2006

Drawing From a Larger Canvas – a Gestalt Perspective on Location-Based Services

Jeni Paay
Aalborg University, jeni@cs.aau.dk

Jesper Kjeldskov
Aalborg University, jesper@cs.aau.dk

Drawing From a Larger Canvas – a Gestalt Perspective on Location-Based Services

Jeni Paay
Jesper Kjeldskov
Aalborg University
Department of Computer Science
DK-9220 Aalborg East, Denmark
Email: jeni@cs.aau.dk, jesper@cs.aau.dk

Abstract

Location-based services (LBS) provide mobile users with information and functionality tailored to their geographical location. Within recent years these kinds of mobile information systems have received increasing attention from the software industry as well as from researchers within a wide range of disciplines concerned with the development and use of computer technology. This paper presents a user study of a prototype location-based service providing an informational overlay to the civic space of Federation Square in Melbourne, Australia. In analysing our field data, we reintroduce the perspective of "gestalt theory", and argue that describing people's use of location-based services through gestalt theory's principles of proximity, closure, symmetry, continuity, and similarity can help explain how people make sense of small and fragmented pieces of information on mobile information systems in context.

Keywords

Location-Based Services, Gestalt Theory, Field Studies, Human-Computer Interaction

INTRODUCTION

Location-based services (LBS) represent an emerging class of information systems, which provide mobile device users with information, and functionality tailored to their geographical location. Within recent years these kinds of mobile information systems have received increasing attention from the software industry as well as from researchers within a wide range of disciplines concerned with the development and use of mobile computer technology (i.e., computer science, information systems, human-computer interaction, etc.). Location-based services open a new market for developers, network operators, and service providers to develop and set up value-adding new services for user on the move, such as advising users of current traffic conditions, supplying routing information, and helping them find nearby shops.

Recent advances in technology have fuelled the development and uptake of a wide range of location-based services. PDAs and 3G mobile phones with GPS and other positioning capabilities have become increasingly affordable and popular, and more and more service providers have begun to develop and offer innovative information services that integrate wide-area broadband Internet access, web resources and geographical information. Also, generally available geographical information systems (GIS) such as Google Earth and Google Maps have rapidly become popular media for people to access location-related information and even publish it themselves (i.e., using Google's KML file format to relate picture blogs content to geographical places and publishing GPS coordinate trails for others to follow).

The development of location-based services for mobile devices faces many challenges ranging from issues of determining people's location and orientation in physical space, how to combine satellite imaging, 3D modelling and cartography, through to issues of what information to provide in response to a particular location, and how to facilitate suitable user interaction with this content. Within the Mobile HCI community it has been widely argued that researchers, designers and software developers need to look more broadly at the context of use of mobile devices and systems in order to understand mobile use better and to be able to produce good and relevant solutions (Johnson 1998). In response to this, huge efforts have been put into ethnographic-based studies of mobile work activities, mobile technology use, and field evaluations of mobile systems prototype designs. Ethnographic studies of work activities and technology use provide insight into the current practices of a specific use domain. Field studies of new prototype systems indicate how people may change their behaviour and give us an idea about what future practice may look like. While unquestionably invaluable approaches to understanding use contexts and the usability and usefulness of existing and new technology, a lot of our knowledge about mobile device use (including location-based services), thus far seems to have focused on *either* the context *or* the technology and not so much about how the two fit together, that is, how people perceive the ensemble of mobile devices and use context. Contributing to this discussion, this paper presents a user study of a prototype location-

based service and looks at peoples' use of such information systems from the perspective of "gestalt theory" and its principles of *proximity, closure, symmetry, continuity,* and *similarity.*

We have been studying the use of location-based services through a 2-year project investigating the deployment of mobile and pervasive computing technologies in urban environments. The *e-Spective* project took its origin in the newly opened civic structure of Federation Square in Melbourne, Australia and involved of a series of field studies of urban socialising behaviour within the built environment of inner cities as well as the development and evaluation of a prototype location-based service providing an informational overlay to Federation Square (Kjeldskov & Paay 2005, Paay & Kjeldskov 2006). In addition to learning about interaction design for location-based services on mobile devices, one of our most interesting (and somewhat surprising) findings from studying people's use of the prototype location-based service was that people were extremely good at making sense from small and fragmented pieces of information. When faced with incomplete or ambiguous information, people *wanted* to put the pieces together. They wanted to connect the dots, and they were very good at it. This finding prompted two questions: 1) How can we explain this phenomenon?; and 2) How can knowledge about this phenomenon inform the design of similar location-based services? Motivated by these questions we have revisited our video and interview data from field evaluations of the prototype system from multiple theoretical angles. In doing this, we have found that the perspective of "gestalt theory" provides a very useful, and yet simple lens for describing and explaining how people try to make sense of mobile information systems situated in context. In this paper, we focus on the first question of explaining the observed phenomenon.

The paper is structured as follows. First we briefly introduce related work within Mobile Internet technologies and location-based services for mobile devices. We then turn our attention towards gestalt theory and how this theoretical approach to human perception and thinking has previously been applied within information system design and used to explain qualities of graphical screen design. Following this, we briefly introduce the Federation Square case study, the prototype system developed and the field study of use. Illustrated with examples from our findings, we then reflect on the ensemble of mobile device and use context of our location-based services from a gestalt theory perspective. Finally, we conclude on our research and indicate avenues for further work.

RELATED WORK: THE MOBILE INTERNET AND LOCATION-BASED SERVICES

Within the last decade there has been a huge focus on the development of mobile information and communication technologies bringing the potentials of the Internet to the mobile user within a wide range of use domains, for work as well as for leisure. Following the widespread uptake and commercial success of the Short Message Service (SMS) on mobile phones since the late 1990's, significant attention and resources have been devoted to the development of the next generations of mobile network services, protocols and infrastructure, known as 2½G and 3G mobile telephony (see Sacher & Loudon 2002). MMS (Multimedia Message Service) was developed as an extension of SMS, allowing users to exchange rich media content rather than just text and simple graphics, and WAP (Wireless Application Protocol) was developed to allow mobile access to a downscaled version of the World Wide Web. On the network level, GPRS (General Packet Radio Service) allows faster, affordable and always-on data connections to the Internet from mobile devices. With the introduction of the UMTS (Universal Mobile Telephone System) (3G) network, the speed of mobile data connections now matches their hard-wired counterparts, thus allowing realistic mobile use of, for example, to the World Wide Web. However, while commercially available technologies have made the Internet mobile, fast, accessible and relatively cheap, the uptake of Mobile Internet technologies by the general population has not yet met the high expectations of the IT industry (see Bassuener 2001, BBC 2002, Costolo 2005). From the points of view of information systems and human-computer interaction there are several reasons for this.

Firstly, while undoubtedly containing information and functionality relevant to mobile users, most Internet services, as we know them, are not well designed for mobile use. They are designed for increasingly larger screens of desktop computers, require a high-level of user input (pointing, clicking and text-entry), and require the user's full visual and cognitive attention. In contrast, the Mobile Internet is typically accessed through PDAs or mobile phones with very small screens and limited means of input being used in highly dynamic use situations. Secondly, services for the Mobile Internet are currently designed to facilitate doing while mobile the things we typically do at our desktop. They do not adapt to the dynamic mobile use context but look the same whether the user is at home, in the bus, in a café, or walking down the street, situations that have very different requirements for information, functionality and interaction (see Kim et al. 2002, Lee et al. 2005). So while it is *possible* to access the Internet on a mobile computer, its usefulness is limited because it is not adapted to the special requirements of mobile users. If Mobile Internet services are to have a higher uptake by the general population they must enable us to do things that couldn't be done before. They must provide an easily obtainable added value for users on the move through contextually purposeful content that is simple to use on a small device while mobile (e.g., walking in the street or driving a car).

Advances in technology have made it possible for mobile computers to sense or access information about the user's context such as their, location, social setting, current activity, etc. Recent research in mobile human-

computer interaction has demonstrated that using such information to make mobile computer systems "context-aware" can increase usability within highly specialised domains such as healthcare (Bardram et al. 2003) and industrial process control (Nilsson et al. 2000).

One of the most promising aspects of user context for a mobile information system to respond to is *location* (e.g., Cheverst et al. 2000, Dix et al. 2000, Fithian et al. 2003, Kaasinen 2003). The potential benefits of location-based services for Mobile Internet are several. By making a mobile information service aware of the user's geographical location, designers can streamline it to present information and functionality that is relevant at a particular place. In this way, the content and functionality offered by the service can be simplified and focused, and the demand for user interaction can be reduced. As a fictive example of this, a location-based service for a train station could be designed to respond to the user's location, time, activity, social setting etc., by presenting only information about departures from the user's present location, within a short period of time, to destinations matching upcoming scheduled appointments. Examples of commercially available location-based services include an emerging range of SMS-based services where information about, for example, changed traffic conditions is sent to subscribing mobile phone users in the affected area, based on the tele-operators' knowledge of their location in the network. Exploring the powers of the 3G-platform and GPS positioning, services such as *ViewRanger* provide 3D models of the user's surroundings with superimposed links to additional information (Figure 1, left). Other services, such as *TrackStick* and *Phone2Gearth*, allow people to track their geographical movements, annotate it with media content such as text, images and video, and then publish it through GIS systems such as Google Earth (Figure 1, right). In a similar fashion, Sony has recently announced that their next generation of cameras and camcorders will be available with an accessory that records position data and makes it possible for people to publish their media on an online map.

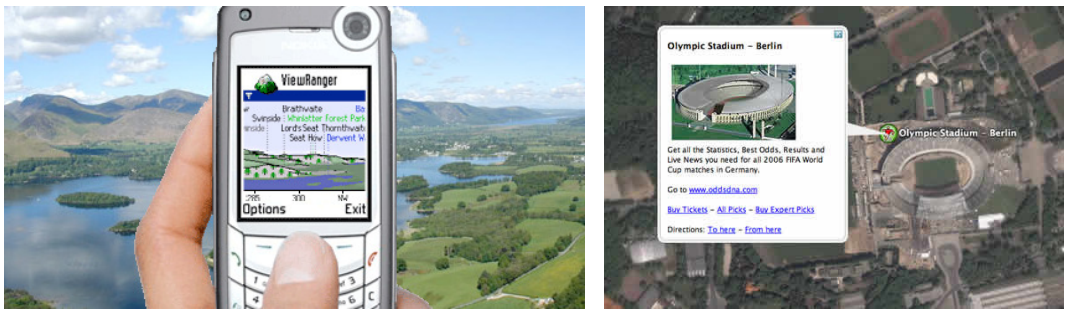


Figure 1: An example location-based service (ViewRanger) providing information about the surrounding environment (left) and location-based information posted in Google Earth (right)

Yet developing successful location-based services is not trivial. It inherits all the challenges of context-awareness described in the literature, such as privacy and user control (see Barkhuus and Dey 2003), as well as introducing new ones. For example, given the novelty of location-based services on mobile devices, little is still known about people's actual use of such of services. It is unclear how users perceive and use information provided through location-based services, what content is considered relevant (and what is not) and how people will adopt and appropriate mobile information services that react to their location. Hence, more research is needed that investigates the use of location-based services.

In the following section, we turn our attention towards a theoretical perspective, which we have found useful in describing and explaining the interplay between context and location-based services on mobile devices.

GESTALT THEORY

Gestalt theory as it has been applied to the design of the human-computer interaction for information systems constitutes an approach and a set of principles applied to interface design to improve communication between user and system. Gestalt theory evolved from explorations of human perception in the discipline of Psychology in the early twentieth century aiming to explain how people organize different information from their environment. The founders of Gestalt psychology are acknowledged as Max Wertheimer, Wolfgang Kohler and Kurt Koffka. Wertheimer applied Gestalt psychology to problem solving, Koffka to applied psychology and child psychology, and Kohler to learning strategies. Gestalt theory has over a hundred different laws that pertain to human perception, including visual and auditory. These laws of Gestalt psychology are fundamental in understanding the way the people see and understand their surroundings (Borchers et al. 1996).

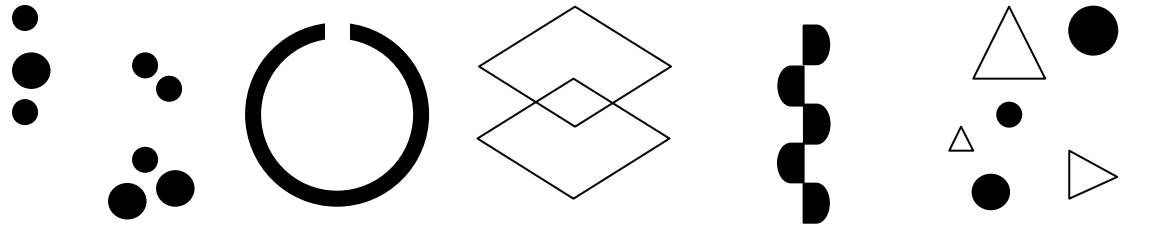
Gestalt theory explains how we perceive objects in our environment. The gestalt viewpoint says, "things are affected by where they are and by what surrounds them" (Behrens 1984, p. 49), acknowledging the importance of context in how we perceived things. Preece et al. (1994) say that it is a combination of the context that something

sits in as well as our prior knowledge that allows us to interpret what we are looking at or listening to. In the gestalt perspective, new information is organized and bridged to prior knowledge to form an organized whole. Gestaltists believe that we intuitively perceive things as a coherent unit or object and that this is an innate human ability (Lauesen 2005). When we are presented with something in our physical environment that is ambiguous, we use our prior knowledge of the world to make sense of it by filling in the blanks in the current information (Smith-Gratto & Fisher 1998-1999).

As it has evolved in human-computer interaction, only a small subset of the original gestalt laws are relevant to the interaction designer and so gestalt theory in human-computer interaction can be represented by a set of key principles of perceptual organization for the purpose of improving both understandability and learnability of information systems. Gestalt theory is included in several prominent human-computer interaction primers (e.g., Benyon et al. 2005, Dix et al. 1998, Lauesen, 2005, Preece et al. 1994), and is introduced for its application in the design of information screens providing an understanding to the interface designer of how their information design is likely to be perceived by users.

For the purpose of this study, we have identified five generally acknowledged key principles of perceptual organization:

- Proximity – things that are located near each other, in space or time, are perceived as belonging together (see Figure 2.1);
- Closure – things are perceived as complete or whole, even when part of the information is missing (see Figure 2.2);
- Symmetry – when things have symmetrical parts or borders, they are perceived as a coherent whole (see Figure 2.3);
- Continuity – we perceive things as continuous patterns rather than disjointed ones (see Figure 2.4); and
- Similarity – things that look or sound alike are perceived as belonging together (see Figure 2.5).



(1) grouping of dots (2) circle seen as closed (3) two large diamonds (4) continuous curve (5) triangles vs. circles

Figure 2: Five key principles of perceptual organization for interaction design derived from Gestalt theory

Gestalt Theory in Human-Computer Interaction Research

The principles of perceptual organization and concepts derived from gestalt laws have influenced many research and study areas such as map reading, graph drawing, image retrieval, computer vision, pattern recognition, design of auditory displays and musical studies. Of interest to this research are those projects that have applied gestalt principles in analysis, design and evaluation of information systems.

Due to the historical starting point of applying gestalt theory to learning strategies, most of the early human-computer interaction research projects began in the instructional design area, with the purpose of restructuring learning materials, including print-based, multimedia teaching presentations through to more recent investigations into the design of computer based education (CBE). The work of early instructional design researchers on the use of gestalt theories aimed at enhancing knowledge gained from written instructions through increasing perceptual accessibility (Driscoll 1993, Moore & Fitz 1993). Later research by Smith-Gratto and Fisher (1998-1999) looked at instructional screen design using gestalt theory to develop a way of planning and presenting informational elements to help students, both in multimedia presentation teaching and at the computer tutorial, to learn more effectively. Using the arrangement of information both on a screen and between screens to facilitate the development and learning of concepts, they produced practical guidelines on how to design instructional screens based on the laws of perceptual organization. More recently, Chang et al. (2001) have distilled their own set of the most relevant gestalt laws for educational computer screen design from the original writings of the Gestalt psychologists to test the usefulness of the laws in visual screen design. To do this they redesigned an existing instructional multimedia application, and then evaluated the redesign to assess both the products visual appearance and its value for learning.

As the graphical user interface (GUI) became the predominant interface to information systems in the 90's, it was important for human-computer interaction research to provide interface designers with an understanding of the affect of human perception for effectively operating these information-rich interfaces. Researchers applied the principles of perceptual organization to create sets of design principles and guidelines to help interface designers in organizing the visual screen layout. Important organizational concepts of interface design, such as consistency, visual hierarchy, grouping, legibility and contrast can be seen as derived from the gestalt laws (Roth 1995). This application of the gestalt laws to interface design is demonstrated by Mullet and Sano (1995), Roth (1995), Borchers et al. (1996) and Lauesen (2005). Aimed at the software engineering community, the work of Mullet and Sano (1995) presents gestalt as a theoretical background to visual principles that govern the graphic design of user interfaces. Roth (1995) also advocates the importance of the use of principles and concepts derived from gestalt psychology to create, comprehend, and communicate effectively using the visual language that digital media requires. Borchers et al. (1996) say that to attract and keep visitors on a commercial service website, interface designers need to create graphically pleasing, clearly laid-out and easily navigable documents. They demonstrate how knowledge of gestalt theory can be used to create layouts and online environments that are easier for users to operate and remember. Lauesen (2005) also gives examples of the application of various gestalt laws in simple screen layouts.

The most recent work on gestalt theory and design guidelines is exploring new paradigms for creating design guidance based on the principles of perceptual organization. Chang and Nesbitt (2005) explore the use of gestalt theory as a foundation for a new framework used to both categorise existing design guidelines in the area of multi-sensory displays and as a basis for developing new design guidelines for interfaces which combine visual, auditory and haptic elements. Flieder and Modritscher (2006) are establishing a theoretical framework that interlinks Gestalt principles and pattern methodology. This new pattern language is intended to support visual design for human-computer interaction, aimed at facilitating the incorporation of findings about human perception into the user interface design at an early stage.

Beyond the creation of guidelines, a few projects have used gestalt theory to analyse existing interface designs. In acknowledging the importance of human perception in measuring the quality of web page design, Hsiao and Chou (2006) used a combination of gestalt grouping principles and fuzzy set theory from mathematics to develop a method to measure the gestalt-like perceptual degrees of a web page design to help evaluate the "wholeness" of that page. Gestalt theory has also been used to develop metrics for testing the usability of existing web sites (Eftos 2005).

Much of the gestalt related research in human-computer interaction is about using gestalt principles to create and analyse interface design. Oviatt et al. (2003) take a broader application of gestalt principles than previous researchers in interface design by using gestalt theory to analyse not just the computer screen but also the interaction situation. Their work aimed at producing adaptive multimodal interfaces provides a framework and insights into human-computer interaction with multimodal information systems. They study people in the context of interactive communication. One of the outcomes from this study was an analysis of how a speaker tailors their language to accommodate the listener's perceptual capabilities. In this way they are using gestalt principles as a theoretical lens to look at both the users' perception of the interface and at the users' production of communication patterns to inform their framework.

In this study we take an approach related to Oviatt et al. (2003). Rather than directly applying gestalt principles to the design of the interface, we view the computer screen as a small area in the larger canvas of the physical environment in which they are situated. In line with gestalt theory of "wholeness", the environment and the screen combine to create a unique perceptual whole, rather than the simple sum of the individual parts. Our study looks at the interaction situation of the user of location-based computing in the context of the environment, to analyse key aspects affecting what the user perceives and understands in the communication.

CASE STUDY: THE "JUST-FOR-US" LOCATION-BASED SERVICE

Inquiring into the use of location-based services we have designed, implemented and evaluated a prototype mobile web service, *Just-for-Us*, providing an informational overlay to the civic space of Federation Square in Melbourne, Australia (Figure 3, left). Federation Square is a new civic structure covering an entire city block, providing the people of Melbourne with a mixture of digital and architectural elements that provides a variety of activities to visitors including restaurants, cafés, bars, a museum, galleries, cinemas, retail shops and several public forums. The intention for the space was to incorporate digital technologies into the building fabric creating a combination of virtual information space and physical building space for people to experience, making it an interesting setting for studying a geographically small-scale location-based service.

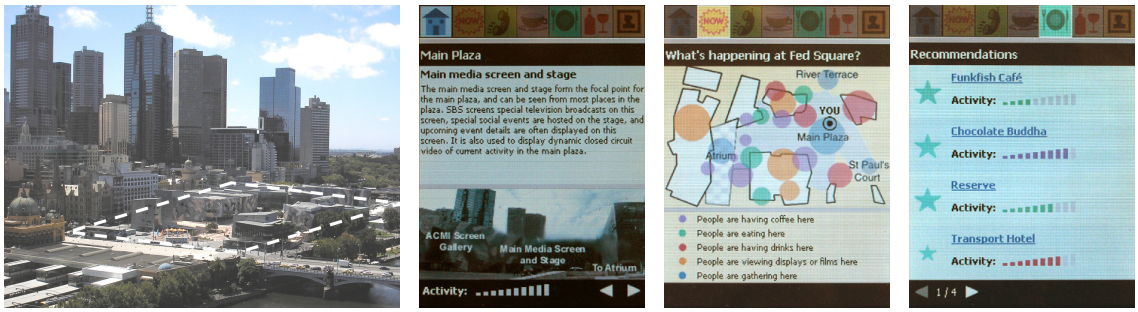


Figure 3: Federation Square, Melbourne, Australia, with surrounding skyline, train station and the river (left) and screen shots from the Just-for-Us location-based service (right)

The Just-for-Us system (Figure 3, right) keeps track of the location of the user and friends within close proximity. It also keeps a history of visits to places around the city (for details see Kjeldskov and Paay 2005). On the basis of this the service allows the user to explore his or her immediate surroundings through a series of annotated panoramic photographs. It also provides an overview of the level and nature of social activity taking place within proximity, and can make suggestions for places to go based on convenience, history, and social setting.

The design of the prototype system was informed by a field study of situated social interactions at Federation Square exploring the interplay between people, technology and interactions in place guided by the categories of McCullough's (2001) typology of "on the town" everyday situations. Three different established social groups participated in the study. Each group consisted of three young urban people, mixed gender, between the ages of 20 and 35, who had a shared history of socialising at Federation Square together. Prior to the field visits each group received a 10-minute introduction to the study followed by a 20-minute interview about their socialising experiences and preferences. Each field visit lasted approximately 3 hours.

The use evaluation of the prototype location-based service involved 20 established social pairs familiar with Federation Square (Figure 4). Inspired by rapid ethnography (Millen 2000) we gave the participants a number of scenarios for socialising, which prompted them to explore different parts of the system. Inspired by the constructive interaction approach to thinking-aloud studies with more than one user, the groups were asked to talk among themselves about their perception of and interaction with the system interrupted only with questions for clarification. The evaluations were video recorded by means of a miniature wireless camera attached to the mobile device mixed with a third-person view of the users. Participants wore directional wireless microphones, ensuring high-quality sound. For testing purposes, the user's position, people and friends in vicinity etc. were entered manually in a "Wizard of Oz" fashion. Each evaluation session lasted approximately 1 hour.

Figure 4: Studying prototype use at Federation Square with wireless micro camera attached to the mobile device

Video data from the evaluations were analysed using content analysis and subsequent affinity diagramming (Beyer & Holtzblatt 1998) into higher-level concepts. In revisiting our data from the perspective of gestalt theory, we went back to the video data and our initial themes and affinity diagrammed these again, this time guided by the grouping concepts of proximity, closure, symmetry, continuity, and similarity.

DISCUSSION: DRAWING FROM A LARGER CANVAS

In this section we discuss qualitative findings from our field study of location-based service use from the perspective of gestalt theory's principles of perceptual organization as presented earlier as a lens for describing and explaining how people perceived the relationship between the mobile location-based service and their environment.

Proximity

Proximity played an important role in the way that people interpreted the information presented by the Just-for-Us prototype. This happened on two levels. Firstly, it happened within the screen, in line with general screen design principles. The onscreen annotations on the panoramic photographs were perceived as belonging to the object or location that they were directly placed on top of, and also grouped annotations were perceived as belonging together. In addition, circles on the map were perceived as applying to the places they were located near and groups of circles on the map were perceived as representing "busy" areas.

Interestingly for the design of location-based services, the information on the mobile device itself was seen as an annotation of the place that people were situated in. People were grouping the system with objects in the environment, that is, the physical space acted as a "larger canvas" to draw from, on which the location-based service was just another piece of information to be perceived and integrated into the whole.

In our evaluation we found that people understand when information presented by the system is specific to their current physical location, and they like it when they are automatically given information relevant to where they are. In fact, the proximate relationship between the system and the world made people perceive the information content of the service as true. For example, this happened when given the menu for a cafe while they were at that particular café, or when presented with an annotated panoramic photograph of their location.

Closure

Closure is the gestalt principle that best describes the phenomenon that people are capable of making sense from small bits of information. Pieces of information on the mobile device are combined with pieces of information from the physical environment to create a "whole", and missing parts of this combined picture are filled in on the basis of peoples' prior knowledge. As described by this gestalt principle, people supply the missing information themselves, drawing from a larger canvas in "connecting the dots" to make it easier to understand their environment.

In our evaluation we found several examples of this. Although the maps used in the prototype were extremely simplistic line drawings with only a few annotations, people naturally perceived this as representing the much more complex real world around them. Annotations on the panoramic images supported people in "completing the picture" of what was behind the surrounding facades even though a large part of that picture was not visible to them. People also used their knowledge of familiar places referred to by the system as anchor points to resolve the layout of unfamiliar areas.

As another example, closure played a major role in the manner in which people used the wayfinding information provided by the system. The principle of closure describes how people mentally complete incomplete graphical figures, such as a partial circle. In relation to wayfinding we found that this principle also applied to visualising a series of transition points as a complete path from A to B. As opposed to guidance systems that give highly detailed step-by-step instructions we found that people only needed fragmented detail to find their way around the space. Useful types of transition points were found to be references to familiar places, major entrances, landmarks (i.e., the river), or distinct architectural elements (i.e., the green glass wall).

Another important finding in relation to closure was that in reducing the information presented to the user of a location-based service, the significance of the remaining information is increased. This means that even though people are highly capable of connecting the dots, they still need carefully chosen "dots" to do so.

Symmetry

Because people have a preference for symmetry, they made an effort to eliminate any asymmetry between the system and the real world. This was not used as much to piece together information to be able to understand it, as it was for the comfort of creating a coherent base on which to build understanding.

In our evaluation we observed that people strived for symmetry between the system and the world. Visually this was evident as they worked to align the panoramic images on the mobile device screen with the buildings around them even though this was not necessary to operate the system. Some people even expressed that they would like the panoramic images to automatically correspond to the direction they were physically facing. Offsets between the viewpoint of the panoramic images on the screen and the user's location affected the symmetry between the two. People found this disconcerting, even though it was only a few degrees difference in view and they could still easily make sense of the representation. The same phenomenon was observed when using maps in the system. In this situation many people changed the orientation of the mobile device so that it aligned with their surroundings in striving for symmetry between the system and the physical environment.

Continuity

In looking at the use of location-based services, the principle of continuity applies strongly to interaction over time. The fact that people have preferences for familiar places and familiar paths indicates that interactions in a place do not happen as isolated events but are often an extrapolation of past experiences there. People have a trail of past interactions that they like to share with others as much as they like to incorporate the trails of others into their own current experience. Rather than a random set of disjointed events, people tend to perceive their past experiences as interwoven in a continuous pattern. In this sense the larger canvas, which people draw from, consists not only of their mobile device and physical surroundings but also of their memories.

In our evaluation we found that although interested in exploring new places, people were primarily interested in information about current events at their familiar places. In this way, they continue to weave a story of interactions over time. When exploring new places, people preferred places that had been recommended to them by friends, and other trusted sources (i.e., reputable food guides), drawing on the experiences of others rather than starting from nothing. In this way they are adding to the continuity of other peoples' stories as well as enriching their own. Continuity also played a role in relation to the interpretation of descriptors used in the system. Here there was a clear preference for persistent descriptors, for example, "the black building", which refers to a constant quality of that building, rather than "the sitting steps", which refers to a transient activity at those steps.

The importance of continuity also came to our attention in relation to a part of our prototype system where people misunderstood or were surprised that the location-based service adapted not only to location but also to their history of visits. Specifically, this happened when the system made suggestions for places to go based on where they had been in the past, but without indicating the rationale behind these recommendations. From the perspective of continuity, we had failed to represent to the user the trajectory of experiences from which these suggestions were drawn, thus making it impossible for people to see the recommendations as a part of their continuing experience with a place and an extrapolation of their past experiences.

Similarity

Finally, similarity played an enormous part in people's ability to make sense of the location-based service. Things in the physical environment were continuously aligned with images and other representations on the screen that matched or looked alike. Through this, information content in the system was perceived as belonging to the corresponding location or object in the world. This was not necessarily always a visual matching process. People were also able to draw on similarities between images and annotations on the screen and their knowledge about the physical environment, within and beyond visual range.

In our evaluation, similarity was primarily evident in matching physical objects and structures, such as media screens, a satellite dish, etc., to images on the screen. People looked for similarities in the outlines in their immediate, as well as distant, surroundings, such as the shape of buildings and the general skyline. They also used distinct features in their environment as anchor points for matching up the system and the world, for example, landmarks, unique patterns and colours on buildings.

Making sense on the basis of similarity happened not only on an iconic level, but also on a symbolic level. People often matched annotations on the screen, such as "the river", to the corresponding places in the world, and also matched up names in the system with signage in the physical environment. In fact, people found it perplexing if dominant signage in the world was not duplicated on the screen. Additionally, names in the system that hinted at the activity of a place, for example "Chinotto Café", were easily matched to a place if that activity was visually evident, in this case by the presence café tables and umbrellas. Again it was evident that in the use of the prototype location-based service people were drawing conclusions from the larger canvas – not just from the system or from the context.

CONCLUSIONS

This paper has addressed the issue of explaining how people perceive and make sense of mobile location-based services situated in context. Prompted by the finding that people are extremely good at making sense from small and fragmented pieces of information when using location-based services, we have revisited empirical data from a user study of such a system in pursuit of explanations of this phenomenon. In response, we have suggested the use of gestalt theory as an analytical perspective for describing and explaining the interplay between people, information systems on mobile devices, and context of use. Exemplified by qualitative findings from our use evaluation, we have shown how gestalt principles can be applied to location-based services as a way of explaining peoples' use of well functioning as well as problematic system design. In the use of location-based services, people are not just drawing conclusions from their mobile device or their surroundings; they are drawing from a larger canvas to which both are contributing.

Proximity explains how information on the mobile device screen was seen as belonging to peoples' current physical location. *Closure* explains the phenomenon of people relating and making sense of fragmented information and adding the missing bits themselves. *Symmetry* describes the desire to align representations in the location-based service with the real world in order to obtain a coherent image from which to act. *Continuity* adds a temporal dimension and describes how information in a location-based service does not exist in isolation from peoples' history of interactions with it. Finally, *similarity* describes the mechanism of grouping specific elements in the system with corresponding elements in the surroundings.

This research is still ongoing and evolving. Motivated by the promising outcomes from the initial reanalysis of our empirical data presented in this paper, we are again revisiting the original video recordings from our evaluations in more detail. Our further research will expand on the descriptions of gestalt theory principles as experienced by people in relation to their use of location-based services. Finally, we are using the gestalt perspective to inform a set of design heuristics for location-based services on mobile devices.

REFERENCES

Bardram, J., Kjær, T. A. K. and Nielsen, C. (2003) Supporting Local Mobility in Healthcare by Application Roaming among Heterogeneous Devices, *Proc. Mobile HCI 2003*, LNCS, Springer-Verlag, Berlin.

Barkhuus, L. and Dey, A. K. (2003) Is Context-Awareness Computing Taking Control away from the User? Three Levels of Interactivity Examined, *Proc. UbiComp 2003*, LNCS, Springer-Verlag, Berlin.

Bassuener, K. (2001) Weak Mobile Data Uptake? Studies Point Fingers, NEWS@2 DIRECT, http://www.wirelessweek.com/article/CA524587.html.

BBC (2002) Mobile users unexcited by 3G, BBC News, June 18, 2002, http://news.bbc.co.uk/1/hi/business/2050994.stm, accessed 6 August 2006.

Behrens, R. (1984) *Design in the Visual Arts*, Prentice-Hall, Englewood Cliffs, NJ.

Benyon, D., Turner, P. and Turner, S. (2005) *Designing Interactive Systems*, Addison-Wesley, Harlow, England.

Beyer, H. and Holtzblatt, K. (1998) *Contextual Design*, Morgan Kaufman. San Francisco.

Borchers, J., Deussen, O., Klingert, A. and Knorzer, C. (1996) Layout Rules for Graphical Web Documents, *Computer Graphics*, 20 (3), 415-426.

Chang, D., Dooley, L. and Tuovinen, J. (2001) Gestalt Theory in Visual Screen Design – A New Look at an Old Subject, *Proc. WCCE'01, Volume 8*, Copenhagen, Denmark, 5-12.

Chang, D. and Nesbitt, K. (2005) Developing Gestalt-based Design Guidelines for Multi-sensory Displays, *Proc. MMUI2005*, Workshop on Multi-modal User Interaction, Sydney, Australia, ACS.

Cheverst K., Davies N., Mitchell K., Friday A. and Efstratiou C. (2000) Developing a Context-aware Electronic Tourist Guide: Some Issues and Experiences, *Proc. CHI 2000*, ACM, 17-24.

Costolo, D. (2005) Mobile Operators Seek Incremental Revenue from the Mobile Internet, SYS-CON Media, http://wbt.sys-con.com/read/40977.htm, accessed 6 August 2006.

Dix, A., Finlay, J., Abowd, G., Beale, R. (1998) *Human-Computer Interaction*, Prentice Hall Europe, London.

Dix, A., Rodden, T., Davies, N., Trevor, J., Friday, A. and Palfreyman, K. (2000) Exploiting Space and Location as a Design Framework for Interactive Mobile Systems, *ACM TOCHI*, 7(3), 285-321.

Driscoll, M. P. (1993) *Psychology of Learning for Instruction*, Allyn & Bacon, Needham Heights, MA.

Eftos, M. (2005) Investigating Gestalt Theory and Usability Testing Techniques in the Web Design Process, Unpublished Honours Thesis, Department of Computer Science, University of Western Australia.

Fithian, R., Iachello, G., Moghazy, J., Pousman, Z. and Stasko J. (2003) The Design and Evaluation of a Mobile Location-Aware Handheld Event planner, *Proc. Mobile HCI 2003*, LNCS, Springer-Verlag, Berlin.

Flieder, K. and Modritscher, F. (2006) Foundations of a Pattern Language Based on Gestalt Principles, *Proc. CHI 2006*, Work-in-Progress, Montreal, Quebec, Canada.

Hsiao, S. and Chou, J. (2006) A Gestalt-like perceptual measure for home page design using fuzzy entropy approach, *International Journal of Human-Computer Studies*, 64, 137-156.

Johnson, P. (1998) Usability and Mobility; Interactions on the move, *Proc. the First Workshop on Human-Computer Interaction with Mobile Devices*, Glasgow, Scotland, GIST Technical Report G98-1.

Kaasinen, E. (2003) User Needs for Location-Aware Mobile Services, *Personal and Ubiquitous Computing*, 7, 70-79.

Kim, H., Kim, J., Lee, Y., Chae, M. and Choi, Y. (2002) An Empirical Study of the Use Contexts and Usability Problems in Mobile Internet, *Proc. HICSS'35*, IEEE, 132-142.

Kjeldskov, J. and Paay, J. (2005) Just-for-Us: A Context-Aware Mobile Information System Facilitating Sociality, *Proc. Mobile HCI 2005*, Salzburg, Austria, ACM, 23-30.

Lauesen, S. (2005) *User Interface Design: A software engineering perspective*, Addison-Wesley, Harlow, England.

Lee, I., Kim, J. and Kim, J. (2005) Use Contexts for the Mobile Internet: A Longitudinal Study Monitoring Actual Use of Mobile Internet Services, *IJHCI*, 18(3), 269-292.

McCullough, M. (2001) On Typologies of Situated Interactions, *Human-Computer Interaction*, 16, 337-347.

Millen, D. R. (2000) Rapid ethnography: time deepening strategies for HCI field research, *Proc. DIS 2000*, New York, ACM, 280-286.

Moore, P. and Fitz, C. (1993) Gestalt Theory and Instructional Design, *Journal of Technical Writing and Communication*, 23 (2), 137-157.

Mullet, K. and Sano, D. (1995) *Designing Visual Interfaces: Communication oriented techniques*, Prentice Hall, Englewood Cliffs, NJ.

Nilsson, J., Sokoler, T., Binder, T. and Wetcke, N. (2000) Beyond the Control Room – Mobile Devices for Spatially Distributed Interaction on Industrial Process Plants, *Proc. Handheld and Ubiquitous Computing, HUC 2000.*

Oviatt, S., Coulston, R., Tomko, S., Xiao, B., Lunsford, R., Wesson, M. and Carmichael, L. (2003) Toward a Theory of Organized Multimodal Integration Patterns during Human-Computer Interaction, *Proc. ICMI'03*, Vancouver, British Columbia, Canada, ACM, 44-51.

Paay, J. and Kjeldskov, J. (2006) Understanding Situated Social Interactions: A Case Study of Public Places in the City, *Computer-Supported Cooperative Work* (to appear).

Preece, J., Rogers, Y., Sharp, H., Benyon, D., Holland, S. and Carey, T. (1994) *Human-Computer Interaction*, Addison-Wesley, Wokingham, England.

Roth, S. (1995) Visual Literacy and the Design of Digital Media, *Computer Graphics*, November 1995, 45-47.

Sacher, H. and Loudon, G. (2002) Uncovering the New Wireless Interaction Paradigm, *Interactions*, 9(1), 17-23.

Smith-Gratto, K. and Fisher, M. (1998-1999) Gestalt Theory: A Foundation for Instructional Screen Design, *Journal of Educational Technology Systems*, 27 (4), 361-371.

ACKNOWLEDGEMENTS

This research is supported by the Danish Technical Research Council's (project reference 26-04-0026) and The University of Melbourne's PORES program. The authors thank everyone participating in the field study and in the evaluations of the prototype system. We also thank Steve Howard and Bharat Dave for valuable input.

COPYRIGHT