Can CASSM bridge the gap between InfoVis and the user?

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ABSTRACT

Traditionally, information visualisation (InfoVis) tools are built to visually represent large amount of abstract data on a computer screen to aid experts make sense of abstract information. There is a current need for better methods to evaluate the utility of InfoVis tools to encourage more widespread adoption by non-expert users. The theory of harmonious flow (Faisal, 2008) argues that positive interaction with an InfoVis tool is achieved through having a good conceptual fit between user's internal conceptualisations of the represented domain and the external design. As CASSM (Concept-based Analysis of Surface and Structural Misfits) focuses on capturing the conceptual misfits between the user and system, this thesis argues that CASSM is suitable for evaluating the conceptual fit between users and InfoVis tools. Social networking InfoVis tools were chosen as the application domain as they are designed for general audiences.

User concepts were gathered from users of the social networking site Facebook via interviews and a think-aloud while they interacted with two social networking InfoVis tools (Friend Wheel and TouchGraph). System concepts were obtained from the running system and existing documentation. The CASSM analysis involved comparing user and system concepts to identify if they were being represented within the user and system. CASSM was useful in capturing users' conceptualisations of their social networks, and the conceptual misfits between users and the InfoVis tools, which provide valuable design opportunities for social networking InfoVis tools. This research contributes to the InfoVis community by offering a method which can improve the conceptual fit between user and InfoVis tools so that they can be designed better to suit users' needs.

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CHAPTER 1. INTRODUCTION

This study investigates the utility of CASSM (Concept-based analysis of surface and structural misfits) in evaluating information visualisation (InfoVis) tools in the social networking domain. Users of the social networking site (SNS) Facebook were recruited to interact with two social networking InfoVis tools: Friend Wheel and TouchGraph. Users were interviewed about their understanding of their social networks, and were required to perform a think-aloud while interacting with the tools. Verbal data was transcribed and analysed using CASSM, which gave rise to design possibilities. The overall findings were related to existing literature, and limitations were presented together with avenues for future research.

1.1 Research motivation

Traditional InfoVis tools are designed by experts in very specific domains and are mainly used in research laboratories where large amount of abstract data is transformed into visual representations to aid its expert viewers make sense of abstract information. However, InfoVis is becoming more prevalent and reaching more general audiences. Yet, there are still no systematic or standardised methods to evaluate these tools to ensure that they are meeting users' needs. In fact, the InfoVis community has acknowledged that current evaluation metrics are insufficient for evaluating InfoVis tools, and new approaches which go beyond assessing the usability of these tools are required (Bertini, Perer, Plaisant, & Santucci, 2008; Plaisant, 2004). Hence, this paradigm shift where more focus is now directed towards assessing the utility of InfoVis tools to better meet users' needs is the main driving force behind this study.

Faisal (2008) found that it was important to take into account users' conceptualisations of a represented domain of knowledge while designing InfoVis tools. This is because a positive sensemaking experience during the interaction with InfoVis tools is dependent upon achieving a good conceptual fit between the externalised design and users' internal conceptual structure of the represented domain. Hence, it is clear that there is a need for an evaluation method which captures the level of this conceptual fit between the user and the InfoVis tool. The idea of conceptual fit forms the backbone of CASSM, a fairly new analytical evaluation method which focuses on capturing the misfits between the user and the system

(Blandford, Green, Furniss, & Makri, 2008). Hence, it is logical that CASSM would be a suitable evaluation method for capturing this conceptual fit between users and InfoVis tools.

This is an exploratory study in the sense that no past research has ever utilised CASSM in InfoVis evaluation. As the focus is on InfoVis tools for the general population, social networking InfoVis tools were chosen as the application domain. Being one of the most popular SNS, many social networking InfoVis tools have been built for Facebook (e.g., Friend Wheel and TouchGraph), and are good representations of "popular InfoVis" tools (Danzinger, 2008) designed for non-expert users.

1.2 Research question

The aim of this thesis is to investigate whether CASSM as an evaluation method is useful for uncovering users' conceptualisations of their social networks, and whether these concepts are being represented by current social networking InfoVis tools. It will contribute to the field of InfoVis evaluation so that better methods which inform redesign can be adopted by both evaluators and designers alike to produce InfoVis that suits users' needs. Moreover, the discovery of user concepts will be valuable for the design of future social networking InfoVis tools.

1.3 Structure of current study

Chapter 2 reviews current literature relating to InfoVis research, InfoVis evaluation, CASSM, and the social networking domain, and provides a brief description of the rationale and direction of this research. Chapter 3 outlines the data gathering methods of the current study. Chapter 4 provides a full account on the CASSM analysis conducted, and the results obtained. Chapter 5 discusses the overall findings by relating them back to existing literature, and presents the limitations of the current study together with avenues for future research before reaching a conclusion.

CHAPTER 2. LITERATURE REVIEW

This chapter reviews the current literature surrounding InfoVis research with a focus on "popular InfoVis" targeted at more general users rather than experts of specific domains. Literature on InfoVis evaluation will be discussed to provide an overview of the current developments in this area within the field. An argument on why CASSM is useful for evaluating the utility of InfoVis tools will be made. The rationale behind choosing social networking InfoVis tools for this current evaluation study will also be presented. Lastly, the rationale and direction of this current research is discussed.

2.1 What is InfoVis?

Information visualisation (InfoVis) is traditionally a scientific field with roots mainly from computer science. It involves experts creating computer programmes, or in this context, InfoVis tools, which translate abstract data into visual representations to aid other experts in making sense of abstract information in specific domains such as biology, geography, financial data analysis etc. However, the advancement of technology and commercial adoption of software tools have resulted in an increasing emergence of "popular InfoVis" circulating outside the traditional research laboratories, reaching more general users who Danzinger (2008) refers to as the "masses" or "non-expert audiences". Among many, commercial InfoVis tools such as IBM's Many Eyes (http://manyeyes.alphaworks.ibm.com/manyeyes/) allow public users to upload datasets and select from a variety of visualisation options (e.g., tag cloud, treemap, etc.) to generate visualisations from the data. Hundreds of different InfoVis tools are also available from visualcomplexity.com which features visualisations ranging from biology, music, to social networks and pattern recognition.

Regardless of whether it is targeted at experts or general users, the main purpose of InfoVis is to help its users make sense of abstract data. The most widely cited definition of InfoVis by Card, MacKinlay, and Shneiderman (1999, p. 7) is "the use of computer supported, interactive, visual representations of abstract data to amplify cognition". It aids its perceiver in making useful discoveries by transforming data of all forms (e.g., quantitative, categorical, ordinal, relationships) and senses (auditory, visual, sensory) into pictures, allowing users to gain insight and achieve useful discoveries which Spence (2007) refers to as the ‘Ah Ha!’ reaction. This act of visualising information relieves the perceiver from having to perform all the cognitive activity in his or her head (Card et al., 1999), aiding people in decision-making or information processing when the amount of information exceeds one’s cognitive capabilities.

Acknowledging the potential of InfoVis in aiding our daily information processing activities, Few (2008) argued that it is the responsibility of researchers to provide the world with useful and usable InfoVis tools. However, how can we increase more widespread adoption of InfoVis tools? It would be logical to think that people would use tools that help them meet their goals. Hence, it is important to find out if InfoVis tools are currently meeting users’ needs, and one way to do this is via evaluation. However, most InfoVis evaluation has focused on usability rather than utility, with studies mainly conducted under experimental settings using either unrealistic data sets or focusing on assessing the wrong things (Ellis & Dix, 2006; Tory & Staub-French, 2008).

Shneiderman and Plaisant (2010, p. 572) proposed the current 9 challenges of InfoVis research as listed below:

1. Importing and cleaning data
2. Combining visual representations with textual labels
3. Finding related information
4. Viewing large volumes of data
5. Integrating data mining
6. Integrating with analytical reasoning techniques
7. Collaborating with others
8. Achieving universal usability
9. **Evaluation**

The focus of this thesis is on the last challenge, the evaluation of InfoVis tools. This issue has been widely acknowledged by the InfoVis community as exemplified by the BELIV 2006 (BEyond time and errors: novel evaLuation methods for Information Visualization) and BELIV 2008 workshops in Italy which were dedicated to address this issue.

2.2 Evaluating InfoVis

This section introduces the current methods and challenges surrounding InfoVis evaluation, and argues why CASSM is suitable for the evaluation of InfoVis.

2.2.1 Current InfoVis evaluation methods

There are several existing methods to evaluate InfoVis ranging from traditional lab-based studies which utilise scientific approaches, to field studies under realistic settings which adopt more qualitative approaches. However, despite having an array of different techniques, there is still no consensus on what is the ultimate purpose of, and method for evaluating InfoVis tools. This section describes how the evaluation of InfoVis has evolved from traditional lab-based methods to more qualitative approaches over the years.

The field of traditional InfoVis seems to favour the more scientific approaches of lab-based quantitative analysis methods which typically involve users completing pre-determined tasks using the InfoVis tools being studied. For example, Kobsa (2001) examined three different commercial InfoVis tools *Eureka*, *InfoZoom*, and *Spotfire* by comparing users' task performance in terms of speed and accuracy based on several benchmark tasks. He found that the success of the InfoVis tools depended on properties of the visualisation offered by the tools, actions that users can perform with the tools, design-related issues, and also usability problems. However, as these tools were inherently different from each other in terms of design, interaction styles and visualisation techniques, his findings were more likely to be speculations rather than actionable outcomes. More importantly, the study only focused on how well users performed the benchmark tasks using the InfoVis tools but it did not address the utility of these tools.

Following the realisation of the shortcomings of quantitative methods in InfoVis evaluation, recent work are favouring qualitative approaches which are better at capturing users' subjective experiences while interacting with InfoVis tools (Faisal, Craft, Cairns, & Blandford, 2008; Isenberg, Zuk, Collins, & Carpendale, 2008; Tory & Staub-French, 2008). It is worth noting that one of the strengths of qualitative studies is the triangulation of methods used. The use of different data gathering methods including observation, interviews, video-recording, longitudinal studies, field studies, case studies, focus groups and expert reviews are all valuable in probing different types of information, resulting in an array of very rich data which is then analysed.

However, an important point brought forward by Tory and Staub-French (2008) was that there is not much guidance on how to analyse the data collected from these studies. In fact, several researchers have identified the challenge of data analysis during the process of evaluating InfoVis tools (Tory & Möller, 2005; Isenberg et al., 2008), and some even failed to mention how data was analysed in their studies. For example, Valiati, Freitas, & Pimenta (2008) conducted a multi-dimensional in-depth long-term case study examining expert users of different InfoVis tools (e.g., a geographer, an expert insurance broker) over a 3 to 4 months period via participatory observation of the evaluators and interviews. Although the findings were positive, it was unclear as to how the results of the study were analysed.

Another issue in InfoVis evaluation is the context where the research was carried out, and the use of real data sets. As argued by Valiati et al., (2008), studies which evaluated InfoVis were carried out mainly under experimental settings which produced less valid results. Ellis & Dix (2006) also highlighted the importance of using realistic tasks during InfoVis evaluation where users have a clear understanding of both the application domain and the data in order to be able to assess the utility of a tool.

These issues were addressed by Tory and Staub-French (2008) where they conducted a 7-month field study observing and interviewing a team of building design experts (e.g., architects, construction managers) conduct meetings in a real setting. The main purpose of their study was to understand how visualisation tools were used during these meetings to facilitate discussions with stakeholders of the projects, so that design guidelines can be identified. The initial data was analysed quantitatively and subsequent data was analysed qualitatively using Grounded Theory which the researchers described as time consuming but led to more in-depth findings with greater validity than their quantitative approach. They concluded by advocating the use of field studies and qualitative analysis methods to complement the more widely adopted lab-based quantitative methods by the InfoVis community.

Another study which utilised Grounded Theory for data analysis was carried out by Faisal (2008) which will be described in section 2.2.3. However, the main gist is that qualitative analysis evaluation methods are powerful in revealing users' subjective experiences of InfoVis interaction, and the lack of a systematic approach to analyse such data warrants much attention from the field. As stated by Plaisant (2004, p. 110) " we need to understand how to improve our methods of evaluation in order to present actionable evidence of measurable benefits that will encourage more widespread adoption" .

2.2.2 Usability vs. utility: the current challenges

InfoVis has always mesmerised its viewers' with their visually appealing features, having a high "wow" value (Stasko, 2006). However, their actual utility to its users remains doubtful. As acknowledged by the InfoVis community (Bertini et al., 2008; North, 2006; Plaisant, 2004; Stasko, 2006), there is a need to evaluate the utility of InfoVis where the focus should not solely be on the usability of InfoVis tools but also on the ultimate purpose of the visualisation. This shift from usability to utility in the field of InfoVis evaluation remains a challenge due to several reasons.

As most InfoVis tools are domain specific, it is often hard to evaluate the tools with domain experts under realistic situations (Plaisant, 2004). Similarly, empirical studies that reveal better design choices which increase task performances do not necessarily inform us on whether the tools are allowing users to achieve their goals (Kobsa, 2001). As argued by North (2006), the purpose of a visualisation will determine how it should be evaluated. Hence, in order to increase more widespread adoption of InfoVis tools, it is important to understand what InfoVis users require from the tools.

According to Faisal (2008)'s theory of harmonious flow, a positive experience with an InfoVis tool is achieved when the user is able to internalise the externalised information without any interference. In other words, a good conceptual fit between the external visualisation and users' internal conceptualisations of the represented domain would result in a 'seamless interaction' during the sensemaking process. Also, given that the purpose of InfoVis is "to use perception to amplify cognition" (Card et al., 1999), it is vital to probe into the perceiver's mind to ensure that what is perceived is consistent with what is being conceptualised. The following section introduces CASSM as a possible evaluation method for assessing InfoVis tools to bridge the gap between the user and the tool.

2.2.3 Why CASSM for InfoVis evaluation?

The rationale of using CASSM for this current study is based on an experiential qualitative study by Faisal (2008) which examined users' subjective experience of interacting with an academic literature domain (ALD) InfoVis tool. In the study, users were given high-level or non-restrictive tasks to explore the ALD using the tool being studied so that their sensemaking experiences of the ALD can be captured.

Subsequently, interview and observational data of users' experiences on interacting with the tool were analysed using Grounded Theory. The findings resulted in the theory of harmonious flow, which posits that positive experience is a result of a "seamless interaction" between *manipulative activities* and *sensemaking activities* while interacting with InfoVis tools. The former encompass activities such as manipulating the interface with the tool while the latter involve more in-depth understanding of the insights gained to achieve user-goals during the sensemaking process depending on the users' conceptualisations of a specific domain. Also referred to as epistemic activities, these *sensemaking activities* are dependent on users' experiences and knowledge of the represented domain, which affect how users conceptualise information. A harmonious flow is achieved when the interaction between the user and the InfoVis tool occurs without interference. This is based on the rationale that users make sense of information by interacting with the external representation, which they then internalise. Combined with personal experiences and knowledge, users then adopt personal strategies to make sense of the represented domain.

Hence, the theory of harmonious flow posits that positive experience of interacting with an InfoVis tool is achieved when there is a good conceptual fit between the user's internal conceptualisation of the related domain and the external design. Based on that assumption, I argue that CASSM allows the evaluator to determine if the visualisations match users' conceptualisations of the represented domain and hence is suitable for evaluating the utility of InfoVis tools.

2.3 CASSM

This section provides a brief overview on the theoretical concepts behind CASSM and explains why it is suitable for the evaluation of InfoVis.

2.3.1 CASSM as an evaluation method

CASSM was developed in the field of human-computer interaction (HCI), and is a systematic approach which supports the analysis of misfits between users' conceptualisations of information, and the representations implemented within the system (Blandford et al., 2008a). Pronounced as "chasm", the core concept of CASSM is to identify the surface and structural misfits between the user and the system so that the gulf between the user and system can be bridged through new design possibilities.

Surface misfits consist of: concepts that are relevant to the user but not represented within the system, concepts represented by a system but is not salient in the user, or user and system concepts which are similar but non-identical (Blandford, Connell, & Green, 2004, p. 7-8), hence causing difficulties during the user interaction. **Structural misfits** occur when there is a mismatch between the way users perceive and the way the system represents relationships between user concepts. As such, difficulties arise when a change in a system representation does not match the user's model.

The main driving force behind CASSM's development was to complement most of the task-oriented evaluation methods by looking at user and system concepts, and the relationships between them. It fills a niche in existing analytical usability evaluation methods such as Heuristic Evaluation (Nielsen, 1994) and Cognitive Walkthrough (Wharton, Rieman, Lewis, & Polson, 1994) by focusing on user concepts rather than on identifying usability problems of an interface based on evaluator expertise. This was validated by studies which illustrated CASSM's utility in identifying usability problems which were not directly observable. For example, Connell, Blandford, and Green (2004) found that CASSM managed to uncover usability issues which were not directly observable from London Underground ticket vending machines. A different study found that CASSM managed to identify issues in a robotic arm related to the quality of conceptual fit between user and system, which were not readily identified by the other methods who fared better in identifying problems related to system design, user misconception, physical, and contextual issues (Blandford, Hyde, Green, & Connell, 2008).

In addition to the previous examples, CASSM has also been applied in the evaluation of a digital library, drawing tool (Blandford et al., 2008a), ambulance dispatch system, and a heating controller simulation (Blandford et al., 2004).

2.3.2 Why is conceptual model important?

The idea of 'conceptual fit' behind CASSM is similar to Norman (1986)'s three conceptual models. According to Norman's model, the designer needs to ensure that the design of a system matches the users' conceptual model of the system. This is achieved by ensuring that the designer's mental model - *design model*, is consistent with the user's understanding of the system - *user's model*. As this is only achievable by designing a *system image* which reflects the way users understand things, it is important to find out how users conceptualise specific knowledge domains so that there is a conceptual fit between the design and the user. In a way, Norman's conceptual model corresponds to the idea of CASSM's surface misfits where the presence of a surface misfit indicates a mismatch between the user model and system image.

An example of a good conceptual fit between user and system in InfoVis is the tag cloud. Originally used to indicate tagged content from websites, it is also now referred to as a text cloud or word cloud in cases where only word-frequency for a particular text is being visualised. There are several usages for tag clouds, but it is commonly used to visually represent the frequency of word occurrences in a particular text by using features such as font size, colour, and weight (Halvey & Keane, 2007). The tag cloud is successful because of its simple mapping of font size to quantity of words in a text. The idea of "big is more" matches users' conceptualisations where bigger font sizes correspond to higher word occurrences in a specific text. Figure 2.1 illustrates this simple yet effective concept of a tag cloud which was generated using text from section 2.3 of this thesis.

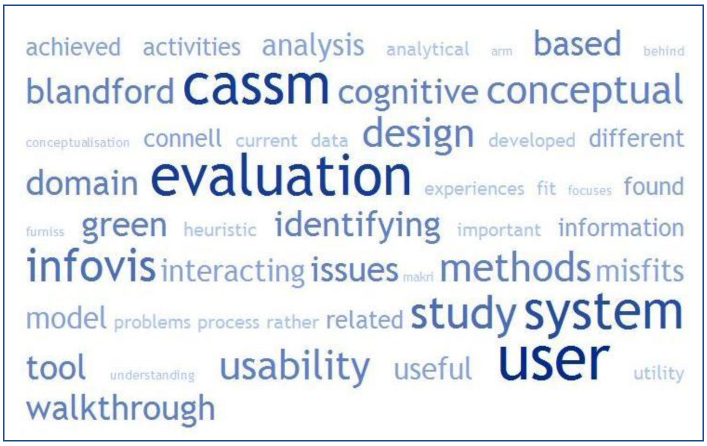

Figure 2.1. The tag cloud is an example of a good conceptual fit between the user and the InfoVis where a word with a bigger font size indicates its high number of occurrences within a particular text. [Tag cloud generated from http://tagcrowd.com/ using text from section 2.3 of this thesis]

Based on the above arguments, it is apparent that having a good conceptual fit between the user and system is imperative to ensure a positive user experience during user-InfoVis interaction. As CASSM is by far the only evaluation method which captures the conceptual fit between the user and the system (Blandford et al., 2008a), it is most suitable for the evaluation of InfoVis tools to bridge the gap between the user and tool.

2.4 Visualising social networks

This section explains why social networking InfoVis tools were chosen as the application domain for this research.

2.4.1 Birth of social networking InfoVis tools

Technology-mediated social interaction (e.g., blogs, SNS, instant messaging services) has become increasingly popular over the past years. Social InfoVis design, as Danzinger (2008) calls it, is when social media meets InfoVis, and is a good example of InfoVis targeted at the non-experts. The social network domain is a very good example of "popular InfoVis" as it is relevant to almost everyone who has friends. Hence, social networking InfoVis tools were chosen as the application domain for the current study to investigate if InfoVis tools are meeting the needs of its general users.

The visualisation of social networks started off within the social sciences as social network analysis, a powerful method for understanding the importance of relationships between people (Perer & Shneiderman, 2006). The main idea is to look for *social groups* and *social positions* where the former refers to people who are closely linked to each other and the latter to people who are linked to the social system in a similar way (Freeman, 2000). Following the advancement of social media, these social relationships can now be inferred from different sources including email contact lists, blog 'friends', and friends on SNS (Perer & Shneiderman, 2006). The introduction of sophisticated computer programmes has also enabled the visualisation of more complex social interactions, allowing the development of structural insights and providing a medium for these insights to be communicated to others (Freeman, 2000).

As such, abundant data from SNS paired together with the advancement of social network analysis techniques provided more convenient ways of collecting and presenting social network data, which encouraged the development of social networking InfoVis tools. An exhaustive list of such examples can be found from visualcomplexity.com.

2.4.2 Facebook

The surge of SNS such as Facebook, Friendster etc. is extending real-world social relationships into the digital realm, allowing offline friends to maintain their relationships and enabling the formation of new connections (Ellison, Steinfield, & Lampe, 2007). The SNS Facebook was chosen for this study as there are currently several InfoVis tools designed specifically for generating visualisations from the Facebook application programming interface (API). Its mass appeal is also evident from being the 3rd most visited website in the world after Google and Yahoo! (Alexa the Web Information Company, 2009) on the 19th of August, 2009. Facebook was created initially for Harvard students to connect within their network, which eventually expanded to other colleges, high schools, corporations, and the whole world. It currently has more than 250 million active users worldwide and more than 120 million of these users logon to Facebook at least once a day (Facebook, 2009).

2.4.3 Evaluation of social networking InfoVis tools

To the extent of this current literature review, only one case-study has been found to have evaluated a social networking InfoVis tool. This evaluation was on *Vizster*, a tool designed for users to discover and increase their awareness of one's online social networks through exploratory play and search functions on the SNS Friendster (Heer & boyd, 2005). *Vizster* was evaluated under a party-setting with 500 Friendster users and an informal laboratory setting with five users. The studies were mainly observational and revealed interesting findings related to the discovery of connections and information about one's networks. However, while the reported findings focused on the design techniques of *Vizster* (e.g., connectivity highlighting, X-ray mode, etc.) it was not clear whether the tool was meeting users' needs apart from the fun-factor obtained from several user quotes.

In all, given the pervasiveness of SNS and existence of various commercial social networking InfoVis tools, it is imperative to find out if these tools are generating visualisations that match the way people conceptualise their social networks.

2.5 Rationale of current research

Section 2.2.1 outlined several issues in current InfoVis evaluation. This research addresses these issues based on the following arguments. First, as the current study will be investigating the social network domain, users of the study will all be experts of their own social networks. Second, the use of Facebook is not context-dependent, and users tend to log on to Facebook regardless of time and location, hence a laboratory setup should not affect the findings. Third, the visualisations of social networks are less scientific compared to studies that investigated visualisations of expert domains. This will more likely contribute to a better understanding on the utility of CASSM in evaluating InfoVis tools without being plagued by the complex nature of the application domain.

2.5.1 Direction of CASSM analysis

CASSM encompasses both the data gathering and data analysis stages of an evaluation study. Hence, these two parts will be explained separately in chapter 3 and 4 following the flow as shown in Figure 2.2 below. Chapter 3 describes the data gathering stage (Figure 2.2a), and chapter 4 delineates the data analysis stage and the results obtained (Figure 2.2b and 2.2c).

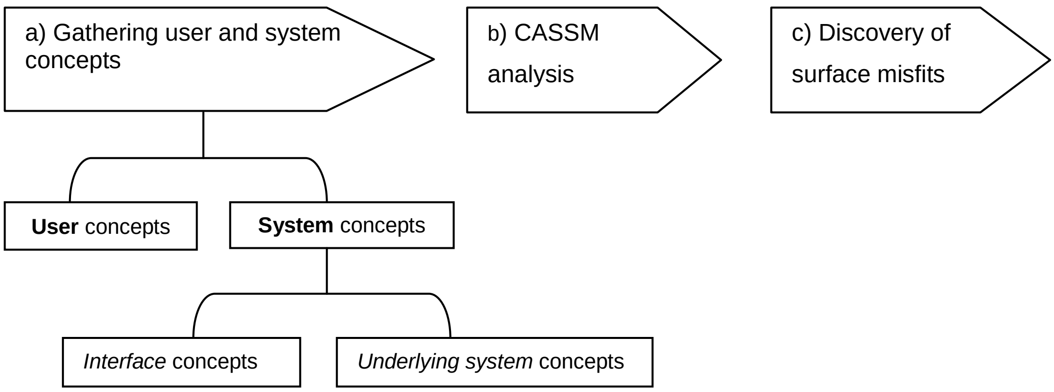

Figure 2.2. A CASSM analysis starts by a) gathering **user** and **system** concepts so that b) data analysis of comparing user and system concepts can lead to the c) discovery of surface misfits which directly informs redesign. Note that **system** concepts can be further broken down into *interface* and *underlying system* concepts depending on the depth of analysis required.

Figure 2.2 shows the stages of a CASSM analysis. The initial stage involves gathering user and system concepts, where system concepts can be further broken down into the *interface* and *underlying system* to identify more surface misfits as an analysis deepens. This will be explained in more detail in chapter 3. Following that, the user and system concepts are then compared against each other to identify if they are being represented within the user and system. This then yields surface misfits which provide opportunities for redesign. It is important to note that Figure 2.2 does not depict a full-length CASSM analysis, but rather the direction adopted by the current research.

CASSM was developed with an open-source analysis tool- Cassata for supporting analysis (Green & Blandford, 2004). However, the current study did not utilise Cassata as it is possible to conduct a full CASSM analysis without using it (Blandford et al., 2004). Also, the fact that Cassata itself is a tool to be learned and contains specific terminology might complicate the analysis process. As this exploratory study assesses the utility of CASSM in evaluating InfoVis tools, there is a need to provide a method which is comprehensible to and accessible for all. More details on Cassata can be found in Green and Blandford (2004).

2.6 Summary

This chapter delineated the shortcomings of current InfoVis evaluation techniques and the lack of investigation into the utility of InfoVis tools targeted at general users. CASSM is proposed as a suitable method for InfoVis evaluation given its focus on identifying the conceptual fit between user and system. Facebook users are the ideal target population for the purpose of this study, and given that everyone is the expert of their own social network, the user concepts captured during the study will unlikely be confounded by different levels of expertise. This overcomes one of the major problems in the field of InfoVis evaluation of finding real users to perform real tasks using real data. The overall goal is to identify an evaluation method which can provide users with InfoVis tools which suit their needs.

CHAPTER 3. DATA GATHERING METHODS

This chapter describes the methods used to gather data on users' conceptualisations of their social networks, and how the *interface* and *underlying system* concepts were obtained as depicted in Figure 3.1a.

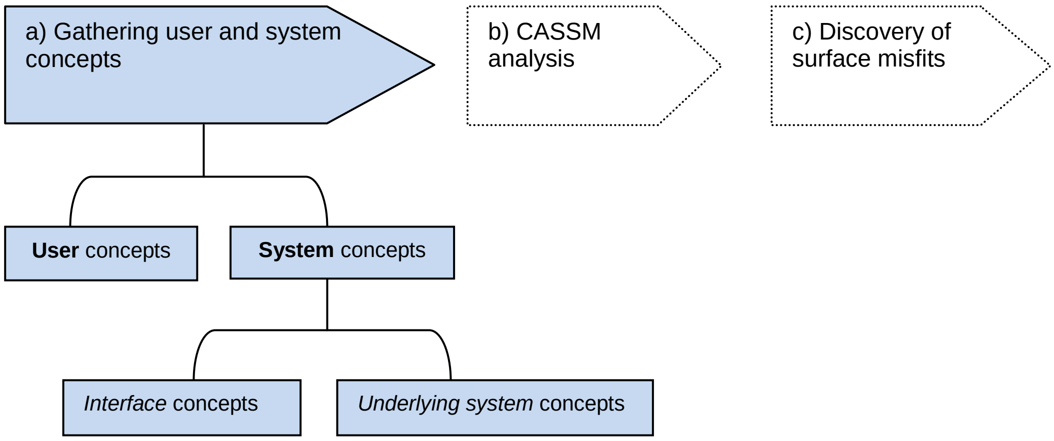

Figure 3.1. This chapter describes the process of a) gathering **user** and **system** concepts where the **system** concepts are then further broken down into *interface* and *underlying system* concepts to reveal a more thorough understanding on the source of misfits between user and system.

3.1 Gathering user concepts

The purpose of gathering user concepts is to capture users' understanding towards the domain that they are working with so that comparisons can be made to identify if these user concepts are being represented within the system. This is usually done by collecting some form of verbal data from several users of a system, then integrating the common concepts into a single user profile to represent the typical user of the system (Blandford et al., 2008a). Users' conceptualisations of their social networks were captured through interviews and a think-aloud session which they engaged in while interacting with two different social networking InfoVis tools.

3.1.1 Participants

Participants of the SNS Facebook (www.facebook.com) were recruited via flyers posted around the University College London (UCL) campus area, departmental email, the SNS Twitter, and word-of-mouth. A total of 11 (4 females, 7 males) participants with an age range from 21 to 35 years, and of different nationalities took part in the study. All participants were fluent in English, had normal or corrected-to-normal vision, and were completing their MSc in HCI with Ergonomics at UCL during the time of study. Eleven participants were recruited as the data successfully reached a saturation point towards the 11th participant. Participants will be referred to as users hereafter to better reflect them as being the users of the InfoVis tools being studied. Users' details are summarised in Table 3.1.

Table 3.1

Summary of user details related to Facebook usage and experience with social networking InfoVis tools.

User	Sex	Age	Facebook-membership period (approximately)	Facebook-logon frequency	Number of Facebook friends (approximately)	Prior experience with social networking InfoVis tools
1	M	31-35	1 year	Daily	100	No
2	F	26-30	4 years	Daily	200	Friend Wheel
3	M	18-25	4 years	When receives mail notices	200	No
4	M	18-25	2 years	Once a week	100	No
5	M	26-30	2 years	Several times a day	90	Friend Wheel
6	M	31-35	4 years	Every few days	500	Application name unknown
7	F	18-25	2 years	several times a day/ when receives updates	150	Generated Friend Wheel , looked at it and closed the page
8	F	31-35	2 years	once a week or more if there is a special activity	80	No
9	F	31-35	3 years	At least once a week	400	No
10	M	18-25	4 years	Daily	290	No
11	M	18-25	4 years	Less than once per month	270	Friend Wheel and TouchGraph

Table 3.1 provides a summary of users' Facebook usage details, and experiences with social networking InfoVis tools prior to the study. Out of the 11 users, four had prior experience with using social networking InfoVis tools, one had seen some sort of social networking InfoVis tool, and six had no experience with such tools prior to the study.

3.1.2 Materials

Two different social networking InfoVis tools were sourced from visualcomplexity.com, a unified resource site featuring hundreds of InfoVis tools. Both InfoVis tools, Facebook Friend Wheel (Fletcher, 2007), and TouchGraph Facebook Browser (TouchGraph, 2007) were available as Facebook applications to generate visualisations of users' social networks during the time of study. Facebook users were able to add and run both applications on their Facebook accounts by allowing the applications to access their profile information, photos, users' friends' information, and other content that the applications require in order for the tools to work.

Facebook Friend Wheel

The Facebook Friend Wheel (referred to as FW hereafter) application uses the Facebook Development Platform to retrieve users' friends and all of the links between them to generate a wheel-like visualisation of users' social network. All users interacted with the static and interactive FW on their default settings (see Appendix A) which displayed a visualisation of only the user's own social network.

The default **static** version of FW displays all the names of users' Facebook friends around the wheel and line connections between friends within the users' social network in a colour spectrum (Figure 3.2a). The default grouping algorithm *FriendGroupster4000* categorises people base on their interconnectivity where people who are highly interconnected are placed next to each other on the wheel. To illustrate, a higher density of lines within a specific area in the wheel indicates that people around that area are highly interconnected, hence are more likely to be from a same group.

The default **interactive** flash version of the wheel shows a similar display of names around the wheel in the same colour spectrum. However, instead of presenting all connections simultaneously, only mutual connections are highlighted when a name is being moused-over (Figure 3.2b). In addition, several direct manipulation options allow users to highlight, zoom, select and move the nodes on the interactive wheel. Other settings are also available for users to customise their FW as shown in Appendix A. It is worth noting that the colours do not carry specific meaning as revealed by users' responses.

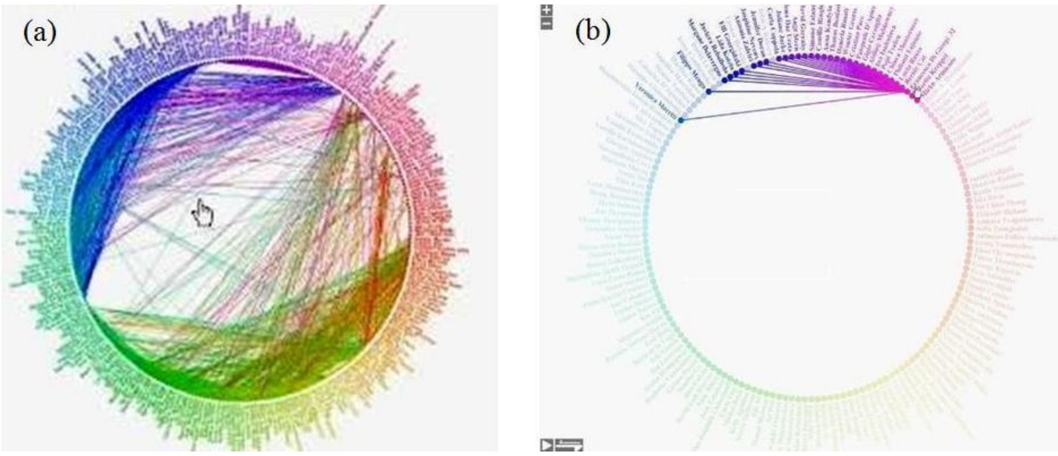

Figure 3.2. (a) A default static version of the Friend Wheel showing all the connections between friends and (b) a default interactive flash version showing the connections only when a user mouses-over a specific name. Buttons for zooming in and out the wheel (upper left of figure 3.2b), a play button which rotates the wheel, and a button which changes the direction of the rotation (bottom left of figure 3.2b) are available on the interactive wheel.

Touch Graph Facebook Browser

The TouchGraph Facebook Browser (referred to as TG hereafter) application displays an egocentric view of one's social network, showing the connections between the user and his/her immediate friends.

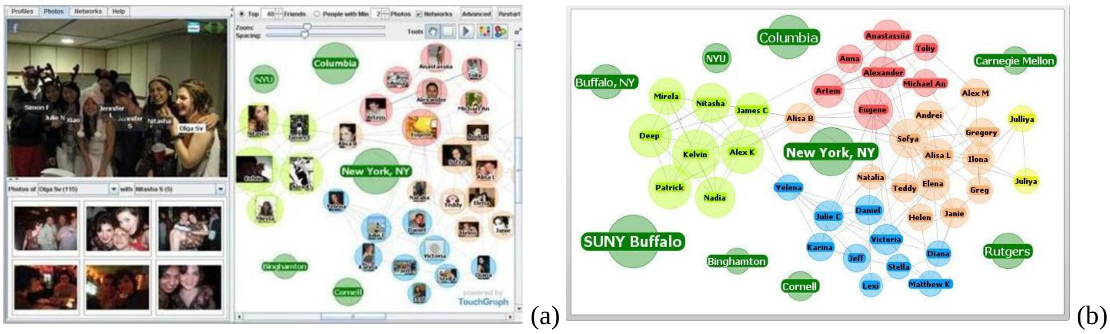

Figure 3.3. The TouchGraph application (a) showing users the connections between and networks of their friends, and photos shared with a specific friend, (b) which can be zoomed out for a more complete view but without photos on the names. [Screenshots obtained from http://www.touchgraph.com/TGFacebookBrowser.html]

The default TG interface consists of two panels as shown in Figure 3.3a. The left hand panel contains four different tabs showing: the profile of the users and their friends; photos shared with a particular friend; networks of users and their friends; and a help page. The right hand panel of Figure 3.3a displays the actual visualisation of users' social networks. Apart from the name of friends, TG also displays friends' profile photos in the visualisation as shown in the right hand panel of Figure 3.3a. As the left hand panel was not directly related to the visualisation, all users were instructed to hide it during their interaction with the TG interface as depicted in Figure 3.3b. Note that Figure 3.3b depicts a zoomed out version of the visualisation where a zoomed in visualisation resembles the right hand pane of Figure 3.3a on a full screen.

The TG visualisation layout computes in real time, where users can see the nodes (friends) and links move around while they are being generated. It also uses a spring embedding algorithm which assigns forces to nodes so that they repel when two nodes are too close together and are drawn to each other when too far apart. Direct manipulation functions also allow users to drag nodes around to re-organise the network layout by putting the visualisation on "pause" mode. The **recompute clusters and colour** functions enable users to control the number of clusters that their friends are divided into, and select different colours for the clusters.

TG groups people into networks (e.g., companies, educational institutions, countries) that they belong to, as illustrated by the dark green circles in Figure 3.3b. Additionally, users can also view networks of friends who are tagged in their photos by clicking on a camera icon which appears when users mouse-over a specific friend. The default TG visualisation presents users with their Top50 friends. **TopFriends** uses betweenness centrality as a factor while ranking friends where higher rankings are assigned to friends who are connectors between different groups, indicating the importance of a person within a network. Users can also increase or decrease the number of friends being visualised on the TG interface. More functions of TG are listed in Appendix B.

Lab-based equipment

Two different desktop computers installed with two different screen recording software with audio recording were used for launching the FW and TG applications on users' Facebook accounts. The ZD soft screen recorder software was used on a Dell XPS710, (2.40 GHz, 2.00 GB RAM) and the CamStudio screen-recording software was used on a Dell GX280 (3.00 GHz, 1.00 GB RAM). All interviews and think-aloud sessions were recorded using the Sony (ICD-UX71F) digital voice recorder.

3.1.3 Procedure

Pilot study. Three pilot studies were conducted to ensure all materials and interview questions were appropriate and sufficient for achieving the evaluation goals. Observations from the pilot studies revealed that users employed different strategies while exploring the InfoVis tools according to their own interests and goals. This informed the actual study instructions where users were told to explore the tools as they would in real-life to understand their social networks. The pilot studies were also crucial for ironing out technical issues related to launching the InfoVis applications on users' Facebook accounts under different privacy settings.

Actual study. All 11 study sessions were conducted under a laboratory setting in two different rooms with a similar setup. Users were seated in front of a desktop computer and were first told to read the information sheet (Appendix C) before agreeing to sign the consent form (Appendix D). It was stated on the information sheet and consent form that the research was approved by the UCL Research Ethics Committee and is bounded by the Data Protection Act 1998. Following that, users then completed a short questionnaire, pre-interaction interview, interactive tasks with the InfoVis tools, and a post-interaction interview. Details of these different stages are outlined below in sequence:

1. *Questionnaire*

Users were required to complete a questionnaire (see Appendix E) which gathered their demographic data as depicted in Table 3.1. This information was mainly to eliminate non-frequent Facebook users and users who are new to Facebook. The number of one's Facebook friends was found to affect the visualisations during the pilot study hence was collected for comparison purposes.

2. *Pre-interaction interview*

The pre-interaction interview was added from the 5th user onwards following iterations as the study progressed. The purpose of this interview was to capture users' general conceptualisations of their social networks without being influenced by their interactions with the InfoVis tools. A semi-structured interview style with open-ended questions (see Table 3.2 for a sample of questions used) ensured that specific topics (e.g., who users class as friends, how users visualise their social network) were covered, whilst allowing flexibility for further probing depending on individual responses. The interviews were recorded using a digital voice recorder and lasted for approximately 15 minutes per session.

Table 3.2

Sample of pre-interaction and post-interaction interview questions used in the study.

Pre-interaction interview questions	Post-interaction interview questions
• Who would you class as your friends? • How do you classify your friends? • How do you usually get updates about your friends? • What types of information about your friends are most important to you? • How do you visualise your social network in real life?	• Are the visualisations different from the way you think about your social networks? • Do you categorise your friends on Facebook? • Tell me what you think about using visualisation tools to represent your social networks. • Is there a specific tool which you prefer over another? • Did the tools allow you to achieve your goals in making sense of your social networks? Please feel free to use examples of the specific tools while describing your experience. • Is there anything else that you want from a visualisation tool that was not being offered by the previous tools that you interacted with?

3. Think-aloud session while interacting with the InfoVis tools

Upon completing the pre-interaction interview, users were given an instruction sheet (Appendix F) which provided a description on how to perform a **think-aloud** (Ericsson & Simon, 1980). The think-aloud method required users to verbalise their thoughts, including what they were looking at, thinking, doing, and feeling, while interacting with the InfoVis tools. A sample of a think-aloud transcript was also provided in the instruction sheet (see Appendix F) to ensure users understood what was expected from them. However, as the users in the study were from a postgraduate HCI course, all of them were familiar with the think-aloud method prior to the study. The think-aloud method was used as it is the best way to gain insight on users' cognitive processes (van Someren, Barnard, & Sandberg, 1994), in this case, to capture users' conceptualisations of their social networks while interacting with the InfoVis tools.

The instruction sheet also informed users of their main task during the think-aloud session, which was to interact with FW and TG as they would in real-life. Unlike most evaluation studies which required users to perform benchmark tasks, the current study allowed users to explore the tool without being given specific instructions or a tutorial on how to use it. This was to ensure the ecological validity of the results obtained. After reading the instruction sheet, users were allowed to ask questions before they logged on to their Facebook account.

The sequence of presenting the InfoVis tools was counterbalanced across all users to control for possible carryover effects. Basic instructions were provided to ensure that all users interacted with the InfoVis tools on the default settings. For FW, users started by generating a **static** version of the wheel, and then proceeded to the **interactive** flash version according to their own pace. Users were then left to decide if they wanted to regenerate their wheel using different settings or quit the application. This was to ensure that users' actual sensemaking experiences were being captured.

For the TG application, users first interacted with the default visualisation which showed them their Top50 friends. The concept of **TopFriends** (see section 3.1.2) was explained to every user to ensure they understood the rationale behind the visualisation. Following that, users were instructed to change the option on the interface to visualise all their friends, and they were then allowed to explore the visualisation according to their own preferences. Users were told about the **re-compute colour and clusters function** (see section 3.1.2) as it was found after several trials that it was a difficult concept to understand without reading the Help page.

It is important to note that user 2 was unable to launch the TG application during the study hence was given instructions and explanations to visualise her social network based on two TG screenshots as shown in Figure 3.3. The results obtained from her TG think-aloud session, and her responses related to comparisons between FW and TG during the interview were eliminated from the analysis.

Users' interactions with the InfoVis tools were recorded using screen recording software as described in the section 3.1.2. The think-aloud data was recorded using both a digital voice recorder and a microphone connected to the computer. The entire think-aloud session took an average of 30 minutes, with approximately 15 minutes allocated for each InfoVis tool.

4. Post-interaction interview

After interacting with both FW and TG, users were interviewed on their overall experiences with the InfoVis tools. Similar to the pre-interaction interview, a semi-structured interview style with open-ended questions (see Table 3.2 for a sample of questions used) were adopted to maintain consistency while allowing for flexibility to accommodate for personal differences in the answers provided. The interview lasted for an average of 15 minutes, and users were reminded to remove both the FW and TG application from their Facebook accounts before logging off their Facebook accounts on the lab computers. This was to protect users from showing others that they have participated in the study. Users were then thanked for their participation and compensated with chocolates.

3.2 Gathering system concepts

This section explains how the system was further broken down into *interface* and *underlying system*, and how the *interface* concepts and *underlying system* concepts were gathered for the subsequent CASSM analysis.

3.2.1 Defining the *interface* and *underlying system*

After collecting user concepts, the system was further broken down into the *interface* and *underlying system*. As the system refers to the system as a whole which the user interacts with, it is logical to refer to the FW and TG visualisations as the *interface*, and the Facebook homepage as the *underlying system*. This is based on the rationale that the FW and TG visualisations were essentially representations of users' profile information derived from their Facebook accounts. Also, users were very well aware that the information about their friends as depicted on the interfaces of FW and TG was derived from their friends' Facebook profiles. This indicated the need to differentiate between the *interface* and the *underlying system* for a clearer analysis to identify the root of the conceptual misfits between the user and the system as a whole.

3.2.2 Gathering *interface* concepts

Data sources for *interface* concepts are usually obtained by having access to a working system or interface description (Blandford et al., 2008a). In this case, the *interface* concepts were gathered from the TG and FW visualisations and other functions on the computer screen during users' interactions with both InfoVis tools. In addition, the following data sources were also used:

FW: A Frequently Asked Questions (FAQ) page (http://thomas-fletcher.com/friendwheel/faq.php) and the FW settings page (see Appendix A)

TG: A user Help page containing basic information on the functions of the TG InfoVis tool (see Appendix B)

3.2.3 Gathering *underlying system* concepts

Underlying system concepts for a CASSM analysis are usually obtained from developers, the running system, or descriptions of the system in forms of user manuals, and system documentation. In this study, the **Facebook homepage** was the main source of *underlying system* concepts. Also, the **wall page** and **information page** were included in the analysis given that users' responses and most information depicted by TG and FW correspond to information contained by these sections on a Facebook user's account.

3.3 Summary

This chapter illustrated the data gathering stage including a description of the social networking InfoVis tools used in the study, how users' conceptualisations of their social networks were captured, and how the system concepts were obtained. The next chapter describes the data analysis process and the findings.

CHAPTER 4. DATA ANALYSIS & RESULTS

This chapter presents a detailed account of how the data was analysed using CASSM (Figure 4.1b), and the results obtained (Figure 4.1c).

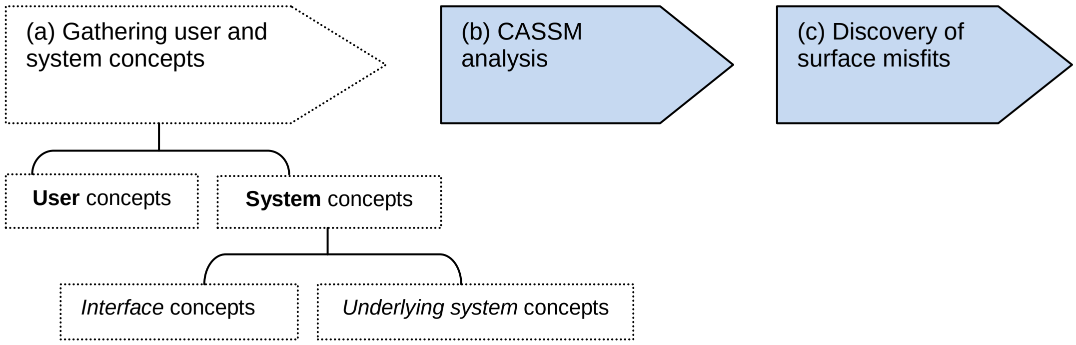

Figure 4.1. After (a) gathering user and system concepts, the next stage in a CASSM analysis is to (b) identify if these concepts are being represented within the user and the system. This will then lead to (c) the discovery of surface misfits between the user and the system.

First, an overview of a CASSM analysis is provided. Next, specific details on the direction adopted by the current study will be discussed, followed by the results of the actual analysis. Users' subjective experiences and task-related usability issues were also identified from users' verbal data which will be discussed briefly. Design implications based on the overall findings are presented towards the end of the chapter.

4.1 Overview of CASSM analysis

An overview is first outlined to provide the reader with a general understanding on the phases involved in a CASSM analysis. Following that, a more specific description of the direction adopted by this research is explained in detail. As it is not the purpose of this study to provide a full account of how to conduct a CASSM analysis, readers should refer to the CASSM tutorial by Blandford et al. (2004) for more detailed information.

In general, a CASSM analysis involves 4 main phases as shown in Table 4.1. The first and second stages are crucial in revealing surface misfits between the user and system. As these first two stages are the main focus of the current study, they will be described in detail below. Conversely, the last 2 stages will only be mentioned briefly as it is beyond the scope of this research.

Table 4.1

The general phases involved in a CASSM analysis process presented in usual order, with words highlighted in bold indicating main outcomes of each stage.

CASSM analysis process
1. Identifying user and system concepts, yielding first level **surface misfits**
2. Distinguishing between entities and attributes, and the interface; and considering whether each concept is present, absent, or difficult in the user, interface, and underlying system, yielding more **surface misfits**
3. Considering **actions** and how the user changes the states of the system
4. Identifying **structural misfits** by adding information about relationships between concepts to the analysis

[Adapted from "Evaluating system utility and conceptual fit using CASSM," by A. Blandford, T.R.G. Green, D. Furniss, & S. Makri, 2008, *International Journal of Human-Computer Studies, 66,* p. 398]

4.1.1 Identifying user-system concepts

As shown in Table 4.1, the initial analysis phase involves identifying *user* concepts. This is achieved by coding users' verbal data using qualitative analysis methods similar to Grounded Theory (Strauss & Corbin, 1998). The aim is to derive core user concepts of a specific domain so that the analyst can identify if these concepts are being represented within the system. Details on the coding methods used by the current study will be described in section 4.2.1. *Interface* and *underlying system* concepts can be obtained from existing system documentation and the running system as described in section 3.2 previously. Depending on the depth of analysis required, this initial phase is sufficient to yield first-level surface misfits.

4.1.2 Distinguishing between entities and attributes, and the interface

As an analysis deepens, *user, interface,* and *underlying system* concepts can be broken down into entities and attributes to achieve better clarity during the evaluation process. According to Blandford et al. (2004), an entity can either be created or deleted within a system, or can be something which exists within the system but contains attributes that can be changed. Attribute is a property of an entity which can be set or changed accordingly. Similarly, as an analysis progresses, the analyst might also want to further identify the *interface* from the *underlying system*. Details of this process was described in section 3.2 hence will not be repeated here.

After identifying *user, interface,* and *underlying system* concepts, and breaking them down into entities and attributes, the analyst then identifies if these concepts are present, absent, or difficult within the *user, interface,* and the *underlying system*. The definitions for **present**, **difficult**, and **absent** as delineated in Table 4.2 were adapted directly from Blandford et al. (2004, p.9). In addition, the definition of a concept which is **difficult** within the *underlying system* has been added to fit the context of this research.

Table 4.2

Definitions for concepts which are present, difficult, and absent within the user, interface, and underlying system.

Concept	Present	Absent	Difficult
User	Concept is clearly represented within the user	Concept is absent within the user	**Implicit:** ideas that users are aware of but were not expecting to deal with until explicitly required while interacting with the system. **Has to learn:** concepts that are inconsistent with the user's existing concepts, where concepts need to be learned in order for user to interact with the system. **Irrelevant:** concepts that are irrelevant to the user
Interface	Concept is clearly represented within the interface	Concept is absent within the interface	**Disguised:** a concept which is hard to interpret by user **Delayed:** a concept which does not become apparent to user until later on during the interaction **Hidden:** a concept where the user has to perform an explicit action to reveal its state **Undiscoverable:** a concept which is only obvious to users with good system knowledge but not to others
Underlying system	Concept is clearly represented within the underlying system	Concept is absent within the underlying system	* Information which is available on Facebook but not presented in an obvious manner.

**Definition added to fit context of current study*

[Adapted from "Concept-based Analysis of Surface and Structural Misfits (CASSM) Tutorial notes," by A. Blandford, I. Connell, & T.R.G. Green, 2004. CASSM Working Paper from http://www.uclic.ucl.ac.uk/annb/CASSM/downloadables/CASSMtutorial.pdf, p.9]

As shown in Table 4.2, a concept which is **present** indicates that it is clearly represented within the *user*, *interface*, and *underlying system*, and a concept which is **absent** simply indicates otherwise. A concept which is **difficult** within the *user* could be one that is implicit and inconsistent with the user's existing concepts, or is irrelevant to the user. A concept which is **difficult** within the *interface* is represented within the interface itself but could be hard to interpret and is less apparent, hidden, or undiscoverable by the user.

Although it was assumed by the developers of CASSM that concepts are either present or absent within the *underlying system* (Blandford et al., 2004), the current findings revealed the need to include a description for concepts which are difficult within the *underlying system*, i.e., Facebook. It will be presented later on in the results that this distinction is important for explaining the conceptual misfits between the user and system. As such, a concept which is **difficult** within the *underlying system* refers to information which is available on Facebook but is not presented in an obvious manner. An example is the concept of *frequency of social interactions* (entity) for *non face-to-face* interactions (attribute) as described in Table 4.3. This concept is present in the *user* but difficult within the *underlying system*. For example, the number of wall posts or photo comments on a user's Facebook account is not presented in a salient way which allows the user to make comparisons between users and across time to gauge the frequency of such non face-to-face social interactions.

By the end of this phase, concepts that are found to be present in the user and absent/difficult in the system or vice versa reveal further **surface misfits**, providing opportunities for redesign.

4.1.3 Considering actions and identifying structural misfits

Depending on the depth required by the analysis, the analyst can also consider how easy or difficult it is for users to perform **actions** to change the state of the system. This is usually done by defining whether a user can create or delete an entity; and set or change the value of an attribute. However, as CASSM focuses on conceptual and structural misfits, this phase is only of secondary concern in a CASSM analysis (Blandford et al., 2004), and will not be considered in this research.

The final phase in a CASSM analysis is identifying **structural misfits** (see section 2.3.1 for definition) by adding relationships to concepts to see how changes in the system might cause difficulties for the user. However, as structural misfits are usually considered in very detailed analyses, and are partly dependent on action information (Blandford et al., 2008a), it is considered to be beyond the scope of this study. Detailed information on how to consider actions and structural misfits can be found in the aforementioned CASSM tutorial.

4.1.4 Direction of current study

In theory, a CASSM analysis can stop after any of the phases outlined in Table 4.1. This is because the value of a CASSM analysis lies in its utility rather than thoroughness (Blandford et al., 2008a), and it is not necessary to proceed until the final phase if an analyst has achieved his/her goal of an evaluation study. The decision to terminate an analysis at any stage can also be made based on the costs associated with the analysis.

This research investigates the utility of CASSM in evaluating social networking InfoVis tools by following the stages outlined in Figure 2.2, which essentially encompass the first two phases in Table 4.1. As described in section 4.1.3, actions and structural misfits were not included as they are beyond the scope of this research. It is worth noting that screen-recording data was only used to fill in the blanks of the think-aloud data, and the questionnaires were only used to collect demographic data as shown in Table 3.1 and were not analysed further.

4.2 CASSM analysis of social networking InfoVis tools

This section delineates the CASSM analysis carried out in this research which involved eliciting main user and system concepts and then comparing them against each other to determine if they were represented within the user and system. Note that system refers to both the *interface* and *underlying system* when it is not necessary to distinguish between these two concepts during the analysis.

4.2.1 Identifying user concepts

In order to capture users' conceptualisations of their social networks, verbal data from the interviews and think-aloud sessions were transcribed and analysed using qualitative data analysis methods similar to Grounded Theory (Strauss & Corbin, 1998). This involved coding nouns which revealed main categories related to how users perceive their social networks, and adjectives which illustrated how salient these categories were to the users. Similar to Grounded Theory where concepts are derived and then grouped into higher categories, re-occurring patterns and themes extracted from all users of the study were integrated into a set of user concepts to form higher-level categories as shown in Table 4.3.

This process can be exemplified by how the *social context where connection was made* category was generated (see Table 4.3). Throughout the interviews and think-aloud sessions, users grouped their friends based on educational institutions, jobs, country names, activities/hobbies, which were in fact places where users first met their friends. As stated by user 9:

> U9: ... I have friends that I met through work and friends I met through other activities in my life, so I sort of keep them separate [in my head, and in real life].

After forming the main user concepts, they were then further broken down into entities and attributes. Using the previous example, the concept of *social context where connection was made* (entity) was further broken down into attributes such as educational institutions, jobs, activities, and geographical location.

Table 4.3

User concepts broken down into entities (in bold) and attributes (in bullet points) representing users' conceptualisations of their social networks. Additional notes explain the concepts in more detail.

User concepts	Notes
1. Social context where connection was made - educational institution - job - activities/hobbies - geographical location	Users grouped their friends based on where they met them. These included school, college, university, job, activities and hobbies, and also geographical locations including countries and cities.
2. Relationship distance/importance - family/relatives - close friends - good friends - acquaintances - random people	Apart from physical categories, users also classify their friends based on proximity where more important people are conceptualised as being "closer" to them. On the contrary, people who they do not care or like are perceived as "further away".
3. Friends' current status - geographical location - work - activities - relationship status - mood	Knowing how one's friends are doing is the most important information that users wanted to know about their friends. This includes getting updates on friends' current location, work-life, relationship status, activities that they are doing, and if they are doing well in general.
4. Frequency of social-interactions - face-to-face - non face-to-face (wall-posts, photo comments, private messages)	Frequency of social-interactions is one of the indicators of relationship distance. Friends who users are frequently in contact with are generally perceived as closer than those who they are in less contact with. However, it is important to note that users can have good friends who they do not contact frequently.
5. Stages of friendship in life - past friendship groups - current friendship groups	Users conceptualise their friendships on a timeline based on the different stages of their lives to distinguish between present and past friendship groups.

The qualitative data analysis elicited interesting findings on how users conceptualise their social networks in general, including both online and offline friendships. One of the interesting findings was despite allowed to explore the InfoVis tools freely, all users exhibited a similar sensemaking process while interacting with FW and TG. The interaction sequences for FW and TG are presented in Appendix G. However, only re-occurring themes were analysed in detail and presented for the current study as shown in Table 4.3, and these user concepts are described in detail in the following section.

4.2.2 Users' conceptualisations of their social networks

This section describes the five main user concepts of how users conceptualise their social networks using user quotes as examples.

1. Social context where connection was made

The most basic and general user concept was how users mentally grouped their friends based on the social context where the users first met them. When asked about how users classify their friends, they assigned common characteristics to a few friends to form a group. These include sharing the same educational institutions; working in a same company; engaging in similar activities and hobbies; and having connections to a geographical location due to the prior factors. For instance, user 8 described her group of friends based on the educational institution where she met them, and also the geographical location where she stayed at:

> U8: My main good friends I guess are people who I originally met at university first time ... and then there's people from where I used to live in [name of place] ... then there's people that I met on the course like classmates

It is crucial to note that these groupings were not mutually exclusive and can overlap with each other as illustrated by user 11:

> U11: These people seem to be people I was only in halls with, and these were people I was in halls with and in psychology with ... up there are people I was just in psychology with.

2. Relationship distance and importance of friendship

The next level of grouping is based on relationship distance and the importance of friendship where users assign "importance-levels" to people within their social network. Generally, family members (e.g., siblings and partners) are grouped as being the closest to the users, followed by close friends and good friends. Acquaintances and random people (in the context of Facebook) are usually perceived as being further away. Note that this relationship proximity can be at an abstract level and is not easily quantifiable as illustrated by user 4:

> U4: ... so these are important people, people I identify with, or people that I know that I don't necessarily identify with but I know they hang out with other people so they form this larger group

3. Frequency of social interactions

Similarly, the frequency of social-interactions is an important user concept where users want to ensure they interact enough with people who are close to them. Additionally, frequent interactions with a friend also indicate the importance of a friend as stated by user 2:

> U2: For example if you and I are best friends and we talk back and forth on Facebook and write on each other's walls 20 times a day, so if you can see that as a visualisation, it is an important indicator of who is important to you.

4. Friends' current status

Knowing one's friends' current status is fundamental in social networking. This is due to the fact that social-interactions are essential in maintaining friendships, and having updates on friends' current statuses is useful for initiating conversations when necessary. For example:

> U9: So recently a friend of mine decided to leave a company that he worked for many many years and it was a difficult decision for him and he was struggling with the decision and I wanted to know that he is in trouble so I knew to reach out to him and get more information.

This need of wanting to know about friends' statuses is also based on understanding what is important in one's life. More interestingly, users seem to have a mental profile of what they think are important to certain friends and vice versa. Based on this understanding, they then choose to gain more information or ignore certain information about their friends' statuses. For example:

> U11: It obviously depends on the person like some people if a relationship goes bad they don't care but some people it will be like a big deal to them. So that's something like I would rather know about it if it's the person who is a big deal, whereas if the person is just like lost another one, it is not really [important to know]

5. Stages of friendship in life

Users conceptualise their friendships based on a timeline which can be broken down into past and current friends. This distinction revealed how different social groups were more dominant throughout the different stages of one's life. As indicated by user 7:

> U7: Now I've went to university I've sort of lost touch with my old friends, we used to meet up occasionally ... so now my friends are from Birmingham, from undergraduate, so I keep in close contact with them rather than my old school friends in sixth form, college

In all, the findings indicated that users conceptualise their social networks at an abstract level. Still, despite it being very personal and abstract in nature, users did exhibit similar user concepts about their social networks in general.

4.2.3 Identifying system concepts

As described in section 3.2, the system as a whole was broken down into the *interface* and *underlying system* to further identify the conceptual misfits between the user and the system. The *interface* concepts identified for the analysis are presented in Table 4.4, which includes *interface* concepts that users interacted with the most, and the FW and TG default settings which all users interacted with. It is evident that TG and FW utilised similar concepts to represent social networks including the visualisation of *mutual friends* and *individual connections between friends*. Grouping was another important concept in social network visualisation which was done albeit differently by TG and FW. While TG groups friends based on the *networks people belong to*, FW groups friends based on the number of connections they share with each other, i.e. the *interconnectivity between people*.

Table 4.4

Interface concepts obtained from FW and TG broken down into entities (in bold) and attributes (in bullet points).

FW interface concepts	TG interface concepts
Grouping based on the connectivity between friends **All friends on Facebook** - Mutual friends - Individual connection between friends	**Friend ranking** - TopFriends (ranking based on betweenness centrality) - Number of shared photos **Friend's networks** - Geographical location - Educational institutions - Companies **All friends on Facebook** - Mutual friends - Individual connection between friends

Similarly, the *underlying system* concepts obtained from users' Facebook **homepage**, **wall page**, and **information page**, were concepts that users mentioned repeatedly during the interviews and think-aloud sessions. These concepts are presented in Table 4.5 below.

Table 4.5

Underlying system concepts obtained from Facebook homepage, wall page, and information page broken down into entities (in bold) and attributes (in bullet points).

Underlying system concepts	
Basic information - Networks - Family members - Relationship status - Hometown/neighbourhood	**Education and work details** - College/university - High school - Employment
Personal information - Activities/Hobbies - Preferences in music, movies, books, TV shows	**Friend's current statuses** - Wall posts - Status updates
All friends on Facebook - Mutual friends	**Photos** - Comments - Tags

As shown in Table 4.5, most of the *underlying system* concepts consist of personal information which overlaps with most of the *user* concepts shown in Table 4.3. These include *friend's current statuses*, *education and work details,* and some attributes under *basic information*. It is important to note that due to the personal nature of such information, not every Facebook user shares this information on their account. Some of them set up privacy settings to protect their information, which affects the visualisations. However, for the sake of analysis, the Facebook accounts involved in this current study were assumed to be sharing all of the above information on their Facebook profiles, i.e., the relevant concepts were assumed to be present in the *underlying system* during the CASSM analysis.

4.2.4 Comparison between *user*, *interface*, and *underlying system* concepts

After compiling *user, interface,* and *underlying system* concepts, they were then integrated into a list of concepts as shown in Appendix H. Overlapping concepts were eliminated and comparisons were made to identify if the concepts were present, absent, or difficult (see Table 4.2 for definition) within the *user,* the FW and TG *interfaces*, and the *underlying system* Facebook (see Appendix H).

The process of identifying concepts that were present or absent within the user and system was fairly straightforward. However, the difficulties encountered during users' interaction with the InfoVis tools were coded more carefully to reveal the types of conceptual misfits between the user and system. This involved coding negative statements such as "*I don't understand"*, "*I don't know what the colour means"*, *"why is my cousin up there but not here"* etc. The results of the comparisons were a list of surface misfits between the user and the system which will be discussed in the next section.

4.3 Surface misfits

This section describes the surface misfits that emerged from the CASSM analysis. The definition of surface misfits was presented in section 2.3.1, and more details of the different surface misfits will be illustrated using user quotes. As mentioned in section 4.1, structural misfits were not considered in the current analysis as they are outside the scope of this research.

It is worth mentioning that surface misfits between the *user* and the *underlying system* will not be discussed in detail as it was found that concepts which were present, absent, or difficult within the *underlying system* were only helpful in explaining the surface misfits between the *user* and the *interface*. In other words, the TG and FW visualisations were generated by extracting data from users' Facebook profiles. Hence, a concept which is absent or difficult within Facebook explains the problems encountered by the FW and TG *interfaces*. Nevertheless, these findings are valuable design opportunities which will be discussed towards the end of this chapter.

4.3.1 Surface misfits between user and FW

The CASSM analysis revealed that most of the user concepts were absent from the FW interface (see Appendix H), which will be discussed in section 4.3.3. This section elaborates on the concepts that were present within the user but absent/difficult within the FW interface as exemplified by Table 4.6.

Table 4.6

Example of a surface misfit between user and the FW interface.

Entity/attribute	User	FW interface	Facebook
Social context where connection was made	P	Absent	Absent
Educational institution	P	D	P
Job	P	D	P
Activities/hobbies	P	D	P
Geographical location	P	D	P

Key: P (present); D (difficult)

As shown in Table 4.6, the entity of the user concept *social context where connection was made* was absent within the FW interface. While users categorised their friends based on the *social context where they first met* them, FW's grouping algorithm was based on the *interconnectivity between friends*. This resulted in a re-occurring problem where friends with fewer connections within a particular group were placed outside the region of the group, resulting in an inaccurate visualisation of users' mental grouping of friends. For example, user 5's statement below revealed a conceptual misfit between how he understood his friend grouping and how FW grouped his friend.

> U5: This is a bit surprising because this friend is part of the same group so she should be over there but I don't know why it put her over here

Interestingly, the attributes of how users mentally group their friends based on educational institutions, jobs, activities, hobbies, and geographical location managed to coincide with FW's grouping algorithm based on the *interconnectivity between* *friends*. As a result of that, users still managed to make some sense out of the FW grouping despite this surface misfit, albeit with a certain level of difficulty as described above.

4.3.2 Surface misfits between user and TG

Most of the user concepts that were absent within FW were present within TG but with varying levels of difficulties as presented in Table 4.7. Examples of these difficulties are described below.

Table 4.7

Example of surface misfits between the user and TG interface.

Entity/attribute	User	TG interface	System
Social context where connection was made	P	Absent	Absent
Educational institution	P	D	P
Job	P	D	P
Activities/hobbies	P	D	P
Geographical location	P	D	P
Relationship distance/importance	P	D	D
Family/relatives	P	D	P
Close friends	P	D	P
Good friends	P	D	P
Acquaintances	P	D	P
Random people	P	D	P
TG Friend ranking	D	P	Absent
TopFriends	Absent	P	Absent
Number of shared photos	Absent	P	D
TG Friend's networks	P	P	P
Geographical location	P	P	P
Educational institutions	P	P	P
Companies	P	P	P

Key: P (present); D (difficult)

Similar to FW, TG's grouping based on *networks that people belong to* managed to coincide with how users group their friends based on the *social context where they first met them* (e.g., geographical location, educational institution). Therefore, despite the conceptual misfit between the *user* and the TG *interface*, users managed to figure out most of the groupings due to this unintentional matching. Nevertheless, as this matching was coincidental and not perfect, it caused users difficulties while trying to understand the friend groupings as indicated below:

> U10: These are all my friends at home and these are all my friends from university together, and it is being unclear as to why [they are grouped together]

Another surface misfit was that TG did not support the user concept of having social-groups which overlap with each other. As described by user 8:

> U8: So TG for example sort of quite blandly grouped all people I met in [country] or the work when I was doing there where that basically encompasses my entire social life that took place when I was living there, so for that reason there are loads of different groups of people including sort of best friends, or associates, or just work people and it hasn't captured or couldn't capture any of that, because the information is only in my head really

Additionally, users also assumed from the TG system properties (e.g., size of bubbles, thickness of lines, and spatial distance between bubbles) that friends were assigned different levels of importance. However, this concept was represented differently by TG via the **TopFriends** (see section 3.1.2) function and **number of shared photos**, criteria which did not match users' conceptualisations of relationship distance/importance. As illustrated below, there was a conceptual misfit between user 6's personal ranking of his top friends and TG's **TopFriends** ranking.

> U6: this is not my Top10friends, I don't know why is this my Top10friends ... I want it to give me an option to say who is in my top 10 list, because they are doing it wrong ... and my wife is not my 1st friend, very bad

Similarly, TG's friend ranking based on the **number of shared photos** did not match the user concept of relationship distance and importance. This was expressed by user 11 who explained how there might be a correlation between the number of photos shared with a person and the relationship importance, but this could be distorted by having friends who love taking photos:

> U11: ... so he'll take like a million photos ... while I am close to these guys, I wouldn't say that I am closer to them than my little sister, to me that doesn't seem like a natural way ... because I just don't see it as the number of photos we share.

4.3.3 User concepts absent within the *interface* and *underlying system*

This section summarises the concepts that are present within the user but absent/difficult within the FW and TG *interfaces* and *underlying system* Facebook as summarised in Table 4.8.

Table 4.8

Entities of main user concepts which were present within the user but absent within the FW and TG interfaces, and underlying system Facebook.

Concept (Entity only)	User	FW	TG	Facebook
1. Social context where connection was made	P	Absent	Absent	Absent
2. Relationship distance/importance	P	Absent	D	D
3. Friend's current status	P	Absent	Absent	P
4. Frequency of social interaction	P	Absent	Absent	D
5. Stages of friendship in life	P	Absent	Absent	Absent

Key: P (present); D (difficult)

Concepts that were absent within the system cause less complicated surface misfits as they indicate a rather straightforward solution, which is to include it during the redesign of the system. As shown in Table 4.8, it is clear that apart from friend's current status, the other four main user concepts were either absent or not clearly represented within the *underlying system* of Facebook. This comparison is important as it partially explains why these concepts were not being represented within the TG and FW *interfaces*. As the FW and TG visualisations were generated from users' Facebook profile information, the lack of these user concepts within the *underlying system* itself would render it impossible for them to be visualised on the *interface* of FW and TG. Hence, this provides an important opportunity for redesign which will be discussed towards the end of this chapter.

4.3.4 Conceptual fit and user preference

The discovery of surface misfits indicated the lack of conceptual fit between the user and the InfoVis tools. However, the strengths of the current InfoVis tools can also be exemplified by concepts that achieved a good fit between the user and the system. This section investigates whether there is a relation between good conceptual fit and user preference for a specific InfoVis tool.

The think-aloud and post-interaction interviews were analysed to reveal which InfoVis tool did users prefer, and these findings are summarised in Table 4.9.

Table 4.9

User quotes indicating preferences for FW and/or TG.

User	Friend Wheel	TouchGraph	Preference
1	Nice, cute	Useful, better grouping	TG
3	Confusing, horrible colours, does not match mental model	Better grouping based on regions	TG
4	Easier to see connections on wheel	Better grouping	Goal-dependent
5	Clearer connections	Overcomplicating the connections between friends	FW
6	Not a good mapping of mental model	Better just because can see photos and names	No preference
7	Better interaction	Can see photos	No preference
8	Looks pretty, less useful, less meaningful	Better utility, can understand groupings quickly	TG
9	Pretty, does not match mental model	More informative	No preference
10	Better usability, and sense of friend connections	Better visualisations, but poor usability	No preference
11	Nice to look at, better at sharing unexpected connections	Better at showing groupings, more functions	TG

** Note that user 2 only interacted with TG screenshots hence have been excluded from this comparison chart*

As shown in Table 4.9, four out of the ten users preferred TG, one preferred FW, four had no preference, and one stated that it would depend on his goals for using the InfoVis tools. In general, FW was better at visualising connections between friends, and TG was better at visualising the different friend groupings. However, the ultimate question was, did better conceptual fit resulted in preference for a specific tool? This was answered by examining the comparisons between the relevant user and system concepts as shown in Table 4.10.

According to Table 4.10, there was a better conceptual fit between the user and FW in terms of the visualisation of mutual and individual connections between friends. This was evident from several user quotes in Table 4.9 where users indicated that FW did a better job than TG at visualising the connections between friends. As indicated by user 5:

> U5: On Friend Wheel, the interactive one, I can really see who she is connected to; here on TouchGraph I don't see anything.

On the other hand, there was a better conceptual fit between the user and TG in terms of grouping friends according to networks. As described before, this grouping overlaps with how users conceptualise their friends based on the *social context where connection was made*. Therefore, although this concept was difficult within both TG and FW, TG managed to compensate for this surface misfit better by grouping friends based on the networks that they belong to. As stated by user 3:

> U3: I like [TouchGraph] better because they separate by region and company, networks, school ... I like this so much better than the wheel because it tells me by region

Table 4.10

Examples of good conceptual fits between user and system (sections highlighted in gray)

Entity/Attribute	User	FW	TG	Facebook
Social context where connection was made	P	Absent	Absent	Absent
Educational institution	P	D	D	P
Job	P	D	D	P
Activities/hobbies	P	D	D	P
Geographical location	P	D	D	P
All friends on Facebook	P	P	P	P
Mutual friends	P	P	D	P
Individual connection between friends	P	P	D	P
TG Friend's networks	P	N/A	P	P
Geographical location	P	N/A	P	P
Educational institutions	P	N/A	P	P
Companies	P	N/A	P	P

Key: P (present); D (difficult); N/A (not applicable)

In general, the results suggest that preference for certain aspects of an InfoVis tool did depend on the conceptual fit between the user and the InfoVis tool as illustrated in Table 4.10. However, as shown in Table 4.9, users' preferences did not solely depend on conceptual fit, and were also affected by other factors related to affective experiences and task-related usability issues which will be discussed in the next section.

4.4 Additional analysis

In general, users' experiences with the InfoVis tools were largely influenced by their interaction with the InfoVis tools. These included whether users were able to gain new insights from the visualisations, and whether they were able to achieve their goals while using the tools. These findings were categorised under *users' subjective experiences* with the tools. In addition, as with most usability studies, *task-related usability issues* also emerged from the think-aloud data. As these issues are not the focus of the current research, only key findings will be discussed here.

4.4.1 Users' subjective experiences

One of the important findings from the study was that the overall experience of interacting with the InfoVis tools was influenced by the **accuracy of information** depicted by the visualisations. In fact, there were many instances where users expressed the great disparity between the FW and TG visualisations and the real-life situation. For example the concept of TG's **TopFriends** did not match users' ranking of their friends:

> U1: It may match what's happening inside the computer, but it certainly does not match my perception of the world.

Due the artificial nature of SNS, user 4 also expressed that the social connections on Facebook do not necessarily match his offline social networks:

> U4: I know maybe this person is connected to a lot of people but that doesn't mean that they are friends ... because this is superficial networking it is not necessarily real and true...

Another important point worth mentioning is the **privacy issue** surrounding the visualisations of social networks. As aforementioned, the FW and TG visualisations were generated by extracting information from users' Facebook profile, including their friends' profile information. This was not a major problem for FW as its visualisation only involved connections between friends. However, this was a major issue for TG as its accuracy was affected by the information that people share on their Facebook profiles and privacy settings of one's account. Information that was affected included friends' current networks, profile photos, individual networks for a particular friend, and possibly others that were not discovered during this study. In fact, several users indicated the possibility of invading people's privacy using InfoVis tools such as TG as illustrated below:

> U11: It could certainly be used for good for research, and for evil ... you won't know what things would show up, it could show weird things about your friends, it could really really invade people's privacy.

It is also worth mentioning that the **"wow" factor** of the visualisations was an important determinant in users' subjective experiences. For example, almost all of the users complimented on the aesthetic properties of FW especially its rainbow colour scheme which some described as "pretty". As portrayed in Table 4.9, users generally found FW more aesthetically pleasing but TG was seen as more useful.

4.4.2 Task-related usability issues

Task-related usability issues of FW and TG emerged from users think-aloud data, and these re-occurring problems are summarised in Table 4.11 below:

Table 4.11

Re-occurring task-related usability problems for FW and TG.

Re-occurring problems for FW:	Re-occurring problems for TG:
• Clarity of the name of friends decreases after exceeding approximately 200 friends	• Clarity of the name of friends decreases with an increase in the number of friends
• Some of the custom setting functions were unclear to users (e.g. grouping algorithm, colour scheme)	• Loading time for the visualisation increases as number of friends increases
• Direct-manipulation functions unclear to users	• Interaction with the visualisation becomes delayed as the number of friends increases
• Shape of the wheel does not match users' mental models of their social networks	• Users wanted a *show all friends* function as most of them do not remember the exact number of friends that they have on Facebook
	• Direct-manipulation functions unclear to users

Table 4.11 highlights the re-occurring task-related usability issues that users deemed as most important. Some of the main user requirements in terms of usability included being able to interact with the visualisations smoothly without delays, having clear indicators that the visualisations are directly manipulatable, having a clear display of all friends, and also having options that are comprehensible.

4.5 Design implications

One of the strengths of a CASSM analysis is that the discovery of surface misfits and user concepts are valuable for the design of social networking InfoVis tools. Design implications and suggestions for improving the conceptual fit between users and social networking InfoVis tools are discussed below.

4.5.1 Design requirements for social networking InfoVis tools

The main five user concepts of their social networks (see Table 4.3) provide valuable guidelines for the design of future social networking InfoVis tools. The incorporation of these user concepts into social networking InfoVis tools can ensure a certain level of good conceptual fit between the user and the tool. For example, as users categorise their friends based on the geographical location where they met their friends, this suggests a design solution where friends can be visualised on the world map.

Users' verbal data is also useful for redesign as it provides detailed information on problems that users were facing, and the possible solutions. For example, the *frequency of social interactions* that occur on Facebook can be visualised in a way which enables users to gauge the number of wall posts they receive from a particular friend, or a visual alert can be used to remind users of messages that they have not replied to. As suggested by user 8:

> U8: If somebody's maybe sent me three wall posts or email I haven't got back to them it can be a bit of an alert to let me know that I need to get back to this person and by just scanning the whole lot you can see these people that I haven't spoken to in a while, or the last time you are in touch with people. It is suppose to help social interaction.

However, it is noteworthy that these user concepts might only be useful for SNS such as Facebook and ones of a similar genre. Professional SNS such as LinkedIn might require a different set of user concepts as they are built for different purposes from Facebook.

4.5.2 Improving conceptual fit

As shown in Table 4.8, the absence of the main user concepts within TG and FW suggests opportunities for redesign where these concepts can be incorporated into the

InfoVis tools. Similarly, user concepts that were present within the user but difficult within the FW and TG interfaces also inform the designer on aspects of the visualisations that can be improved. For example, the CASSM analysis revealed that FW and TG's grouping algorithm did not match exactly onto the way users group their friends based on the *social context where connection was made*. Hence, this surface misfit informs redesign so that a better conceptual fit between the user and system in terms of friend-grouping can be achieved.

Another example of a redesign opportunity is to improve the conceptual fit between user and system in terms of friend-ranking. The surface misfit between TG's **TopFriends** and users' conceptualisations of their friend ranking illustrates the importance of allowing users to rank their friends according to their personal understanding of *relationship distance/importance*. This emphasises the abstract nature of users' conceptualisations of their social networks where most of the meaning is "in one's head". Hence, InfoVis tools should allow for users to externalise what is in their head to ensure the accuracy of information. This highlights the importance of appropriation for InfoVis tools. Personal appropriation of InfoVis tools can increase the accuracy of information and utility of the tools as users can perform actions to achieve their own goals while making sense of their social networks. As how user 10 summed it up:

> U10: Good usability is the main factor ... in the sense of allowing me to do what I want to do when I want to do it ... providing options when I need them.

4.5.3 Improving overall experience

Apart from improving the conceptual fit between the user and the InfoVis tools, it is vital to take into account other factors such as the aforementioned *users' subjective experiences* and *task-related usability issues* while making design changes. For example, there is a need to strike the balance between utility and aesthetics since they are both important to the user and directly influences the overall experience of interacting with the tools. In addition, task-related usability issues should be eliminated so that users are able to achieve their goals with less frustration. For example, being able to visualise all of one's friends clearly on a single canvas is a basic requirement for a social networking InfoVis tool.

4.6 Summary

This chapter provided an overview of how to conduct a CASSM analysis, the direction adopted by the study, and the results obtained. Overall, CASSM was very useful in capturing users' conceptualisations of their social networks and the surface misfits between users and InfoVis tools. Design implications were discussed to illustrate the utility of CASSM in informing redesign. The overall findings will be discussed in relation to existing literature in the following chapter.

CHAPTER 5. DISCUSSION

The key findings in the previous chapter can be summarised into two broad categories: the utility of CASSM in evaluating InfoVis tools, and the challenges of evaluating social networking InfoVis tools. These findings will be discussed in relation to existing literature, and the limitations of the current study and directions for future research will also be presented. The overall findings will be argued in light of achieving the goals of this research before the concluding statement.

5.1 The utility of CASSM in evaluating InfoVis tools

This section discusses the utility of CASSM in informing redesign by relating it to existing literature. Additionally, the findings will be discussed in relation to the theory of harmonious flow (Faisal, 2008). Personal reflections on the process of applying CASSM to the evaluation of social networking InfoVis tools are presented.

5.1.1 Actionable evidence of measurable benefits

The utility of CASSM in evaluating InfoVis tools, in this case, social networking InfoVis tools, was demonstrated by the discovery of users' conceptualisations of their social networks, and surface misfits between the users and the InfoVis tools. The CASSM analysis elicited five main user concepts on how people perceive and understand their social networks: *social context where connection was made, relationship distance/importance, friends' current status, frequency of social interactions, and stages of friendship in life*. These user concepts were then used in a systematic comparison against system concepts to identify if they are being represented within the user and the system. Surface misfits between the user and the InfoVis tools as a result of this comparison suggest possible design changes for FW and TG. In addition, the five main user concepts are also valuable for the design of future social networking InfoVis tools.

These findings confirmed that CASSM **fills a niche in current existing evaluation methods** by capturing the conceptual misfits between users and interactive systems (Blandford et al., 2008a). The process of capturing users' conceptualisations of their social networks was very important for the subsequent discovery of surface misfits between users and the InfoVis tools. Although abstract in nature, the surface misfits between users' conceptualisations of their social networks and the representation of such concepts within the InfoVis tools emerged from the CASSM analysis. These findings support the ones of previous studies where CASSM captured usability issues which were not directly observable (Connell et al., 2004), and that were related to the quality of conceptual fit between user and system (Blandford et al., 2008b).

Also, the **effectiveness of using verbal protocol** in this current study corresponds to a previous CASSM study which used both think-aloud and contextual inquiry to probe into users' understanding of the ACM digital library system (Blandford et al., 2008a). Analysis of the verbal data in this previous study managed to uncover both strengths and weaknesses of the conceptual model of the ACM digital library. This was also found in the current study where users' verbal data revealed their preferences for an InfoVis tool, which highlighted the strengths and weaknesses of different social network concepts embedded within FW and TG.

In addition, the discovery of users' conceptualisations of their social networks and surface misfits gave rise to **new design possibilities**. This finding supports one of the key objectives in developing CASSM, which is having *downstream utility* to support redesign (Blandford et al., 2008a). Furthermore, the five main user concepts can act as user requirements for the design of future social networking InfoVis tools. As such, the utility of CASSM in informing the redesign of InfoVis tools is in accordance with its objectives as an evaluation method.

It has been argued that there is a lack of guidance on how to analyse data from qualitative studies in the field of InfoVis (Isenberg et al., 2008; Tory & Staub-French, 2008). The current findings addressed this issue by demonstrating CASSM as **a systematic method** for uncovering the conceptual misfits between the user and InfoVis tools. Also, the fact that CASSM encompasses both data gathering and data analysis stages in an evaluation process provides the analyst with a clear scope on what to focus on during both stages of the process. In this case, the main focus was to identify users' conceptualisations of their social networks and whether these user concepts were being represented within the social networking InfoVis tools FW and TG.

Overall, CASSM's utility in uncovering user concepts and surface misfits respond to the need for new evaluation approaches which focus on the ultimate purpose of a visualisation (Bertini et al., 2008; North, 2006; Plaisant, 2004; Stasko, 2006). This was illustrated by the discovery of user concepts and surface misfits which provided insights into the utility rather than usability of the InfoVis tools. Also, the implications of these findings on the design of social networking InfoVis tools suggest CASSM as an evaluation method which presents "actionable evidence of measurable benefits" which could encourage more widespread adoption of InfoVis tools (Plaisant, 2004, p. 110).

5.1.2 Theory of harmonious flow

Another important finding from the current study was the relationship between conceptual fit and user preference. It was found that users' preference for certain aspects of the FW and TG visualisations did depend on the conceptual fit between the *user* and the *interface*. In the case of FW, users preferred its visualisation of *mutual friends* and *individual connections between friends*. For TG, users preferred its grouping based on the *networks that people belong to* as it matches closer to how users conceptualise their friends based on the *social context where they first met them*. This finding supports the theory of harmonious flow (see section 2.2.3) which posits that positive experience of interacting with an InfoVis tool is achieved when there is a good conceptual fit between the user's internal conceptualisation of the related domain and the external design (Faisal, 2008). Although the current study did not investigate users' positive and negative experiences in detail, it is reasonable to assume that preference for an InfoVis tool is related to having a better experience while interacting with the tool itself.

5.1.3 The reflective practitioner

Thus far, the findings have revealed the utility of CASSM in evaluating InfoVis tools. However, as argued by Blandford et al. (2008a), the usability of CASSM was another important factor during its development. This usable factor encompasses a method which is easy to learn, cost effective, fits into existing design practices, and provides a tool to support analysis. Apart from the last factor which will not be discussed here as Cassata was not used in the current study, I will reflect upon the other three factors to shed more light on my experience in applying CASSM to InfoVis evaluation.

In terms of learnability, CASSM contains specific terminology that needs to be mastered. However, the mastering of these concepts does not lie solely on reading the tutorial. In fact, applying CASSM to the evaluation of InfoVis was part of the learning process. Also, as CASSM was intentionally designed to be sketchy to support iterative deepening, the analyst is not tied down to complete all phases to obtain valid results. Still, learning CASSM takes time, but this can be viewed from a cost benefit perspective. Given CASSM's utility in directly informing redesign, it depends on the depth required by a specific evaluation study to determine how much effort needs to be invested to achieve the evaluation goals.

CASSM fits easily into existing evaluation practices which utilise verbal protocol such as think-aloud to probe into users' cognitive processes. In addition, CASSM avoids focusing on interface widgets (e.g., lines, clusters, colour), and tries to uncover users' underlying concepts, which is crucial for InfoVis evaluation. This is because although the design-related features of a tool might appear to be representing certain user concepts, they usually represent a deeper underlying concept which is less instant to the user or observer. Having this clear scope is important to guide the analyst so that only issues related to conceptual misfits are being focused on during a CASSM analysis.

5.2 Challenges of evaluating social networking InfoVis tools

Several challenges arose during the evaluation due to the complexity of social networks. Information about one's social networks is very personal and this was expressed by users during the interviews and think-alouds. Despite being informed that the study has been ethically approved and data will be protected in accordance to the Data Protection Act 1998 (see section 3.1.3), some users remained hesitant while talking about their social networks. For example, some users explained their friend groupings using broad terms to avoid specifics, and some only provided detailed information after the screen recording and voice recording has been turned off. Although perfectly understandable from an ethical point of view, the missing out of information could have meant missing out on important user concepts.

Besides, the accuracy of the InfoVis was highly related to what users know about their friends, which is largely all "in the head", and impossible for a tool to capture. In addition, it is impossible for the system to detect all the complex semantic meanings of one's social relationships without the user feeding specific and detailed information into it. Moreover, different individuals employ different strategies while making sense of their social networks using the InfoVis tools, making it impossible to design an InfoVis tool which suits every single user's needs.

In all, these issues pose a great challenge to the design of social networking InfoVis tools, and as mentioned in the design implications, incorporating **personal appropriation** into the design of these tools seems to be the ultimate solution. In simple terms, appropriation refers to the adapting and adopting of technology to suit one's needs (Dix, 2007). It involves utilising technology in a way which was not anticipated by the designer. Salovaara (2009) argued that the use of technology is expanded via appropriation, and is a desirable phenomenon in the field of HCI.

The need for personal appropriation in the design of InfoVis tools is in line with the findings of Faisal (2008). In this previous study, a marking feature was incorporated into an academic literature visualisation tool and it was found that users utilised the function differently to suit their personal sensemaking strategies. Also, as sensemaking strategies are often personal and dependent on one's background, knowledge and experiences, Faisal (2008) argued that personal appropriation would allow more flexibility to cater for these individual differences.

5.3 Limitations and future research

There were several limitations with the current research. First the accuracy of information was largely affected by users' Facebook account settings. It is important to take this into account while interpreting the current findings. Future research can mitigate this effect by incorporating personal appropriation into the design of social networking InfoVis tools.

Second, the role of the evaluator is a crucial factor in the evaluation of InfoVis tools that are designed to help people make sense of abstract information. It was not surprising that the users experienced difficulties explaining the abstract relationships between their friends. However, as the social networking domain is one that most people are familiar with, it was easy for the evaluator to probe further into different aspects of the visualisations during the study. Nevertheless, a specific application domain which requires expert knowledge in a specialised domain could pose problems for the evaluator during the evaluation process. Hence, it is vital to apply CASSM to the evaluation of InfoVis tools in a different domain to gain a more thorough understanding on its utility in evaluating InfoVis tools in general.

Third, the user concepts elicited from this study were based on users within the 18 to 35 year old age group who were also students of a postgraduate HCI course. This suggests that the users were relatively familiar with technology, and were from an age cohort who relies heavily on SNS and other social media (e.g., instant messaging) to maintain their friendships. Hence, it will be interesting to include a larger group of users from different age cohorts and background to see if they conceptualise their social networks in similar ways.

5.4 Bridging the gap between tool and user

Referring back to Faisal (2008)'s theory of harmonious flow, it was argued that a positive experience while interacting with InfoVis can only be achieved via fulfilling the following requirements: (1) understand users' conceptualisations of the represented domain, in this case, the social networking domain; (2) incorporating these user concepts into the design of the InfoVis tool; and (3) allow for personal appropriation where users can utilise the tools according to their needs and goals.

This research was set out to investigate the utility of CASSM as an evaluation method for InfoVis tools (see section 1.2), and the research findings have demonstrated CASSM's utility in capturing users' conceptualisations of their social networks, which can be incorporated into the design of future social networking InfoVis tools. Moreover, the systematic comparison between user and system concepts revealed surface misfits between users and the InfoVis tools being studied, which provided opportunities for redesign. Also, the current findings demonstrated the importance of personal appropriation to allow users achieve their goals while interacting with InfoVis tools.

As such, apart from meeting the research goals, the current findings illustrated CASSM's ability to fulfil the first and second requirements of achieving a good InfoVis experience as proposed by Faisal (2008), and acknowledged the importance of personal appropriation of InfoVis tools. These findings imply that CASSM has the potential of bridging the gap between users and InfoVis tools, which answers the need of the InfoVis community for evaluation methods which can encourage more widespread adoption of these powerful tools.

5.5 Conclusion

As acknowledged by the InfoVis community, the evaluation of InfoVis is indeed a challenging affair. This is due to the abstract nature of InfoVis tools where the utility of the tool is highly dependent upon individual experiences, background, preferences, and in the case of interaction with social networking InfoVis tools, personality characteristics was also an important factor. In addition, the abstract nature of data as exemplified by the complexity of social networks makes it more challenging during the evaluation of users' sensemaking experiences while interacting with InfoVis tools.

The current study demonstrated the utility of CASSM as an evaluation method in capturing the conceptual misfits between users and InfoVis tools. Not only did surface misfits provide design opportunities, the discovery of user concepts pertaining to the social networking domain are valuable design requirements for future social networking InfoVis tools. The findings also provided insight into the importance of conceptual fit on tool preference, supporting the theory of harmonious flow. Moreover, the use of verbal data was valuable in uncovering users' subjective experiences with and task-usability issues of the InfoVis tools, which although are not the focus of the study, are still crucial in gaining a holistic view on user-InfoVis interaction.

In the end, just like every other user-centred design, the findings from this study further reinforced the importance of designing for the user. In the case of InfoVis, pretty is not enough to encourage more widespread adoption of these tools which can help users make sense of huge amount of information which exceeds their cognitive capacities. Designers and evaluators need to take the utility of these tools into account to design InfoVis tools that meet users' needs, so that the general audience can benefit from the wonders of InfoVis. In the terms of Danzinger (2008, p.79), this would bring the InfoVis community one step closer to designing "information visualisation for the people".

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APPENDIX A

Sample of Friend Wheel settings page with default settings selected

Note: These default settings have been updated by the creator of FW since the time of study.

APPENDIX B

TouchGraph Facebook Browser Help Page

Profiles | Photos | Networks | Help

Overview

Friendships & Photo Connections

The **TouchGraph Facebook Browser** shows connections between users based on friendships and common photo appearances.

Friendships are shown as dark gray lines, and common photo appearances are shown as a lighter gray line with a number in the center. The number indicates how many photos the two people appeared in together.

Personal vs. Friends social networks

* When launched from one's own profile, information about all of one's friends and their friendships is loaded.
* When launched from another user's profile (Using the "TouchGraph Friends + Photos" link below their profile picture) only people tagged in their photos will appear in the graph.

One can not see another person's whole social network because Facebook only allows applications to get a list of one's own friends. For other users it is only possible to get a list of people that they appear in photos with. Perhaps Facebook's policy will change in the future.

Clusters

The **TouchGraph Facebook Browser** determines the clusters/cliques to which one's Friends belong and uses different colors to show each clique. Cliques are characterized by having lots of friendships within a group of friends and few connections to members outside the group.

Rank

Friends are assigned a Rank so that one can reduce clutter by only showing a set of 'Top' friends. TouchGraph gives the highest rank to friends who are connectors between different cliques. Finding connecters involves a metric called Betweeness Centrality which is an established measure for a person's importance within a social network.

LOADING

Missing User Photos

Some users profile pictures don't show up, and a missing icon is shown instead. These users have set their privacy settings to prevent applications from accessing their information. Applications are already prevented from accessing any information that one can not get through regular Facebook use, so these restrictions are not necessary.

To let your friends know that lifting application settings will not allow any non-trusted persons to access their account, refer them to the applications privacy page and ask them to check their profile picture, basic info, and photos.

Loading Friends' Photos

Once one has launched the application, one can explore one's extended social network by loading more photos for friends. Loading photos will add new users who are tagged in photos to the graph, and created edges between them based on friendships and common photo appearances. Note: It is only possible to load photos for friends and people within one's network.

Loading Photos From the Graph

The **load photos** icon appears on Mouse-Over. Clicking it will load more photos for the user.

The **clock** icon will show while user photos are being loaded.

The **check** icon indicates that photos for that user have been loaded.

Use the **Advanced** *Always show photo status* menu check to always show photo icons for users regardless of mouse over.

Loading Photos From the Photo Tab

Photos can also be loaded from the photo tab by clicking the more photos link which appears after the last photo in the thumbnail list.

GRAPH

Click on a node to cycle user's photos:

Clicking on a user the first time will show their profile photo in the Photo tab. Clicking on the same user node repeatedly will cycle through their photos in the photo tab.

Click on an edge to cycle photos together:

Clicking on an edge between two users will cycle through photos of the two users together. A number on the edge shows how many photos the two people have together.

Click on a node to show user's profile + friends:

Clicking on a node will show the users bio in the profile tab. The user list below the profile photo will show a list of the user's friends.

Zooming / Spacing

The Zoom / Spacing sliders are located on the left side of the graph toolbar.

The Zoom slider will proportionately enlarge the nodes and edges. When zooming out beyond a certain threshold user images will disappear and users appear as names only.

The Spacing slider increases spacing between nodes without enlarging the nodes or making the edges thicker. This is useful for seeing connections within tightly connected clusters.

Cluster Colors

Users are colored based on clusters. See the OVERVIEW: Clusters for an explanation of clusters/cliques.

The **cluster dialog** allows one to control how many clusters the users are divided into.

The **color dialog** lets one pick different colors for the clustes.

Pausing the Layout:

Use the Pause button to stop the Automatic Layout. This will allow dragging nodes around the screen without having the rest of the graph rearrange itself. Press the Play to resume Automatic Layout. Pausing the layout is useful for creating screenshots. If several nodes are multi selected, click-dragging one selected node will drag all of them.

Uploading & Saving Screenshots

Screenshots can be uploaded to Facebook by pressing the Upload button. Screenshots will be placed in the TouchGraph Photos album, but will not appear in one's profile until they are approved. Friends visible in the screenshot will be tagged in the photos. Up to 20 friends will be tagged.

It is also possible to save screenshots to the one's computer by **right-clicking on the background** and choosing Save Image.

FILTERING

Top Friends #

The Top Friends # spinner filters users according to their rank. See Overview: Rank. Before loading photos for any other users, exactly Top Friend # users will be displayed in the graph. After photos are loaded for some users, users will also be filtered according to their min user pohto #

Networks Check

Use the Networks check to show/hide Network nodes. Showing Network nodes is independent of filtering by network which can be done from the Networks tab. See the Networks section for more info.

Advanced - Show Self

The initially loaded social network only contains one's own friends. Therefore it is redundant to show a node for oneself because it will be connected to everyone else. Unchecking "show self" allows you to see how your friends are connected in other ways then through you.

Advanced - Min User Photo #

Only show users who were tagged in a minimum of N photos. Top Friend # may cause some of your top friends to be displayed even if they don't have the required Min User Photo #.

Advanced - Min Edge Photo #

Only show connections between users that have been tagged in at least N photos together.

Advanced - Min Network User #

Only Show Network nodes containing at least N users.

PHOTO TAB

Overview

The photos tab displays a users photos. A large photo is shown up top, with a list of photo thumbnails below it. Clicking on a photo in the thumbnail list shows the photo up top.

'Photos Of' , 'With' drop downs

One can select someone from the "Photos Of" drop down to see their photos. The user will also be selected in the graph. Selecting a second person from the "with" combo box will show photos of the two people together.

'More photos' Thumbnail

The last thumbnail in the photo list may say 'More Photos'. Clicking on this thumbnail will load additional photos for the user. It is not possible to load photos for user who are not your friends or in your network, in this case the thumbnail will say 'no more photos available'.

Interactive Tags

User name tags will appear when one moves the mouse over the photo at the top of the photo tab. Clicking a name-tag will show the next photo for the user that was clicked (this is different then Facebook.com where clicking a name tag does nothing).

Photo Controls

There are several navigation buttons that appear when one moves the mouse over the photo.

Clicking the **Next/Prev** icons cycle through the photos in the thumbnail list.

Mousing-over the Nametag icon will show names for all users that have been tagged in the photo.

The Facebook icon will open up the photo in an external browser window.

Zooming on the photo

When the photo at the top of the photo tab is clicked somewhere other then on a nametag, the photo will be zoomed in to its full size. Clicking on the photo a second time will zoom out.

PROFILES TAB

Profile Info

The profile info panel at the top of the profiles tab shows a user's photo, networks, birthday, colleges, employer, etc. Some fields like networks appear as hyperlinks.

* Clicking on a network hyperlink will select the network in the graph and will show members of the network in the friends list.
* Clicking on the friends# hyperlink will show friends of the user in the friends list.
* There is also a hyperlink below the user profile picture that says "facebook profile". Clicking on this hyperlink will open a new browser window with the user's facebook profile.

Friend List - Photos vs. List

The friends list is located below the profile info panel in the profiles tab. The friends list can show all loaded users, or just friends of a selected user or users within a particular network.

The **list** / **photos** radio buttons above the friend list let you choose how users are displayed. Choose the **photos** radio button to see user photos, and **list** to see a table containing user names and associated values like friend #.

Friend List - Filtering

Drop downs above the friend list let you filter the list to show all loaded users, or filter the loaded users to friends of a particular user or users within a network. When the application is first started the only loaded users are your friends or friends or friends of a different user who's photos you're viewing.

* Selecting **friends of** from the first drop down and choosing a user from the second drop down will show loaded friends of that user. This can also be done by clicking the user in the graph.
* Selecting **network** from the first drop down and choosing a network from the second drop down will show loaded users in that network. This can also be done by clicking the network in the graph.
* The **All** button will show all loaded users regardless of whether **friends of** or **networks** is selected in the first combo box.

Friend List - Sorting

The friend list can be sorted by clicking the column headers that say **name**, **rank #**, **fiend #**, **photo #**. The sort order is best seen when the radio buttons above the list are set to **list** rather then **photo**.

* The **Name** column header lets the list be sorted alphabetically.
* **Rank** # is the rank as describe in the OVERVIEW: Rank section.
* **Friend** # is the number of loaded friends of the user. For the initial list of users the friend # is the number of mutual friends that user has with you.
* **Photo** # is the number of loaded photos for the user.

NETWORKS TAB

Filtering Users by Network

The networks tab shows a list of networks for loaded users. Networks can be sorted by the number of users or alphabetically.
Checking one or more networks will filter the users in the graph so that only users within checked networks will show.

Other Network Controls

* The networks check in the graph toolbar is used to show/hide Network nodes in the graph.
* Clicking on a Network node will will switch to the Profiles tab and filter the friend list to show users within that network.
* The Advanced - Min Network User # filter can be used to filter the visible networks in the graph.

APPENDIX C

Sample of information sheet used in the study

The utility of CASSM as an evaluation method in evaluating social-networking Information Visualization tools

Name, address and contact details of investigator:

- Yeevon Ooi (y.ooi@ucl.ac.uk)
- UCL Interaction Centre (UCLIC)

This study has been approved by the UCL Research Ethics Committee [Project ID Number]: MSc/0809/003

You will be given a copy of this Information Sheet

We would like to invite you to participate in this research project. You should only participate if you want to; choosing not to take part will not disadvantage you in any way. Before you decide whether you want to take part, it is important for you to read the following information carefully and discuss it with others if you wish. Ask us if there is anything that is not clear or you would like more information.

Information Visualisation (InfoVis) tools help users make sense of abstract data, and there is currently a need for better methods to evaluate these tools as the current methods are insufficient in producing better InfoVis tools to encourage more widespread adoption of these tools by non-expert users.

The purpose of this study is to find out whether CASSM (Concept-based Analysis of Surface and Structural Misfits) as an evaluation method can be used to find out if current social-networking InfoVis tools (e.g., Friend Wheel, Touch Graph) represent visualisations that match the way users interpret their social networks.

You will be required to complete a questionnaire, perform a think-aloud study (verbalising one's thought processes) while interacting with several social-networking visualisation tools to represent your social-networks on Facebook, and then complete an interview with the experimenter. The think-aloud and interview sessions will be voice-recorded, and interactions with the tools on the computer screen will be video-recorded. Video-data will be used mainly to fill-in gaps in the think-aloud data, and data of you and your friends will not be identified in anyway. If screenshots are required for data-analysis, all personal data will be masked so that you and your friends will not be identified in anyway.

The entire session will take approximately 1-hour, and you are free to ask questions as we go along.

It is up to you to decide whether or not to take part. If you choose not to participate it will involve no penalty or loss of benefits to which you are otherwise entitled. If you decide to take part you will be given this information sheet to keep and be asked to sign a consent form. If you decide to take part you are still free to withdraw at any time and without giving a reason.

All data will be collected and stored in accordance with the Data Protection Act 1998.

APPENDIX D

Sample of consent form used in the study

The utility of CASSM as an evaluation method in evaluating social-networking Information Visualization tools

This study has been approved by the UCL Research Ethics Committee [Project ID Number]: MSc/0809/003

Participant's Statement

I agree that I have:

- read the information sheet and/or the project has been explained to me orally;
- had the opportunity to ask questions and discuss the study;
- received satisfactory answers to all my questions or have been advised of an individual to contact for answers to pertinent questions about the research and my rights as a participant and whom to contact in the event of a research-related injury.
- understood that my participation will be taped/video recorded and I am aware of and consent to, any use you intend to make of the recordings after the end of the project.

I understand that the information I have submitted will be published as a report and I can request to be sent a copy. Confidentiality and anonymity will be maintained and it will not be possible to identify me from any publications

I understand that I am free to withdraw from the study without penalty if I so wish and I consent to the processing of my personal information for the purposes of this study only and that it will not be used for any other purpose. I understand that such information will be treated as strictly confidential and handled in accordance with the provisions of the Data Protection Act 1998.

Signed: Date:

Investigator's Statement

I ……………………………………………………………………….. confirm that I have carefully explained the purpose of the study to the participant and outlined any reasonably foreseeable risks or benefits (where applicable).

Signed: Date:

APPENDIX E

Sample of questionnaire used in the study

Sex: Male / Female

Age: 18 – 25
26 – 30
31 – 35
> 36

1. **How long have you been using the social-networking site Facebook?**

2. **How often do you logon to Facebook?**

3. **Do you know how many friends you have on Facebook?** *(If yes, please indicate number)*

4. **Have you ever used Facebook applications to generate visual representations of your friends/social-networks?** *(If yes, please indicate which)*

5. **Check the below applications if you have used them prior to this study.**
   - ☐ Touch Graph Facebook Browser
   - ☐ Facebook Friend Wheel

APPENDIX F

Sample of instruction sheet used in the study

Pre-task interview questions:

- Who would you class as your friends?
- How do you classify your friends? For example on your mobile phone contact list, email list, social-networking sites, diaries
- How do you usually obtain information about your friends?
- What types of information about your friends are most important to you?
- How do you visualise your social-network in real life?

Think-aloud instructions:

We are going to use the think-aloud technique to evaluate the visualisation tools:

- This technique requires you to "think-aloud" where you will need to verbalise your thoughts while interacting with the visualisation tools.
- In other words, you just need to say whatever you are looking at, thinking, doing, and feeling, as you go about using the visualisation tools
- For example, why are you clicking on a particular option or what are you trying to do by performing a specific action using the tool
- An example of a think-aloud interview transcript is provided below for your reference:

  "... I am clicking on Jim's name to see how he is connected to my friends ... Ok, now I can see that these highlighted boxes are probably the people that Jim knows ..."

I will need to apologise in advance for not being able to answer specific questions during the process but again, as there is no right or wrong way to do this, you only need to do what you would do if you are exploring the visualisation tools outside an experimental setting. Just bear in mind that the more information you verbalise during the process, the more it will contribute to a better understanding of your conceptualisations of your social networks.

So if you are ready, we will now start the recording for the think-aloud session. You will be interacting with two social-network visualisation tools:

- Friend Wheel
- Touch Graph Facebook Browser:

Main Task:
Interact with these tools as you will in real-life to understand your social network. We have 15 minutes for each tool and please feel free to interrupt at any point if you have any questions regarding the task instructions.

You will now need to login to your Facebook account **//START Screen recording//**

Search for Friend Wheel

Friend Wheel

Settings: We will first start with the default setting and then go back and play around with the settings throughout the study.

Static/Interactive: We will start off by looking at the static version and then look at the interactive version as we go along.

Search for Touch Graph

Touch Graph

Works

- CHANGE from [Show top 50 friends] to [actual number of friends]
- ***Top friends:*** highest rank assigned to friends who are connectors between different groups, indicating the importance of a person within a social-network.
- *Re-compute colour, & change the number of clusters as required*

Doesn't work

- Imagine this is a visualisation of your social-network on Facebook showing you the connections between your friends.
- It is interactive and the connections between your friends and networks will be highlighted when you mouse-over a specific friend.
- Tell me how you would visualise your network using this tool.

Post-task interview questions:

- Are the visualisations different from the way you think about your social-networks? (If yes, why?)
- Do you categorise your friends on Facebook?
- Tell me what you think about using visualisation tools to represent your social networks.
- Is there a specific tool which you prefer over another? (If yes, why?)
- Did the tools allow you to achieve your goals in making sense of your social-networks? Please feel free to use examples of the specific tools while describing your experience.
- Is there anything else that you want from a visualisation tool that was not being offered by the previous tools that you interacted with?

//STOP Screen recording//

APPENDIX G

Interaction sequences for FW and TG

Interaction sequence for FW:

1. Users first figure out different grouping of friends around the static wheel (Figure 3a), and try to assign meaning to the different colours used for the names around the wheel. For example, a user picks up a random name on the wheel and starts thinking about what do people who are placed next to each other on the wheel have in common. This usually results in the social context of where the users first met their friends such as high school, work, university etc.

2. As soon as users figured out the grouping concept, they start identifying line connections especially ones that cut across the wheel. This is based on the understanding that people from a same group (e.g., high school) are grouped together hence have lines that connect adjacent names. However, lines across the wheel usually indicate interesting connections between disparate groups of friends.

3. At this point, users tend to get bored and will switch to the interactive flash wheel. Compared to the static wheel which is a static visual display, the interactive wheel allows users to mouse-over specific names to highlight the connections for that specific person. This display shows users' the mutual friends that they share with a specific friend.

4. Following that, depending on whether a user discovers certain direct-manipulation options, they tend to perform either or all of the following actions.
    - Regenerate the wheel with different settings (U1, U2, U3, U4, U5, U7, U9, U10)
    - Start exploring the options on the screen:
        - Play button which rotates the wheel (U1, U10, U11)
        - Clicking on a friend's name and dragging the name around the wheel (U2, U9, U11, U10), then slotting names that were in the wrong group into the correct location as perceived by the user (U9, U10)
    - Quit the programme instantly (U6, U8, U11)

Interaction sequence for TG:

1. Users started off making sense of the visualisation which shows them their top 50 friends by default.

2. The usual comments made include:
    - The different groupings based on the displayed networks and geographical locations that friends belong to
    - Users' individual understanding of the groupings based on social context of where they first met their friends
    - The different properties of the visualisations including thickness of lines, spatial distance between individual friends/cluster of friends and user, colour of the individual friends and clusters they are in

3. Users will then change the number of friends to a smaller number or a bigger number to see all their friends on Facebook. The groupings usually become clearer when all the friends are being visualised at once.

4. Depending on individual users, they usually start exploring the other option buttons including:
    - Colour chooser and cluster controls (all users, as it was part of the instruction)
    - Photos shared with friends (U5, U7, U11)
    - Clicking on a specific friend's bubble to view their networks (U1, U3, U5, U8, U10)
    - Moving friends around (U5, U7, U10, U11)

APPENDIX H

User, interface, and underlying system concepts merged together and compared against each other to identify if concepts are present, absent, or difficult within the user, FW and TG interfaces, and Facebook

Concepts (Entity/Attribute)	User	FW interface	TG interface	Facebook
Social context where connection was made	P	Absent	Absent	Absent
Educational institution	P	D	D	P
Job	P	D	D	P
Activities/hobbies	P	D	D	P
Geographical location	P	D	D	P
Relationship distance/importance	P	Absent	D	D
Family/relatives	P	Absent	D	P
Close friends	P	Absent	D	P
Good friends	P	Absent	D	P
Acquaintances	P	Absent	D	P
Random people	P	Absent	D	P
Friends' current status	P	Absent	Absent	P
Geographical location	P	Absent	Absent	P
Work	P	Absent	Absent	P
Activities	P	Absent	Absent	P
Relationship status	P	Absent	Absent	P
Mood	P	Absent	Absent	P
Frequency of social-interactions	P	Absent	Absent	D
Face-to-face	P	Absent	Absent	Absent
Non face-to-face	P	Absent	Absent	D
Stages of friendship in life	P	Absent	Absent	Absent
Past friendship groups	P	Absent	Absent	Absent
Current friendship groups	P	Absent	Absent	Absent
FW Grouping based on connectivity between friends	D	P	*N/A*	P
All friends on Facebook	P	P	P	P
Mutual friends	P	P	D	P
Individual connection between friends	P	P	D	P
TG Friend ranking	D	*N/A*	P	Absent
TopFriends	Absent	*N/A*	P	Absent
Number of shared photos	Absent	*N/A*	P	D
TG Friend's networks	P	*N/A*	P	P
Geographical location	P	*N/A*	P	P
Educational institutions	P	*N/A*	P	P
Companies	P	*N/A*	P	P
FB Personal information	P	Absent	Absent	P
Preferences in music, movies, books, TV shows,	P	Absent	Absent	P
FB Current and previous education and work details	P	Absent	D	P
College/university	P	Absent	D	P
High school	P	Absent	D	P
Employment	P	Absent	D	P

Key: P (present); D (difficult); N/A (not applicable)