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Using Information Visualization to Support Creativity in Service Design Workshops

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Abstract

In this paper we outline ongoing PhD research in which we are exploring how information visualization can be used to make quantitative data more accessible and engaging to key stakeholder representatives during service design workshops. We also outline how such visualizations could be used in conjunction with applied creativity techniques to identify ideas for design requirements that are both novel and appropriate, and therefore considered creative. We illustrate this research with details of a workshop held with customers and staff of E.ON Energy in which the objective was to design new services that utilise the data generated by smart energy meters.

KEYWORDS: information visualization, creativity, smart energy services

Introduction

In this paper we describe research exploring how quantitative data can be used to support the creative ideation of participants in service design workshops. We discuss how information visualization can make data more accessible to a wide audience and how applied creative thinking techniques could stimulate ideas that are both novel and useful. To illustrate this we describe a case study in which customers and staff of E.ON Energy came together for a workshop in which the objective was to design new services made possible by the data generated from smart energy meters. This research is important because a better understanding of how to stimulate creativity in workshop participants can help us address Norman's criticism that user-centred design methods often fail to produce major enhancements (Norman 2005, 2010). In addition, our aim is to find ways of extracting value from data, which compliment more common algorithmic techniques by utilising human creativity.

Background

Data play an increasingly prominent role in modern life. We nearly all carry smart phones that help us contribute to the large amounts of personal, social and location data being generated. In addition, devices such as smart energy meters that generate fine-grained consumption data or 'black box' vehicle monitors that record data about our driving are also becoming increasingly familiar. At the same time, data such as census and demographic information, government spending and service provision, housing market statistics and real-time transport information are readily accessible via websites such as data.gov.uk. These data are becoming key to the way major societal issues are approached. For example, one primary motivation behind the planned rollout of smart energy meters to upwards of twenty four million UK homes and businesses by 2020 is the expected impact the data they generate will have on consumption behaviour. It is hoped that these data will enable new services that encourage customers to shift energy consumption away from peak demand times, reduce the need for standby power stations and help the UK meet sustainability targets (DECC 2012).

Many current approaches to extracting knowledge and therefore value from these data are algorithmic and statistical, often making use of machine learning techniques (Witten 2005). However, there are a number of potential problems with such 'Big Data' methods. These may relate to data's context and meaning, to the ethics of using data, and to claims for data's objectivity and accuracy (Boyd & Crawford 2012). Our research takes a different approach, utilizing human creativity to place data in their wider context, to investigate the impact they might have on the lives of various stakeholders, and to suggest ideas for new products or services that respond appropriately. We believe that these data are an important resource that can be used to inspire creativity, particularly at the front end of design projects, where outcomes are not yet certain. To achieve this we employ information visualization tools to provide representations of quantitative data generated within the domain for which new products or services are to be designed, as part of workshop activities undertaken by representatives of key stakeholder groups.

Information visualization has classically been defined as "the use of computer-supported, interactive, visual representations of abstract data to amplify cognition", its purpose being "insight not pictures" (Card, Mackinlay & Shneiderman 1999:7). To achieve this, information visualization techniques make use of the human visual system's powers of pattern recognition and discrimination to explore large amounts of what may be complex data (for a detailed explanation, see Ware, 2012). Wattenberg and Kriss (2006) have demonstrated how information visualization is an effective method of making data more accessible and engaging to a public audience, encouraging people to undertake data analysis socially. Authors such as Tufte (1983) and Few (2009) have provided influential design guidelines. Information visualization has also been identified as a key tool to support creativity in the 21st century (Shneiderman 2001). In particular, the opportunities it provides for comparing alternatives thoroughly and rapidly by coding with visual variables such as colour and size; using computational power to filter or refine dynamically; and then utilising human perceptual skills to identify patterns trends or outliers and gain insight. Hans Rosling's Gapminder (www.gapminder.com) presentations of international development data, and Aaron Koblin's Flight Patterns (www.aaronkoblin.com) which displays the flight paths of US air traffic, are well known examples showing different styles of information visualization.

A Case Study in Designing Smart Energy Services

This case study describes a workshop held in Milton Keynes, UK with customers and staff of E.ON Energy. The objective of the workshop was to generate ideas for new services that utilise data generated by smart energy meters. There were thirteen participants, ten male and three female. Eleven participants were E.ON customers recruited from households taking part in a long-term trial of smart energy technologies being run by E.ON in Milton Keynes. The remaining two participants were members of E.ON staff, employed on their smart meter programme. All participants were familiar with energy monitoring and the data that smart meters generate, they had prior experience with simple visualizations of energy data through the monitors used in the technology trial. The customers who took part in the workshop were already engaged in and informed about energy related issues. This is evidenced by their voluntary participation in E.ON's technology trial and the commitments required for this.

Visualizing Energy Consumption Data

We designed a custom information visualization (Figure 1) to use in the workshop. This was based on simulated smart meter data generated from a model of typical energy consumption built for the wider project this case study was part of (Gruber & Prodanovic 2012). These data represent seven days' energy use for one household, based on a selection of possible consumption patterns rather than particular demographic factors. There is no single correct description of the people who might make up such a household. The design of this information visualization was informed by a pre-workshop study in which we found that increasing the ambiguity in the visual encoding of data elements resulted in ideas that were considered significantly less appropriate to the domain of domestic energy.

In the information visualization we show the energy consumption data for nine classes of appliance. Each class contains a number of specific instances of appliance. For example, the cooking class contains instances of cooker, hob, kettle, microwave, coffee machine and extractor hood. Consumption can be explored as kilowatt-hours or as a cost in pounds sterling. The appliance type and unit of measure currently selected are indicated with a red highlight. To introduce participants to the idea of tariffs in which the price of energy units vary at different times of day we created five simple price bands covering different periods. These are indicated through colours ranging from green to blue. Such variable price tariffs are one possible route towards shifting peak energy demand.

In designing the information visualization we used in this workshop we were informed and guided by our work with visualization experts at City University London's giCentre, who we were collaborating with to design new visualizations for E.ON energy analysts (Goodwin et al 2013). Further guidance came from considering Tufte's (1983) and Few's (2009) influential design guidelines; Moere and Purchase's (2011) discussion of the role design plays in information visualization; and Wattenberg and Kriss' (2006) description of designing for social data analysis through the use of expressive spectator interfaces. The visualization uses a linear timeline and bubble graph to show consumption over time, with a colour scheme derived from colorbrewer.org to represent the variable pricing scheme, and area chart to depict the percentage of energy used when different prices are in effect (Figure 1 left). Details for each hour's consumption are available by selecting the bubble representing that hour (Figure 1 centre), with further details available for each day's consumption (Figure 1 right).

Figure 1: Screenshots of the information visualization used during workshop activities

This follows Shneiderman's mantra of "Overview first, zoom and filter, then details on demand" (Shneiderman 1996). The information visualization is available in its interactive form online at www.dadc.co.uk/eon . Workshop participants were given the information visualization on iPads. This was to support interactive exploration and because the form factor and portability of an iPad makes it particularly suitable for small group collaboration in a workshop setting.

Workshop Activities

The workshop was made up of five main activities. The first two of these were information gathering, data exploration activities. These activities played the role of the preparation phase common in many models of creative processes such as Wallas' four-stage model, which includes *preparation incubation illumination* and *verification* stages (Wallas 1926). Treffinger (1995) characterises this preparation stage as including processes of mess finding, data finding (through information search), and problem finding. Here, the information visualization played a key role and it is these activities that will be discussed in greatest detail. The third activity was designed to gather evaluation data, this is discussed in the Evaluation section and the fourth was a group brainstorming activity, which is not discussed here. In the day's fifth and final activity, participants developed their favourite ideas and described them at three key stages. This activity will be outlined in more detail in the Activity 5: Generating Service Designs section of this paper. The activities described here were undertaken in small groups of three or four participants. Participants self-selected these groups, with the only criterion being that each group should have at least one member experienced and confident using an iPad, as this was how they would interact with the information visualization.

Activity 1: Who Lives Here?

For this activity each of the small groups was given an iPad showing the information visualization app, an A1 sized worksheet and a creativity toolkit consisting of marker pens, post-it notes, coloured paper shapes, glue, tape, scissors and around three hundred photographs of people, buildings, transport, food and technology.

Participants were asked to explore the information visualization and imagine what type of household might be represented by the energy consumption data it is based on. They were asked to spot patterns of consumption indicating who the household were, what their lifestyle is like and what their attitudes to energy and technology could be. The purpose of this activity was to encourage participants to explore possible energy consumption behaviour and use the insights they found as the basis for discussions about the context in which that behaviour might take place. We wanted participants to share their knowledge, experience and concerns regarding energy related issues. The information visualization is based on simulated data, derived from models of typical consumption patterns rather than from demographics. We had no single correct answer in mind to the question 'Who lives here?'.

Figure 2: Participants creating representative households in Activity 1

Each group used the worksheet and creativity toolkit to create a collage that described the household they imagined best reflected the insights they found in the data (Figure 2). The importance of this type of generative activity has been demonstrated by Sanders (2005), who describes how understanding what participants make, as well as what they do or say, brings to light their experiences and highlights desires or requirements that might not otherwise be expressed. The worksheet contained areas to show the household's members, the type of property they live in, the type of energy consumer they are, how they might feel about technology, what their mealtimes might look like and the ways they travel. The activity ended with each group presenting their household to camera. These representative households were subsequently used as personas that the group would consider when assessing the appropriateness of their smart energy service ideas.

Activity 2: Win a State of the Art Smart Home

In this activity, participants were again asked to explore the energy consumption data represented in the information visualization. This time their task was to suggest ways for their representative household to be smarter in their energy use. This could mean reducing the total amount of energy they consume or changing consumption behaviour to reduce their potential energy bill. Activity 2 took the form of a competition with each group completing an entry form on which they listed their top five ideas. The entry form also contained a tiebreaker question in which we asked each group to briefly describe a piece of smart home technology that would improve their representative household's lives and lead to smarter use of energy.

Activity 5: Generating Service Designs

In the final activity, each group of participants selected one or more of the ideas generated during the day, which they then developed more fully into a new service. This service would utilise smart home energy data and reflect the needs of the representative household they had created in the first activity. Each group was given three more A1 worksheets to describe their service at three key stages. On the first worksheet they were asked to describe what it is like when the household sign up for the new service, addressing factors such as their household's motivations. On the second worksheet they described how it felt the first time that the service was used by their household. On the third worksheet they described what it was like once the service was an established part of their household's life. These worksheets were completed in a similar fashion to those in Activity 1, using the same toolkit. This activity ended with each group presenting their service idea to camera.

Figure 3: Representative households created during Activity 1

Evaluation

We used two methods to evaluate the support the activities incorporating the information visualization provided for participants' creativity. In the first, we asked each participant to complete three postcards. This task was the third workshop activity. On each of these postcards we printed a prompt that addressed aspects of creativity or insight support identified from the literature. These prompts were derived from the Creativity Support Index questionnaire (Carroll et al 2009) that we have used previously and from an understanding of how users gain insight using information visualization derived from Yi et al (2008) and North (2006). Participants were asked to reflect on and respond to these prompts when they completed the postcard. This evaluation method is discussed in detail in (Dove & Jones 2013). Participants' responses were transcribed for analysis, which was undertaken in a manner similar to the analysis of open questions from a questionnaire.

We also assessed the creativity of the outputs produced in the workshop's activities. In the outputs from Activity 1 (Figure 3) and Activity 2 we were looking for evidence that participants had explored a number of possible alternatives and that they had used these to develop rich descriptions of their representative households. A rich description would show detail in their household's background and would consider the context around its energy use. We looked for evidence that insights gained exploring data were developed into rounded characteristics by the addition of aspects from the participants' own experience and knowledge. Here, the differences between each of the groups' representative households and the imaginative details in the stories behind these households would indicate that visualized data can provide effective stimulation for participants' creativity. In the service design outputs created during Activity 5 (Figure 4) we were looking for evidence that participants had developed ideas appropriate for their representative household and which reflected the insights into energy consumption they gained. We were also looking for evidence of novelty in the form of new services or new implementations of services.

Results

Our analysis of the postcards completed by participants during Activity 3 indicates that using the information visualization during Activity 1 and Activity 2 was engaging and supported collaboration. This is demonstrated when we look at individual quotes from our participants: *"Our group was engaged and excited. We really used the tech to answer the Q's"*; *"I felt engaged and absorbed with the tasks…. The technology was very useful"*; "*I fully immersed myself in the activity…. The technology was extremely useful and very interactive*".

Figure 4: Example service design output from Activity 5

We also found that participants were able to build on their existing knowledge, with individual quotes again being informative. *"The iPad data visualisation was very useful as it made it surprisingly easy to look at each piece of data…. I could also use it with my own knowledge which I had to do for the first task."*; *"Easy to imagine the type of people in the house. My existing knowledge fitted well with the issues raised by the data"*; *"It was easy to incorporate this data with existing knowledge"*. Insight seeking was also supported, with both overview, and patterns and relationships being easy to discover. Once more this is well illustrated with individual participant's reflective comments. *"Yes it clearly helped you to understand patterns. Usage, timelines and others quickly"*; *"Definitely. You had a broad overview and you could drill down to get clearer answers"*; *"It was easy to get an overview about each group of data…. and that made it very easy to compare the data and come to assumptions about it"*.

The worksheets completed during Activity 1 (Figure 3) show how each group found insights they thought important in the data and then used their existing knowledge and experiences to develop these into rich descriptions of the kind of household they thought the data might represent. The following are a few brief examples. The first group saw a pattern in which the household used entertainment equipment late at night and another pattern showing relatively frequent washing machine use. They thought the data best represented a family with children. Our second group also saw these patterns but thought that additional patterns showing irregular cooking and repeated use of a hairdryer indicated that the household might be single, urban and female. Our third group also spotted the irregular cooking patterns but thought that this indicated an outdoor lifestyle, which suggested that the household were 'concerned greens'. Finally, the fourth group spotted that more cooking was being done on Monday and thought this meant the household might batch cook meals and reheat them later in the week. They also noted a pattern in the heating that suggested a household member worked from home or worked part-time.

In our assessment of the final service design outputs (Figure 4) we were looking for evidence of two key factors. First, that participants had developed ideas appropriate for their representative household and which reflected the energy consumption patterns they uncovered. Here there was evidence of success as each group's service was a development of the insights and ideas gained exploring the information visualization in the first two activities. In each case we can tell a coherent story of how the service ideas respond to the needs of the representative household users. The second factor we were looking for was novelty in the form of new services or new implementations of services, different from those already familiar to participants. Here the evidence is less strong. Two groups developed ideas for detailed energy audits. This takes the desire for more granular information and for

historic reports, both of which had been expressed elsewhere during E.ON's longer-term technology trial, and extends them into a complete service. A third group developed an automated shopping service based on a smart fridge. This is similar to ideas that have been around for the last decade, occasionally gaining a high public profile (Kuniavsky 2008). The final group developed a service to automatically manage heating and lighting based on what it has learnt about the household's behaviour. This is similar in many ways to the Nest thermostat (www.nest.com), a product the group were aware of. All of these ideas were expressed creatively, with elements of novelty and in a format appropriate to the needs of their users. However, they can be considered to show what one might term incremental creativity as they build on the already familiar and are not suggestions that would necessarily lead to radical new solutions.

Discussion

The type of workshop we describe in the case study requires significant commitment from participants, takes a large amount of planning and can be expensive. Whilst it is important to develop techniques that engage participants and which help them express their existing ideas creatively, our objectives go some way beyond this as we aim to use data to help participants develop ideas they would not otherwise have. Norman and Verganti (2014) discuss the difference between incremental innovation, which leads to doing something better, and the more rare radical innovation, which leads to doing something different. They argue that it is changes in the meaning ascribed to a product or service, perhaps following or alongside the introduction of new technology, which leads to these radical innovations. Such a change in meaning, they say, may be arrived at by exploring wider social and cultural changes that lead to a reframing of current solutions. Such a distinction between incremental and radical innovation echoes our desire to encourage a more radical creativity in the ideas for design requirements expressed by our workshop participants, and perhaps offers a framework that we can borrow to inform the design of future workshop activities. It is not uncommon in co-creation workshops for designers to work with participants, helping to facilitate and hone or develop ideas. In future workshops it may be useful for designers to help identify and explore social changes and future technologies and use these to direct participants' ideas towards areas of greater novelty.

Another approach that may prove instructive can be found in applied creative thinking techniques. Prominent examples of which include Osborn and Parnes' Creative Problem Solving (Parnes 1992), Gordon and Prince's Synectics (Gordon 1961), and De Bono's Lateral Thinking (De Bono 1970) and Six Thinking Hats (De Bono 2000). These techniques all start from the common premise that everyone has the capacity to think creatively and that the skills needed to do so can be systematised. Such applied creativity techniques have been effectively incorporated into the process of gathering requirements for large-scale socio-technical systems (Maiden Gazikis & Robertson 2004). Here, workshops using techniques such as constraint removal, brainstorming with creativity triggers and analogical reasoning, have helped stakeholder representatives generate important ideas for requirements that were considered both novel and appropriate and that may otherwise have remained unexpressed. These techniques again suggest a framework through which we could deliberately provoke participants to explore ideas that are outside their normal frame of reference, leading them to generate novel ideas for design requirements. In particular, the techniques characterised by McFadzean (1998) as being "paradigm breaking" offer a way to view a given problem or opportunity from different perspectives. Such a deliberate reframing of the problem at hand

has been shown to promote creativity and innovation (Seelig 2012), and offers a possible way to explore new meanings.

Future Work

One of our key challenges is to develop workshop activities that enable participants to critically explore data in the context of wider trends. Another is to use the insights found through data exploration as inputs to applied creative thinking activities. Through this we aim to prompt participants towards greater novelty and increased creativity in their idea generation. Additionally we should seek to use information visualization to identify domain constraints. Onarheim (2012) has discussed how manipulating constraints can enhance design creativity.

Conclusion

Data are likely to play an increasingly prominent role in the design of new services. In this paper we have discussed how information visualization can make these data more accessible and engaging to key stakeholder representatives during design workshops. We illustrated this with examples from our case study in the energy domain. We also outlined how applied creative thinking techniques could be used to extend these methods; stimulating creative, novel and appropriate ideas for design requirements that may not otherwise be expressed.

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References

Boyd, D., & Crawford, K. (2012). Critical questions for big data: Provocations for a cultural, technological, and scholarly phenomenon. *Information, Communication & Society*, *15*(5), 662-679.

Card, S. K., Mackinlay, J. D., & Shneiderman, B. (Eds.). (1999). *Readings in information visualization: using vision to think*. San Francisco: Morgan Kaufmann.

Carroll, E. A., Latulipe, C., Fung, R., & Terry, M. (2009, October). Creativity factor evaluation: towards a standardized survey metric for creativity support. In *Proceedings of the seventh ACM conference on Creativity and cognition* (pp. 127-136). ACM.

DECC, (2012). Key milestone for smart meters rollout. Retrieved November 24th 2014 from https://www.gov.uk/government/news/key-milestone-for-smart-meters-rollout

De Bono, E., (1970). *Lateral Thinking: a textbook of creativity*, London: Ward Lock Educational

De Bono, E., (2000) *Six Thinking Hats*, London: Penguin

Dove, G., and Jones, S., (2013, April) *Evaluating Creativity Support in Co-Design Workshops*, Presented at ACM CHI'13 Workshop, Evaluating Methods for Creativity Support Environments,

Few, S., (2009) *Now You See It*. Oakland: Analytics Press

Gordon, W. J. (1961). *Synectics: The development of creative capacity*. New York, Harper & Brothers

Goodwin, S., Dykes, J., Jones, S., Dillingham, I., Dove, G., Duffy, A., Kachkaev, A., Slingsby, A., & Wood, J. (2013). Creative User-Centered Visualization Design for Energy Analysts and Modelers. *Visualization and Computer Graphics, IEEE Transactions on*, *19*(12), 2516-2525.

Gruber, J. K., & Prodanovic, M. (2012, November). Residential energy load profile generation using a probabilistic approach. In *Computer Modeling and Simulation (EMS), 2012 Sixth UKSim/AMSS European Symposium on* (pp. 317-322). IEEE.

Kuniavsky, M., (2008) Evolution of the Fridge Computer. Retrieved November 24th from http://www.orangecone.com/archives/2008/01/the_fridge_comp.html

Maiden, N., Gizikis, A., & Robertson, S. (2004). Provoking creativity: Imagine what your requirements could be like. *Software, IEEE*, *21*(5), 68-75.

McFadzean, E. (1998). The creativity continuum: towards a classification of creative problem solving techniques. *Creativity and Innovation Management*, *7*(3), 131-139.

Moere, A. V., & Purchase, H. (2011). On the role of design in information visualization. *Information Visualization*, *10*(4), 356-371.

Norman, D. A. (2005). Human-centered design considered harmful. *Interactions*, *12*(4), 14-19.

Norman, D. A. (2010). Technology first, needs last: the research-product gulf. *interactions*, *17*(2), 38-42.

Norman, D. A., & Verganti, R. (2014). Incremental and radical innovation: Design research versus technology and meaning change. *Design Issues*, *30*(1), 78-96.

North, C. (2006). Toward measuring visualization insight. *Computer Graphics and Applications, IEEE*, *26*(3), 6-9.

Onarheim, B. (2012). Creativity from constraints in engineering design: lessons learned at Coloplast. *Journal of Engineering Design*, *23*(4), 323-336.

Parnes, S. J. (Ed.). (1992). *Source book for creative problem-solving: A fifty year digest of proven innovation processes. Buffalo*, NY: Creative Education Foundation Press.

Sanders, E. B. N. (2005, March). Information, inspiration and co-creation. In *Proceedings of the 6th International Conference of the European Academy of Design*.

Seelig, T. (2012) *InGenius: A Crash Course on Creativity*. London: Hay House.

Shneiderman, B. (1996, September). The eyes have it: A task by data type taxonomy for information visualizations. In *Visual Languages, 1996. Proceedings., IEEE Symposium on* (pp. 336-343). IEEE.

Shneiderman, B. (2001). Supporting creativity with advanced information-abundant user interfaces. In *Frontiers of human-centered computing, online communities and virtual environments* (pp. 469-480). Springer London.

Treffinger, D. J. (1995). Creative problem solving: Overview and educational implications. *Educational Psychology Review*, *7*(3), 301-312.

Tufte, E. R. (1983). *The visual display of quantitative information*. Cheshire, CT: Graphics Press,

Wallas, G. (1926) *The Art of Thought*. New York: Harcourt Brace.

Ware, C. (2012) *Information visualization: perception for design*. London: Morgan Kaufmann

Wattenberg, M., & Kriss, J. (2006). Designing for social data analysis. *Visualization and Computer Graphics, IEEE Transactions on*, *12*(4), 549-557.

Witten, I. H., & Frank, E. (2005). *Data Mining: Practical machine learning tools and techniques*. Burlington, MA: Morgan Kaufmann.

Yi, J. S., Kang, Y. A., Stasko, J. T., & Jacko, J. A. (2008, April). Understanding and characterizing insights: how do people gain insights using information visualization?. In *Proceedings of the 2008 Workshop on BEyond time and errors: novel evaLuation methods for Information Visualization* (p. 4). ACM.