Data Visualisation, User Experience and Context: A Case Study from Fantasy Sport

Rob Euman and José Abdelnour-Nocera

Sociotechnical Centre for Internationalisation and User Experience
University of West London, Ealing, W55RF, 69121 United Kingdom
rob.euman@lab49.com, jose.abdelnour-nocera@uwl.ac.uk

Abstract. Fantasy Football is a rapidly growing online social game. As users become more sophisticated and technology advances, the amount of data that is available to inform users' decision making is growing rapidly. Representing this data in an informative and engaging way can be a challenge but data visualisation offers many ways to achieve this. This paper focuses on the design of interactive solutions that are measured against existing products by way of a comparative evaluation. In order to study the impact on user performance, efficiency and accuracy are measured for clearly defined tasks carried out on each design. The user experience is measured to understand the satisfaction and perceived ease of use of each visualisation system. This study will be useful to validate or challenge existing principles of data visualisation design and perception as well as offering suggestions for improving fantasy football products. The study will also serve as a case study to support further research into data visualisation evaluation methods. The paper concludes by discussing the findings and possible areas for further research and design.

Keywords: HCI, social games, data visualisation, design, evaluation.

1 Introduction

Fantasy sports users are becoming increasingly sophisticated in the way they consume and analyse sports data. However, the ways in which this data is represented has not evolved as much as in other fields. There may be opportunities for the fantasy sports world to learn from domains such as finance, science and healthcare by using data visualisation techniques to improve the performance and experience of its users.

The design rationale for this study follows the hypothesis that data visualisation can improve the both the performance and experience of fantasy football users. In challenging this assumption, empirical research was conducted involving real fantasy football users to understand their current experience and ways in which this could be improved. The research was conducted over a limited time period and focused on the English Premier League season of 2011/12.

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A comparative study was conducted which required a solid understanding of existing fantasy football games that fairly represents the existing fantasy football experience and comparing this with new systems that were designed and prototyped as part of the research process. Although the prototypes evaluated represent only a subset of a fully functioning product, they were adequate as concepts and included enough functionality to test and challenge the hypothesis.

2 Existing Literature

2.1 Data Visualisation

Information Visualisation is the accepted term for the field of graphical communication that data visualisation sits within. Underpinning the design solutions and data analysis in this study are well established principles of human perception and statistical graphics. Clevelend & McGill [1] wrote a foundational paper in this field where visual elements such as colour, size and shape were tested to measure their effectiveness in communicating quantitative information. In addition to this, Bertin's *Semiology of Graphics* [2] looks at the language of visualisation techniques and Ware's *Information Visualisation* [3] looks at the subject from the perspective of perceptual science. Almost all research on this subject will reference the work of Edward Tufte who's books [4, 5] are ground breaking in their approach to information presentation and visual literacy.

The field of interactive data visualisation is broad and continuously evolving due to advances in technology. Ben Shneiderman has been responsible for many milestones in this research field. The paper *Visual Information Seeking* [6] is often referenced as one of the first papers to consider visualisations beyond static representations of data and promoted the benefits of interactivity. In the paper *The Eyes Have It,* Shneiderman [7] looks at a taxonomy system for interactive visualisation techniques that are categorised by data type.

2.2 Data Visualisation Evaluation

As demand for new ways of visualising data increases, so does the need for standards and guidelines to support their creation. There is a growing body of work that focuses purely on data visualisation evaluation and the challenges this field faces that are not common in standard interactive systems evaluation [8]. Plaisant [9] addresses these challenges and recommends improving access to repositories of data, toolkits and development tools and case studies that could encourage greater investment in the field. Carpendale [10] discusses the trade-off between generalisability, precision and realism and recommends a mixed methods approach to evaluations which includes both qualitative and quantitative research. Lam et al [11] recommend evaluation approaches specific to seven specific scenarios of which *Evaluating User Performance* and *Evaluating User Experience* are key to this study.

3 Methodology

3.1 Evaluation Approach

The main challenge in evaluating data visualisation systems lies in the fact that it is difficult to replicate the conditions in which these systems are used. A standard usability evaluation may involve a controlled or informal study of a user interacting with a particular system. Tasks are often brief and satisfaction, efficiency and effectiveness can all be measured within the test. Systems that involve large amounts of data, whether visualised or not, are usually used in a more exploratory way and discovery is a key part of the experience. It may take some time before the user completes a task such as finding a specific piece of information amongst the data and this can happen long after use of the visualisation system. Furthermore, a visualisation system's effectiveness may lie in answering questions you didn't know you had [9].

In order to avoid some of these common pitfalls of data visualisation evaluation, this research has used a combination of methods that are supported by previous research and case studies. As there is no universally applicable methodology for evaluating data visualisation systems, care has been taken to focus on scenarios that are relevant to the context of this study. This study focuses on two scenarios in challenging the above hypothesis. These are *Evaluating User Performance* and *Evaluating User Experience* [13].

3.2 Research Design

In this study three ways of visualising fantasy football data in an interactive context are compared in the form of interactive prototypes. These prototypes represent only a subset of a fantasy football game as the study only focuses on the visual representation of player data. Taking this approach is also beneficial as a fully horizontal prototype containing unnecessary functionality would distract the user and take up unnecessary design and development time.

Prototype A (Fig. 1) is a table that reflects the conventional format of existing fantasy football products. This prototype served as a benchmark to measure the other two data visualisation techniques against. Prototype B uses the same table format but with the player points data from each match of the season represented in a graphical format. Prototype C uses the same dataset as A and B but it is presented as a treemap. The comparison involved carrying out a simultaneous study of each interface using real fantasy football users carrying out tasks reflective of their normal pattern of use.

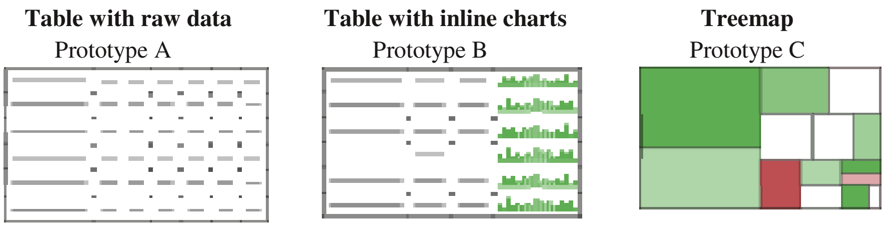

Fig. 1. Three prototypes to be evaluated

3.3 Identification of Variables

To maximise the accuracy of this evaluation, each of the variables has been identified (Table 1). Data visualisation techniques, represented by the three prototypes, are the independent variables that have been managed throughout the evaluation. The dependant variables of user performance and experience were measured in relation to the independent variable. There were a number of controlled variables that did not change throughout the evaluation. Where it was not possible to control these variables, it is acknowledged and considered in the analysis of the results.

Table 1. Independent, Dependant and Controlled Variables

Independent	Dependant	Controlled
Data visualisation technique: Table with raw data, table with inline charts, treemap.	**User Performance:** Task completion time, task error rates. **User experience:** Perceived ease of use, satisfaction.	**Participants:** Domain knowledge, technical ability. **Evaluation:** Tasks, questions, device, environment.

3.4 Evaluation Methods

In order to make valid judgments on the three prototypes they were measured against specific metrics (Table 2) through a variety of evaluation methods. The mixed methods approach helped capture both objective and subjective information in order to measure the impact each visualisation technique has on user performance and experience.

Table 2. Metrics to be Measured Throughout the Evaluation

User Performance	User Experience
Completion time: The efficiency of the system as participants complete the tasks. **Error rates:** The effectiveness and tolerance of the system.	**Ease of use:** The participants' perceived ease of use. **Satisfaction:** Whether the system was enjoyable to use and likelihood of adoption.

Quantitative Methods

Timed Tasks. These are scripted tasks that ask participants to interact with each prototype in a controlled way. Each task reflected that of a real session such as making selections and comparisons based on fantasy player points and prices. The tasks were ordered in such a way that avoided bias toward either prototype or participant.

Error Rates. As part of the controlled experiment, the amount of tasks that are failed or abandoned was also measured. Errors are highlighted as significant issues when measuring the performance of the system.

Qualitative Methods

Observations. Behaviours were observed as the participants performed each task. These are brief, subjective and unobtrusive with the participant being asked to focus on completing the task instead of discussing their actions at the same time.

Voice Mapping. This is a technique for measuring participants' attitudes towards the system. It is particularly useful when making comparisons between systems or measuring the effect of design improvements over time. The participants were asked to plot a mark on an axis (measuring satisfaction and perceived ease of use.

3.5 Prototype Design

Tables. Although the table format reflects existing fantasy football interfaces, there are still a number of variables that need to be controlled such as sorting, filtering and visual design. There are 531 rows, one for each Premier League player. Columns contain alphabetic data including player name, club and position as well as numerical data such as total player points, average player points, player value and games played. The only difference between the two tables is the representation of player points per match. Prototype A lists points as numerical values in a column. Prototype B represents this data both as numerical data and as a bar chart representing each of the 38 matches of the football season (although few players actually made this many appearances).

531 rows of data would have a negative impact on cognitive and page load so it is important for the user to be able to control the amount and order of this information. The default view shows 10 players while a dropdown allows the user to change this to 50 or 100 players. The column headers also allow the user to sort the data in the table. Columns containing individual match player points have had this functionality removed as users are only interested in the cumulative player point totals. However, position, team, player value and points are all categories that users like to sort by.

There were opportunities to improve on the presentation of these tables by applying established design principles of information design. However, this would introduce too many variables to the evaluation and distance both prototype A and B from the existing fantasy football product table design.

Treemaps. Treemaps use colour, size and proximity to represent relevant attributes of the data. This is represented in the form of a 2 dimensional display of nested rectangles. Within each rectangle is a collection of tiled rectangles with varying sizes and colours. The information represented by the colour and size of these rectangles can vary depending on domain and dataset. For the purpose of this study I have chosen to focus on the typical financial use of treemaps where the size of the rectangle represents volume or value while the colour of the rectangle represents percentage change or stock performance.

The Squarified treemap [12] format lends itself well to compare, interact with and perceive structure. While the Squarified algorithm is limited in its ability to order the rectangles, This approach was chosen to create the Fantasy Football treemap as the order of player values is less relevant to the size and colour of the rectangles.

Ultimately fantasy football users are looking for information on the performance of individual players. However, the routes users take to access this information can differ. Some users are looking for the best value players in a specific position, others are looking for the most consistent players of a specific team and others may simply be looking for a specific player. Therefore, it is important to use the hierarchy to allow users to make sense of the data format and access the information they need.

The player performance data in the fantasy football treemap is represented by a graduation of colour from green for positive values to red for negative values. To provide contrast and to avoid undesirable colour blends, white is used as a midpoint. Colours are displayed not on actual points scored but on each player's points in relation to the average point score. This has been done as most players' scores are a positive amount (i.e., the highest score is 2451 and the lowest is -15) which means the treemap will display predominantly green rectangles which will only use around 50% of the colour scale. This will make comparisons more difficult. By assigning colours for player points in relation to the average player point figure there should be an even split of red and green rectangles.

While colour is an effective technique for conveying information, around 10% of the male population suffers from some form of colour blindness. For this reason, an option to change the treemap to use the colours yellow and blue to represent player points should be included in a final product.

3.6 Evaluation

The tasks used in the evaluation were chosen carefully to insure accurate and consistent data could be captured and to reflect the common tasks of the participants' normal usage. It was also important that each participant did not carry out the same task on more than one prototype. This would skew the results as, once a participant had found the information via one prototype, the same task on another prototype would be one of navigation instead of discovery.

Nine tasks were chosen which could be categorised into three groups; overview level tasks, team level tasks and position level tasks. The order of the tasks within each category was consistently varied per user to minimise any distortion as a result of familiarity with any given prototype. However, the lower level overview tasks were performed by each user first to mitigate any learning curve. Learnability and memorability will not be measured as part of this evaluation as participants were not expected to conduct tasks of significant complexity.

4 Findings

4.1 Task Completion Times

The task competition times reveal some interesting patterns relating to the efficiency of each of the prototypes (Fig. 2). It was expected that the three overview tasks that were carried out first would be easier, but there is a surprising drop in completion times for the final three. This could be due to the participants increasing familiarity with each of the systems. What is clearer is that Prototype C is the most efficient of the three systems.

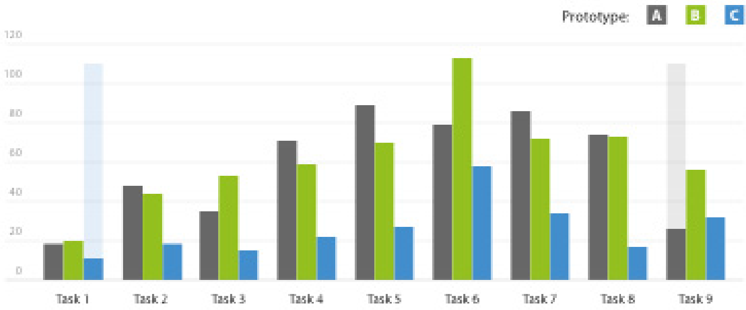

Fig. 2. A voice map measuring ease of use and satisfaction

4.2 Error Rates

There were only three errors made throughout the evaluation. While this is positive, the numbers are too small to draw concrete conclusions from. They do however raise issues that should be addressed in a next phase of design.

Two of the errors were made on Prototype C during the same task where participants were asked to select the player with the most points from the teams overview. In this view, two players (Robin van Persie and Wayne Rooney) stand out as the highest scorers because of the solid green colour of the rectangles but, as their points are so similar, it is difficult to differentiate between them. Further to this, the incorrect selection, Wayne Rooney, appears above Robin van Persie so is the first player the user will see. This lack of control of the treemap layout should be seen as a weakness and clearly demonstrates that this technique is less appropriate as a static representation of data. The error on Prototype A involved the user giving up after 45 seconds which would have been longer than any of the other tasks took to complete.

4.3 Key Observations

The observations that were made were brief in order to not disrupt the tasks that were being carried out. The observations were analysed and categorised into themes that highlight some recurring issues and behaviours throughout the evaluation.

Although all participants found the table sorting functionality of Prototypes A and B easily, three asked to be reminded of the multi-column sorting functionality. The participants that did master this functionality seemed to get there through trial and error, clicking a few times before consistently being able to perform the function correctly.

All participants seemed to find scrolling through the data in Prototypes A and B quite laborious with four confirming this in the later discussion. In this context, Tufte's principle of presenting data-rich displays is less relevant. Although the tables have a large amount of information up front, there is a limit to how much you can display in one view, particularly on the average web browser.

The treemap supports the principle that it is easier to recognise than to recall. Using both table prototypes, users needed to remember data to make comparisons instead of being able to instantly compare relationships through size or colour. The charts in Prototype B are useful for analysing form throughout the season; they are less effective for making easy comparisons based on total player points.

4.4 Ease of Use and Satisfaction

The voice map in Figure 3 highlights some interesting insights into the participants' attitudes to the three visualisation systems. As a measure of satisfaction it seems Prototype B was significantly more successful than Prototype A. Although they compared similarly when measured by task completion times, it seems the participants reflective experience of prototype B was more positive because of the additional graphical representation of player points. This is emphasised by that fact that there was no significant difference in the perceived ease of use.

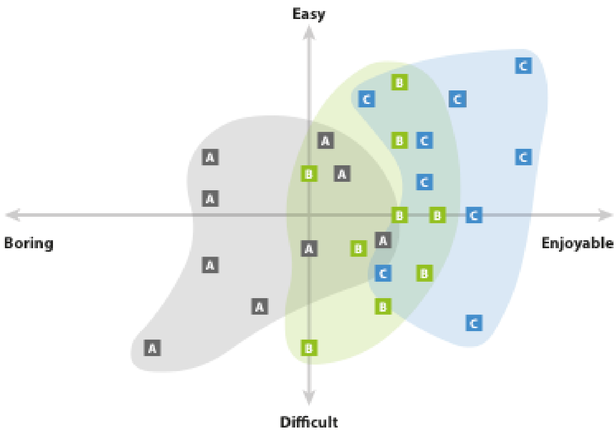

Fig. 3. A voice map measuring ease of use and satisfaction

There is also only a slight uplift in perceived ease of use for Prototype C. Although tasks carried out were completed in significantly less time than Prototypes A and B, the users still felt there was a degree of complexity to it. However, Prototype C performed better on satisfaction which could support the theory that a satisfying experiences make users more tolerant of functional complexity [13, 14].

4.5 Recommendations for Further Design

Although each prototype gave opportunities to sort or navigate through the information, there is a case for offering more effective ways of filtering unwanted information out early. Sliders are a very common interaction design component that enable users to select a value from any given scale. They can have a single control to define a specific value or two to define a range of values. Alternatively, conversational filtering is a technique where filters are positioned in a sentence that is formed in the way that it would be spoken. This can be a more intuitive way of accessing information as it supports the user's mental model of accessing and processing information.

One of the potential challenges with the treemap is that, while it aids comparisons, size and colour are not effective ways of comparing when there is minimal variation in the data. Although the squarified treemap algorithm was created to place nodes of a similar scale together, clear differentiation isn't always guaranteed. Other techniques for organising hierarchical information that help further remove uncertainty should be considered.

One such technique is the 'Slopegraph' as created by Edward Tufte [4]. The slopegraph is a way of comparing the scale of changes over time for a list of variables. Using this technique, the variables of team performance and team spending could be ranked in ascending order and linked by lines, the angle of the lines represent the scale of differentiation. The weight of the lines would represent the scale of team spending with colour illustrating whether the differentiation is negative or positive.

This technique provides an interesting and concise alternative to the treemap layout. Where the treemap's reliance on colour and size to represent information could lead to ambiguity and confusion, the slopegraphs benefits of combining this with the angle and order of connecting lines is clear. It could be safe to assume that the two errors committed in the evaluation when comparing the player points of Robin van Persie and Wayne Rooney could have been avoided using this technique.

Another way to make interactive visualisation more intuitive is by introducing animated transitions as the user manipulates and navigates the data. Animations are a useful way of facilitating the perception of changes when transitioning between data graphics. This would be particularly relevant for the treemap which uses an interaction model of zooming and displaying information on demand.

5 Conclusions

The results of the evaluation prove, with a relative degree of certainty, that data visualisation can improve the performance and experience of fantasy football users. While this validates many of the of the established principles that informed the design, this report also proves that these principles should be used with sensitivity to the context of use. A visualisation system targeted at search and discovery as championed by Ben Shneiderman [6] will not lend itself well to high-resolution data analysis. Equally, data-rich displays of information will not perform well when deep exploration of data is required.

These findings give further weight to the theory that a positive user experience can help appease functional complexity**.** As well as reducing task times, the treemap is designed to enhance the user's emotional engagement instantly making sense of otherwise complex information by highlighting relationships and encouraging comparisons.

To take this research further, it would be useful to conduct a longitudinal study measuring the impact of data visualisation techniques over a longer period of time. This could be conducted as part of a comparative evaluation using real users competing against each other in their natural context of use for the duration of a football season. User performance in this case would therefore be measured by competitive advantage through exploration and discovery as opposed to operational efficiency and user experience would be measured by adoption and engagement metrics.

One participant remarked that he felt empowered when using the treemap system. If fantasy football users could be genuinely empowered through the effective use of data visualisation techniques, could it then compromise competitive advantage? While fantasy football products may want to maintain an element of uncertainty in the data it makes available, this offers many possibilities for other domains.

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