99423 Weimar, Germany
hello@tactiledata.net

ABSTRACT

This paper presents an overview of the research that I have conducted as part of my PhD studies. The objective of this research is to describe and better understand how embodiment influences and augments an audience's experience of data representations. It explores, through creative practice, whether embodying data in alternative modalities contributes to an audience's capacity to construct meaning and empathize with the data source.

Author Keywords

Tangible User Interface, Physicalization, Representation Modality, Qualitative Analysis, Phenomenology, Psychophenomenology, Elicitation Interview Technique, Repertory Grid Technique

ACM Classification Keywords

H.5.2 [Information Interfaces and Presentation]: User Interfaces - Haptic I/O

RESEARCH SITUATION

I am a self-funded external PhD student at the Bauhaus-Universität, Weimar and have just finished my 3rd year of a 4.5-year PhD program, under the supervision of Professor Eva Hornecker. My work is strongly interdisciplinary and may be situated in the field of Interactive Design, at the intersection of Tangible Computing, Human-Computer Interaction and Information Science. Over the past 3 years I have conducted 5 main studies, and I am in the process of planning a final study that will draw together what I learned to round off my thesis.

From attending the Graduate Student Consortium I hope to get senior advice on how to strengthen my argument that embodying data in different modalities influences and augments people's experience of the data representation. Recommendations and feedback on the methodological approach of my further study designs are also highly appreciated.

CONTEXT AND MOTIVATION

In contemporary society, data representations are now an integral part of every aspect of our daily lives. The amount of digital information that is available to us is not only constant-

ly increasing but it is also ubiquitous. The discussion of information visualization as a tool has vastly expanded from the economic and scientific communities to the humanities and the arts and has long entered our everyday life. With this trend, the audiences or target groups that visualizations are designed for are no longer just domain experts or analysts but also everyday people who are confronted with data representations on a daily basis on the newspaper, in advertisements, at the museum, the library or other public spaces.

My research is based on the belief that new insight and meaning can be achieved by representing data beyond the visual modality, which can be touched, felt, heard, held, or even possessed. Consequently, these artifacts act as the embodiment of the data source. They capture the imagination and engage the interpretative and perceptive power of its audience through both their experiential, tactile or artistic qualities. The focus and motivation of my research is to represent data in a manner that exposes insight and affective responses that may be difficult to uncover when using traditional methods such as one-dimensional static graphs and charts. I argue that the use of modalities such as haptic, tactile, auditory - or any combination of these - to represent data can facilitate an experience for people that causes them to empathize with, and be affected by, the data source, in a manner that is significantly different when only the visual modality is used.

BACKGROUND AND RELATED WORK

My research is also motivated by recent literature that emphasizes the felt experience of interaction [8], as well as the re-emergence of phenomenology within the HCI community as an approach to better understand people's experience of technology (cf. [1]). I also seek to build upon theoretical and practical developments in the field of Information Visualization over the past two decades.

The exploration and use of alternative modalities to represent data began with the emergence of visualizations such as Ambient Displays [9]. This approach has been further developed through novel information visualization subfields that include Information Aesthetics [6], Artistic Visualization [13] and Data Art [7]. There has also been recent theoretical investigation into alternative approaches, such as Zhao and Vande Moere [14] who defines the concept of data sculpture and establishes a model of embodiment to analyze the connection between data and representation. Vande Moere followed up this research by introducing different levels of data physicality, which affect how data is mapped and perceived by human senses [11]. My research seeks to build upon this foundation,

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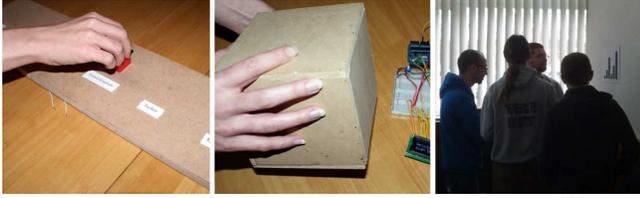


Figure 1 The same data source represented through different modalities. Left: SonicData (auditory), Middle: DataBox (Haptic). Right: Bar Graph (visual)

while focusing more closely on the role that representation modality plays in people's experience and perception of data.

STATEMENT OF THESIS OR PROBLEM

To date, the majority of published research on the evaluation of data representations predominantly address questions regarding user performance, usability, and visualization algorithms; studies that shed light into more open-ended questions regarding insight and discovery and experiences with visualizations are relatively rare (cf. [5].) One possible reason for this is that we still lack evaluation methods that can derive reliable and rich data on experience, insight generation, and discoveries. A goal of my research is to extend the present evaluation framework to include user-experience and, in particular, affective responses when evaluating the quality of data representations. My approach attempts to fill this research gap in order to support work that seeks to represent raw data using alternative modalities. I have a number of research questions, that, over the course of my studies, I have attempted to answer using a number of different methodologies:

- What influence does representation modality have on our experience of data-driven artifacts and how does this affect the way information is accessed and received by the audience?
- What meaning is made from the data, and what are the participative levels of engagement with data artifacts?
- How does embodying data beyond the visual modality, using for instance tangible metaphors contribute to an audience's capacity to construct meaning at its interface?
- How can a better understanding of people's experience of data representations inform future designs?

RESEARCH GOALS AND METHODS

My research attempts to explore the role embodiment plays when experiencing data representations. The approach I take involves designing and producing multiple data representations, each of which have alterations, such as the representation modality (see Fig 1. for example). Through a process of evaluation I aim to expose how these alterations have affected people's experience of the different artifacts.

I further describe my research approach as phenomenological oriented, developing findings inductively. The purpose is to

reveal a general description of people's experience of data representations as well as eliciting a detailed description of the unfolding of this experience. My phenomenologically based studies, which include methods such as the Repertory Grid techniques [3] and Vermersch's Elicitation Interview technique [12], are designed with the aim of revealing this first-person experience, along with the cognitive effects and affective responses when interacting with bespoke data-driven artifacts.

DISSERTATION STATUS

At TEI'15 I will have just completed the 3rd year of a 4.5-year PhD program and I plan to start writing up in the summer of 2015. Over the past 3 years I have conducted a number of studies. In the following I provide a brief overview of these studies in chronological order. I then discuss my plans for a final study that will draw together all the knowledge gained in the previous studies.

Study 1. Representation Modality and the Repertory Grid Technique

The first major study I conducted as part of my doctoral studies involved producing several data-driven artifacts that represent the same data source using different levels of modality. Of the three artifacts created, DataBox used haptic feedback in the form of knocking to represent the raw data, SonicData represented it through auditory feedback, while the same dataset was also represented using a traditional bar graph (see Fig. 1). To investigate the affect these modalities had on people's experience of the data we carried out an adapted Repertory Grid Study. Findings indicate that the modality and modality combinations used to represent data do influence the users' experience and affective responses [2].



Figure 2 (left): Solar Radiation Dowsing Rod. (right) H³

Study 2. Experiencing Live Data

Using some of the findings from the previous RepGrid study, I collaborated with Blackrock Castle Observatory, Cork, Ireland and the Irish National Space Centre to represent live streams of astronomical data. We created two cross-modal data driven artifacts H³ ('Hydrogen cubed') and a Solar Radiation Dowsing Rod, to stimulate curiosity, intrigue and awareness of scientific data in a casual non-expert audience (see Fig.1.) These devices were presented as demos at TEI'13 in Barcelona [3]. To observe their use and assess the user-experience we deployed the devices in Blackrock Castle Observatories visitor centre. Over the course of one week approximately one hundred visitors used the devices while we conducted observations and some informal interviews. The

focus of this study was not to expose any usability issues relating to the use of the devices, but to observe people's responses and to probe them about how they felt while interacting with them. We found that the devices stimulated imagination, and provided a 'tangible' direct experience of the otherwise abstract data from outer space.

Exploring and Extending Methodologies

Data representation is a popular tool to help sense-making, discovery and communicating insights. However, evaluating the impact of these in all their ubiquity is still a challenge [5]. In particular, we are lacking techniques to help us understand how representations are interpreted and experienced by people on an individual and personal level; important aspects when it comes to understanding how insights and discoveries are facilitated (or not) by data representation. Over the course of my PhD studies I have utilized and adapted two techniques to better understand people's experience as well as the insight that is generated by them as they interpret data representations.

Study 3. Blending the Repertory Grid Technique and Focus Groups

In a previous study [2] we used the Repertory Grid (RepGrid) Technique to compare and contrast people's experience of representation modality. During this study we found the RepGrid to have some limitations. Taking these into account, we designed a study to explore the benefits of blending the traditional application of the RepGrid technique with focus groups. In [3] we demonstrated the potential of this blended approach by conducting two empirical studies that investigate the same artifacts, using two different approaches. The first study follows the classic RepGrid approach, while the second adapts this by utilizing the RepGrid in a focus group session. Since the inception of the RepGrid technique, no adaptation has been purported to produce rich qualitative data during a group session. We showed how this blended approach has potential to equip a designer or researcher who wishes to better understand people's experience of designed artifacts while also revealing rich design relevant information.

Study 4. From Phenomenology to Psychophenomenology

Following our exploration of the RepGrid technique we started to look for other methods that would allow us to gather more fine grained accounts of experience as well as revealing insight about the unfolding of this experience over time. The method we chose was Vermersch's Elicitation Interview technique. The interview technique is a form of retrospective interviewing grounded in psychophenomenology. In contrast to traditional interviews, this technique is non-inductive but directive where the focus of the interview remains on a particular experience; the participant reaches and maintains a state of evocation that enables them to re-live their experience while minimizing post-reasoning. Following a number of training sessions in Paris, France with Claire Petitmengin, a key practitioner of the technique, we conducted a study to

illustrate how the Elicitation Interview technique can be used to gather accounts of people's experience with data representations, and to highlight the type of insight it can provide about people's experience of data visualizations, how these experiences unfolded over time and how key moments manifest themselves as part of the exploration of the visualization (*Article Title: "Introducing the Elicitation Interview Technique to Capture People's Experiences of Data Representations" in review at IEEE Transactions on Visualization and Computer Graphics*). In this article we presented a study that interviewed 10 participants about their experience with a static data visualization and examined the transcripts using thematic analysis. We believe that there is evidence to show that this technique offers us an evaluation tool to collect reliable and rich accounts of experience that uncover issues that go beyond common comprehension or usability aspects. In particular, we show that the elicitation technique could bring to the fore details about the formation of meaning, the construction of personal connections to the represented data, and the establishment of a dialogue between the person and the data or creator of the representation.

A Design Space for Multisensory Data Representation

As well as design and evaluation studies presented above, I have also conducted theoretical explorations, one of which was aimed at establishing a design space for multisensory data representations. Over the course of 18 months I surveyed 85 existing examples of data representations that require more than one sensory channel to fully interpret and understand the data. Based on this review we establish the design space along three axes of dimensionality: *use of modalities, representation intent and human-data relations*. The purpose of this study was not only to inform our own research, but to also draw the attention of the wider research and design community to aspects of data representation that have been hitherto either ill-defined or underexplored. The contribution of this study is threefold. Firstly, we attempted to define, for the first time, "multisensory data representation". Also, from 85 existing examples, we surveyed the state-of-the-art in multisensory data representation. Finally, we shed light on theoretical and practical considerations and point toward research challenges and questions that are presently underexplored.

The Final Study

To round off my thesis, I am planning a final study that will draw together the design and evaluation techniques that I have used thus far, to explore, in greater detail, peoples experience of interpreting and perceiving data representing through various modalities (auditory, vibro-tactile and visual.) To accomplish this I have created three tangible interfaces that measure and represent the levels of Carbon Dioxide in indoor air through sound, vibration and visuals (see Fig 2.) Up to this point in my PhD studies, the artefacts that I have produced were either interfaces produced for the sole purpose of exploring representation modality [2] or bespoke designs to be used within a public museum [3]. However, these latest

objects were designed for the home or workplace, which will offer us the opportunity to explore peoples everyday experience of data represented through different modalities. We

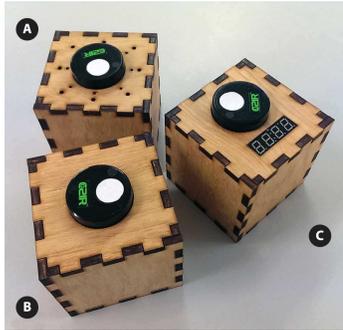


Figure 3. (A) CO₂ Auditory Interface, (B) CO₂ Vibro-tactile Interface, (C) CO₂ Visual Interface

have already conducted a pilot study, which deployed the devices into homes and workplaces to gather initial observations about their use in real environments. From this we learnt that the devices are intuitive, participants had no difficulties operating them and in some cases they were appropriated for situations that we had not envisaged.

The next phase of this project will involve using our adapted RepGrid technique alongside an Elicitation Interview study to gather and analyze fine-grained accounts of people's experience of the different modalities and how this experience unfolded overtime. We hope that these methods will allow us to establish a general description of people's experience of the various representation modalities under investigation.

EXPECTED CONTRIBUTIONS

Recently there has been a dramatic rise in the amount of research focusing on the storage and retrieval of data. We have also seen a rise in the movement to democratize data, as well as new attempts to explore the use of modalities beyond the visual paradigm to represent data (cf. [9]). Questions that have been somewhat ignored include: *how the general public engages with, interprets, and experiences the represented data? What role does representation modality plays in people's experience of data? and What qualities are important to people when describing their experience of data representation?* The main contribution of this research will emerge from answering these questions. However, we also see process of answering these question as important and valuable as the answers themselves. Over the course of the last 3 years we have adapted a relatively underexplored techniques (the RepGrid) and demonstrated how it could be used to elicit rich design relevant insight. We also extended our repertoire of elicitation techniques through the use of Vermersch's elicitation interview. We hope that the work we have conducted on these methods will contribute to the TEI and wider HCI research community; by offering new approaches to reveal rich ac-

counts about people's experience with technology that will inform the design of artifact that represent data beyond the visually modality.

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