Aalborg Universitet

AALBORG UNIVERSITY
DENMARK

Understanding the user experience of location based services

Paay, Jeni; Kjeldskov, Jesper

Published in:
Journal of Location Based Services

DOI (link to publication from Publisher):
10.1080/17489720802609328

Publication date:
2008

Document Version
Peer reviewed version

Link to publication from Aalborg University

Taylor & Francis
Taylor & Francis Group

RESEARCH ARTICLE

Understanding the user experience of location-based services: five principles of perceptual organisation applied

Jeni Paay[a] and Jesper Kjeldskov[ab]*

[a]Department of Computer Science, Aalborg University, Aalborg, Denmark; [b]CSIRO ICT Centre, Sydney, Australia

Within recent years, the development of location-based services have received increasing attention from the software industry as well as from researchers within a wide range of computing disciplines as a particular interesting class of context-aware mobile systems. However, while a lot of research has been done into sensing, adapting to, and philosophising over the complex concept of 'context', little theoretically based knowledge exists about why, from a user experience perspective, some system designs work well and why others do not. Contributing to this discussion, this article suggests the perspective of 'Gestalt theory' as a theoretical framework for understanding the use of this class of computer systems. Based on findings from an empirical study, we argue that the user experience of location-based services can be understood through Gestalt theory's five principles of perceptual organisation: proximity, closure, symmetry, continuity and similarity. Specifically, we argue, that these principles assist us in explaining the interplay between context and technology in the user experience of location-based services, and how people make sense of small and fragmented pieces of information on mobile devices in context.

Keywords: location-based services; user experience; Gestalt theory; field study

1. Introduction

Location-based services represent an emerging class of computer systems providing mobile device users with information and functionality related to their geographical location. Within recent years, this class of *context-aware* mobile computer systems has received increasing attention from researchers within a range of computer science disciplines as well as from industry. Location-based services open a new market for network operators and service providers to develop and set up value-adding new services for users on the move, such as helping find nearby shops or friends, advertising traffic conditions, supplying routing information, and augmenting the built environment of cities with an ubiquitous layer of information about, for example, people, places and activities. 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

*Corresponding author. Email: jesper@cs.aau.dk

available systems 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. relating picture blog 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 models 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, much effort has been put into both ethnographic-style studies of mobile work activities, and field studies of technology in use. However, while a lot of research has been done into sensing, modelling and adapting to context, as well as philosophising over the complex concept of 'context' (e.g. Dourish 2004), very little work has provided theoretically informed foundations for interface and interaction design of context-aware and location-based systems, or explained, from a user experience perspective, why some solutions work well and why others do not. Hence, generally applicable rules and guidelines for interaction design, as we know them for desktop and web applications, do not exist for context-aware and location-based systems, and more research is needed into the user experience of this emerging class of applications.

Contributing to this research, this article presents a user experience study of a prototype location-based service and looks at how people perceive the ensemble of information on mobile devices and use context from the perspective of five principles of perceptual organisation from Gestalt theory: *proximity*, *closure*, *symmetry*, *continuity* and *similarity* as a potential theoretical framework for understanding the user experience of location-based services. In suggesting this perspective on human perception and thinking in relation to technology use, we are inspired by and align ourselves closely with the acclaimed work of Frøkjær and Hornbæk (2002, 2008) on metaphors of human thinking for describing aspects of human–computer interaction (HCI). Reporting on this work in the Journal of Location Based Services, we contribute to the 'urgently needed' area of research of *interaction design for LBS* outlined in Raper *et al.*'s (2007) editorial lead paper of the first issue of the journal. We also respond to the lead paper's recommendation for more user-centred system conception of location-based services (Raper *et al.* 2007, p. 22).

We have been studying the user experience 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 inspiration from the newly opened civic structure of Federation Square in Melbourne, Australia. It involved 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 and Paay 2006, Paay and Kjeldskov 2008). 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, and they did so with high success rates. 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 analysed our video and interview data from field evaluations of the prototype system from multiple theoretical angles. As a result of this, we found that the perspective of Gestalt theory's principle of perceptual organisation provides a very useful, and yet relatively simple lens for describing and explaining how people make sense of the content of mobile information systems situated in context.

First, we introduce a background of related work. We then introduce Gestalt theory and how this theoretical approach to human perception and thinking has been applied within HCI to explain and inform qualities of graphical screen design. Following this, we present the Federation Square case study, our prototype system, and a field study of the prototype in use. We then apply five principles of perceptual organisation from Gestalt theory to our empirical data, describing and explaining the ensemble of mobile device and use context in the user experience of our location-based service. From our findings, we distil a framework for the design and evaluation of location-based service user experiences. Finally, we conclude on our work and outline avenues for further research.

2. Background: 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, 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 (Sacher and Loudon 2002). MMS was developed to allow exchange of rich media content, and WAP allowed mobile access to a downscaled version of the web. On the network level, the development of UMTS means that the speed of mobile data connections now matches many of their hard-wired counterparts, thus allowing realistic mobile use of, for example, the world wide web. However, while commercially available technologies have made the Internet mobile, fast, accessible and relatively cheap, uptake by the general population has not met the IT industry's expectations (e.g. Costolo 2005, BBC 2002). While people are generally increasingly interested in the mobile Internet, very few are actually using it (Ericsson 2007).

From a user experience perspective there are several reasons for this. Firstly, while unquestionably containing information and functionality relevant to mobile users, most Internet services are not well designed for mobile use (e.g. Forrester 2006). They are designed for desktop use, and require a lot of user input and visual and cognitive attention. In contrast, the mobile Internet is typically accessed through devices with small screens and limited means of input used in very dynamic settings. Thirdly, services for the mobile Internet are currently designed to facilitate doing, while mobile, the things we do at our desktop. They do not relate to mobile use context but look the same at home, on the bus, in a café or walking down the street – situations with very different requirements (e.g. Lee *et al.* 2005). If we want to bridge the gap between interest and actual use of the mobile Internet, we must do better. We must support a user experience that takes into account the wholeness of technology and context, and *we must enable people to do relevant things that they could not do before*. The area of location-based services has the potential to fill this void.

Advances in technology have made it possible for mobile computers to sense or access information about users' context such as location, social setting, activity, computational resources, etc. (e.g. Hinckley *et al*. 2005). Recent research has demonstrated that using such information to make mobile computer systems 'context-aware' can increase usability within highly specialised domains such as healthcare and industrial process control. One of the most promising aspects of user context for a mobile computer system to respond to is *location* (Fithian *et al*. 2003, Kaasinen 2003, Jones *et al*. 2004). The potential benefits of location-based services for the mobile Internet are several. By making a mobile Internet service aware of the user's location, developers can streamline it to present information and functionality that is particularly relevant at a specific place or within a specific distance. As a fictive example, a location-based mobile Internet service for a train station could respond to the user's location, time, activity, etc. by presenting only information about departures from this or nearby stations, within a short period of time, to destinations matching upcoming appointments.

The number of commercially available location-based services has increased rapidly over the last 2 years. Fuelled by developments of new technology, new services are emerging that integrate wide-area broadband wireless Internet access, web resources and geographical information for increasingly affordable and popular PDAs and 3G mobile phones with GPS and other positioning capabilities such as the new iPhone and the BlackBerry. As an early example, ViewRanger (Figure 1) provides 3D models of the user's surroundings with superimposed information links on GPS enabled 3G phones in parts of the UK. Other systems and 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 systems such as Google Earth. In a similar fashion, some of Sony's newest cameras and camcorders are able to record GPS position data and allow people to publish their media on an online map.

Yet creating quality user experiences for location-based services for the mobile Internet is still not trivial. Given the novelty of location-based services, little is known about the user experience of such 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 information services that react to their location and combine, for example, web content, satellite imaging, 3D graphics, and cartography. With the work presented in this article, we contribute to an increased understanding of some of these important factors of location-based service design

Figure 1. Example location-based service providing information about the surrounding environment (http://www.viewranger.com/).

and development. We do this by providing theoretically informed explanations of the interplay between context and technology in the user experience of location-based services.

3. Gestalt theory

In this section, we turn our attention towards Gestalt theory and how it has previously been applied to the field of HCI.

Gestalt theory evolved from explorations of human perception in the discipline of psychology in the early twentieth century aiming to explain how people organise 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 people see and understand their surroundings (Borchers *et al.* 1996).

Gestalt theory explains how we perceive objects in our environment. The Gestalt viewpoint says that '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. From the Gestalt perspective, new information is seen as organised and bridged to prior knowledge to form an organised whole, and it is the 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 (Preece *et al.* 1994). Hence, 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 and Fisher 1998–1999).

Although the Gestalt laws are most often applied to visual perception, they also apply to other senses and cognitive processes. As expressed by Köhler (1947, p. 178), 'the concept 'Gestalt' may be applied far beyond the limits of sensory experience. According to the most general functional definition of the term, the processes of learning, of recall, of striving, of emotional attitude, of thinking, acting, and so forth, may have to be included'. As a good example of this extension of the concept of Gestalt, Max Wertheimer, in his address before the Kant Society in Berlin in 1924 (Ellis 1938) raised the question of whether the listener's experience of a melody is simply the sum of individual notes. He concluded that what we experience is rather determined by the character of the whole and that what takes place in each point in a musical piece depends upon the whole. Hence, we perceive patterns and form in music as wholes, and when a song is transposed to another key, we can still recognise it although all of the notes have changed.

3.1. *Gestalt theory in HCI*

Gestalt theory is included in several prominent HCI primers (e.g. Preece *et al.* 1994; Dix *et al.* 1998, Benyon *et al.* 2005, Lauesen, 2005), and is introduced for its general application to the design of information screens and as providing interface designers with a theoretically informed understanding of how information screens are likely to be perceived by users. Gestalt theory, as it has been explored within HCI, consists only

Proximity
Things that are located near each other, in space or time, are perceived as belonging together

Closure
Things are perceived as complete or whole, even when part of the information is missing

Symmetry
When things have symmetrical borders or parts, they are perceived as a coherent whole

Continuity
We perceive things as continuous patterns rather than disjointed ones

Similarity
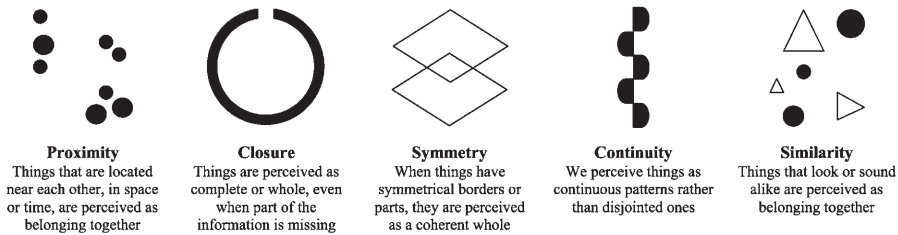Things that look or sound alike are perceived as belonging together

Figure 2. Five key principles of perceptual organisation for interaction design derived from Gestalt theory.

of a small subset of the original Gestalt laws in the form of a set of principles of perceptual organisation that can be applied to interface design to improve communication between user and system. For the purpose of this study, we have identified five such key principles, which are generally acknowledged within HCI. These are illustrated in Figure 2.

The principles of perceptual organisation and other concepts derived from Gestalt laws have influenced many research areas related to HCI such as map reading, graph drawing, image retrieval, computer vision, pattern recognition, design of auditory displays and musical studies. Of particular interest to this article is the research that has applied Gestalt principles to HCI analysis, design and evaluation.

As the graphical user interface became the predominant interface of computer systems during the 1990s, it was important for HCI researchers to provide interface designers with an understanding of the human perception of operating these new information-rich types of interfaces and with guidance on how to design them better. In response, researchers applied Gestalt principles of perceptual organisation to general screen design in order to create sets of design principles and guidelines for optimising their graphical layouts. Important concepts of interface design, which are now considered elementary, such as consistency, visual hierarchy, grouping, legibility and contrast can be seen as derived from Gestalt theory (Roth 1995). This application of the Gestalt laws to interface design is also demonstrated by, for example, Mullet and Sano (1995), Roth (1995), Borchers *et al.* (1996) and Lauesen (2005). In more recent work within HCI, Gestalt theory's principles of perceptual organisation have been used as a basis for developing design guidelines for new paradigms of interaction design with multi-sensory displays that combine visual, auditory and haptic elements (Chang and Nesbitt 2005). Gestalt theory principles have also recently been linked with a pattern methodology for creation of a theoretical framework facilitating the incorporation of knowledge about human perception into the early stages of user interface design (Flieder and Mödritscher 2006). Beyond the creation of principles and guidelines for screen design, recent research has also explicitly used Gestalt theory in the evaluation of 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 evaluate the 'wholeness' of that page.

Of significance to HCI is also the development of the concept of affordances and related cognitive design guidelines. Based on the seminal work of Gibson (1979), who situates the origin of his Affordance Theory in work by Gestalt psychologists, the concept

of affordances was introduced to the general HCI community by Norman (1988) in 'The Psychology of Everyday Things' and has had a huge impact on interface and interaction design. According to Gibson's theory, perceiving one's environment leads to behaviour guided by clues indicating possible actions. Buttons are for pushing, handles are for pulling, knobs are for turning, etc. Extending Gibson's original affordances concept of 'actual' action possibilities available in the environment independent of any individuals, Norman included objects' *perceived* properties highlighting the importance of the human observer/user and aligning it closely with the design philosophy and process of user-centred design (Norman 1999).

While much of the Gestalt-related research within HCI is about graphical interface design, Oviatt *et al.* (2003) take a broader application of Gestalt principles by using Gestalt theory to analyse not just the computer screen but also the *interaction situation*. Aimed at the design of adaptive multimodal interfaces and providing a framework for understanding user interaction with multimodal information systems, they studied technology use in context, and observed how speakers tailor their language to accommodate the listener's perceptual capabilities. Explaining this and other phenomena, they applied Gestalt principles as a theoretical lens to look at both users perception of the interface and their production of communication patterns during its use.

Our approach, as reported in this article, is similar to that of Oviatt *et al.* (2003). Rather than applying Gestalt principles only to the design of the interface, we view the computer screen as merely a small area within the larger context of the physical environment in which it is situated. In line with Gestalt theory's concept of 'wholeness', the environment and the computer screen are seen as creating a unique perceptual whole, rather than as the simple sum of the individual parts. From this perspective, our study looks at the cognitively perceived ensemble of technology and surroundings as experienced when people are using location-based services in context.

In terms of related work into providing better understanding of the user experience of location-based services, our work is particularly related to research systematically and theoretically describing user experiences in relation to important contextual factors beyond peoples' location, such as activity, preferences, and information needs. As examples, Timpf (2002) uses ontologies of wayfinding derived from travellers' perspectives to reflect human models of the world and understand the different needs of a traveller at different stages of a trip. Focussing on the importance of individual preferences and time constraints, Raubal *et al.* (2004) propose a user-centred spatio-temporal theory of location-based services combining time geography with an extended theory of affordances.

Another interesting piece of related work is Raubal and Winter (2002) presenting a method to automatically extract landmarks from geo-coded spatial datasets based on analysis of 'landmark saliency'. This information is then used to improve navigation services with wayfinding descriptions making use of concepts closer to the human user by referring to prominent features in the user's physical environment. What is particularly interesting in the context of the Gestalt approach proposed in this article for understanding the user experience of location-based services is the proposed measures for formally specifying landmark saliency based on visual, semantic and structural attraction. Related to the Gestalt principle of closure, these measures define more specifically what combined properties of a feature in the physical environment make people perceive it as a prominent whole that stands out as a landmark.

4. Case study: the 'Just-for-Us' location-based service

Inquiring into the user experience of location-based services we have designed, implemented and evaluated a prototype location-based service, *Just-for-Us*, providing an informational overlay to the civic space of Federation Square in Melbourne, Australia (Figure 3). Federation Square was chosen because it was a relatively new civic structure, opened to the public in October 2002. It covers an entire city block and provides the people of Melbourne with a creative mix of attractions and public spaces for socialising including restaurants, cafes, bars, a museum, galleries, cinemas, retail shops and several public forums. In just a few years, Federation Square has become a highly popular place to socialise for Melbournians. It is open from early until late, every day of the week, and it hosts a rich range of planned and *ad hoc* activities. Located in the centre of the city, on major tram routes, and adjacent to a major train station, Federation Square is easily accessible, is considered a landmark in itself, and is a convenient place for people to arrange to meet up at the beginning of a night out on the town.

The Just-for-Us system (Figure 4) 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 (2006)). 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 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. Prior to the field visits each group received a 10-min introduction to the study followed by a 20-min interview about their socialising experiences and preferences. Each field visit lasted approximately 3 h.

Figure 3. Federation Square, Melbourne, Australia, with surrounding skyline, train station and the river.

The use evaluation of the prototype location-based service involved 20 established social pairs of mixed gender familiar with Federation Square (Figure 5). Inspired by rapid ethnography (Millen 2000) we gave the participants five overall tasks and 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. Before taking part in the study, each participant pair jointly completed a history survey of their previous visits to Federation Square to simulate history data that the real system would have collected automatically. Each evaluation session lasted approximately 1.5 h.

For testing purposes, the user's position, people and friends in vicinity, etc. were entered manually using the 'Wizard of Oz' technique. Inspired by the 1939 movie by the same name, Wizard of Oz is a technique for simulating system components commonly used for evaluation within the field of HIC (Dahlbäck *et al.* 1993, Buxton 2007). Using this
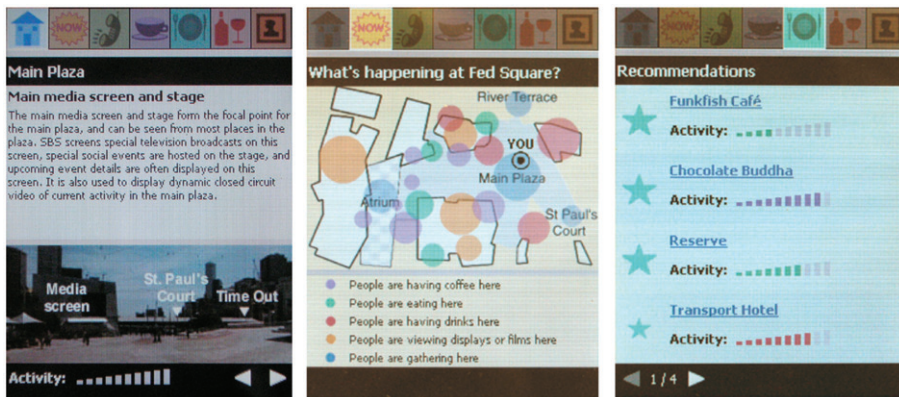

Figure 4. Screens from the Just-for-Us location-based service.

Figure 5. Studying the location-based service in use at Federation Square with wireless micro camera attached to the mobile device.

technique, parts of a system's functionality that are not yet fully implemented are instead simulated 'behind the scenes' without the knowledge of the test subjects. This is done in order to get rapid feedback on user interface design and envisioned functionality early in a design process.

Due to the fact that this was not a grounded theory building exercise but an exploration of the user experience of an example location-based service, we used the rapid ethnography method of collaborative data analysis (Millen 2000) to provide the level of analysis needed. The collaborative data analysis approach was combined with the analytical technique of identifying critical incidents from the video data to produce a list of observations (Sharp *et al.* 2007) each associated with one of the five overall tasks. The video data from the evaluations was then analysed by two researchers using content analysis, and observations were subsequently affinity diagrammed into higher level issues (Beyer and Holtzblatt 1998). The outcome of this analysis was a list of 74 issues. In a second round of affinity diagramming, the two researchers first independently grouped these 74 issues in relation to Gestalt theory's five concepts of proximity, closure, symmetry, continuity and similarity. Following this, the two independent groupings were then merged into one final set of groups in a structured collaborative effort. In case of disagreement between the individual groupings, the grouping of an issue was discussed until consensus was reached. In this process, 11 issues were not associated with any of the principles of proximity, closure, symmetry, continuity and similarity, while the remaining 63 were associated with one or more of the five principles.

5. Findings: five principles of perceptual organisation applied

In this section, we discuss qualitative findings from our field study of location-based service use from the perspective of Gestalt theory's five principles of perceptual organisation as presented earlier as a lens for describing and explaining how people perceive the relationship between the mobile location-based service and their environment. Like the illustrations depicted in Figure 2, Figures 6–10 are designed simply to illustrate the Gestalt principles for location-based services and are not meant as specific design suggestions.

Figure 6. Proximity: perceiving information as an annotation of a place.

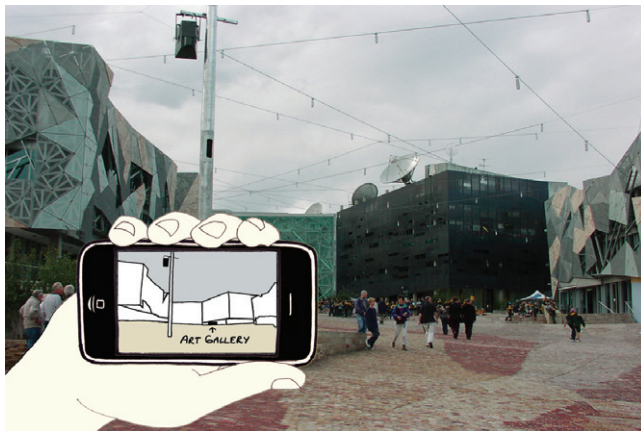Figure 7. Closure: filling in the blanks of ambiguous information.

Figure 8. Symmetry: making a symmetrical alignment between system and surroundings.

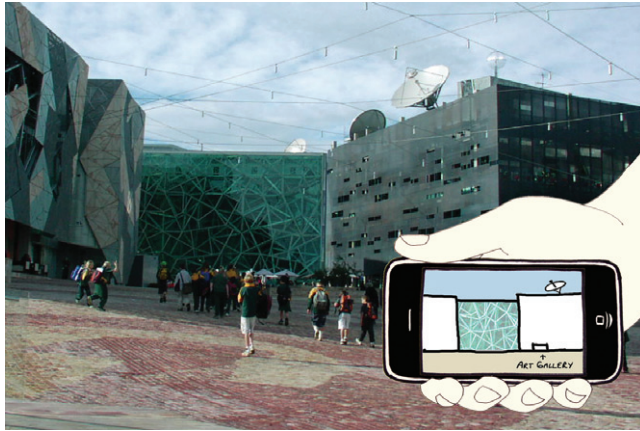Figure 9. Continuity: experiencing a place over time.

Figure 10. Similarity: matching things in system and surroundings that are alike.

5.1. *Proximity*

The principle of proximity defines that spatial or temporal proximity of elements may induce the mind to perceive a collective or totality. Things that are located near each other, in space or time, are perceived as belonging together.

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: (1) in relation to the mobile device screen as an element of the environment, and (2) in relation to the mobile device screen on its own. Below, we discuss these two individually.

Firstly, and particularly interestingly for the design of location-based services, information on the mobile device itself was seen as an annotation of the place 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 experience. Relating digital information to physical locations is the essence of a location-based service. The Gestalt principle of proximity explains, from a theoretical point of view, why this relationship makes sense to users of such services.

In our evaluation we found that people easily 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 close 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 while they were at that particular café, or when presented with an annotated panoramic photograph of their location.

Secondly, the principle of proximity played an important role within the screen, in line with general screen design principles. The onscreen annotations on the panoramic photographs (Figure 4, left) 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 (Figure 4, middle), which represented the number of people at particular places, were perceived as applying to the places they

were located near and groups of circles on the map were perceived as representing 'busy' areas.

5.2. *Closure*

The principle of closure defines that the mind may experience elements it does not perceive through sensation, in order to complete a whole. Things are perceived as complete or whole, even when part of the information is missing.

Closure is the Gestalt principle that best describes the phenomenon that people are capable of making sense from small bits of fragmented and ambiguous 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 and sense-making abilities. 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 visual perception 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 some guidance systems that give highly detailed step-by-step instructions our findings confirm other research showing that people only needed fragmented detail to find their way around urban spaces. 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 remaining information increases. This means that even though people are highly capable of connecting the dots, they still require carefully chosen 'dots' to do so.

5.3. *Symmetry*

The principle of symmetry defines that symmetrical images are perceived collectively, even in spite of distance. When things have symmetrical parts or borders, they are perceived as a coherent whole.

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 actually 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 and providing an egocentric frame of reference.

5.4. *Continuity*

The principle of continuity defines that the mind continues a pattern, even after it stops. We perceive things as continuous patterns rather than disjointed ones. The principle of continuity applies not only to visual sequences, but also to sequences perceived over time, such as a series of tones being perceived as music.

In looking at the use of location-based services in context, the principle of continuity applies strongly to interaction over time. The fact that people have preferences for familiar places and 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. Events experienced close together in time are perceived as a continuous whole. 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 scratch. 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 and disconcerted 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.

5.5. *Similarity*

The principle of similarity defines that the mind groups similar elements into collective entities or totalities. This similarity might depend on relationships of form, colour, size, or brightness. Things that look, sound or feel alike are perceived as belonging together.

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. Finally, they used similarities between the visual style of the places surrounding them and the logos and other graphical elements in the system. 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 matched 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 of 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.

6. Informing design and evaluation of location-based services

The implications of this work for the development of successful location-based services are that the Gestalt principles can assist us in guiding the design and evaluation of quality user experiences of such services. By acknowledging and understanding the close interplay between technology and context in the use of location based services, and the specific implications for location-based services highlighted by the five applied principles of perceptual organisation, we can distil a series of design-oriented questions. These questions can be applied either as a part of the design process of a location-based service as prompts for functionality, or they can be applied as a part of an evaluation of an existing location-based service as a partial set of heuristics used in combination with general interface design heuristics (e.g. Nielsen and Molich 1990).

In Table 1, we summarise the observed implications for the design and use of location-based services, and give examples of key questions to be asked in the design and evaluation of such services. It is important to note that the presented list of questions is open-ended and not complete.

Table 1. Five Gestalt principles, their implications for location-based services and questions for design and evaluation.

Gestalt principle	Implications for location-based services	Key questions for design and evaluation
Proximity	People perceive information content as closely related to their immediate location.	Does the system act as an annotation of its physical location? Can content in the user interface be grouped with objects in the environment?
Closure	People are able to fill in the blanks of ambiguous and fragmented information on the basis of their prior knowledge and sense-making abilities.	Can pieces of information in the user interface and in the surroundings be combined to create a meaningful larger whole? Does the system include clues about the relation between information in the user interface and its context? Does the system leave out redundant information already apparent through the context?
Symmetry	People have a preference for symmetry between system and surroundings in order to create a coherent base from which to interpret the relation between the two.	Does the system align information representations in the user interface with the user's surroundings? Does the system allow the user to align information representations in the user interface with their surroundings?
Continuity	People perceive their own and others' past experiences as an interwoven continuous story that develops over time and not as a series of disjoint events.	Does the system support user experiences that evolve over longer periods of time rather than a set of disjoint interactions? Does the system let the users extrapolate on their own and others' previous experiences in a place? Does the content of the system accumulate over time on the basis of peoples' use of it?
Similarity	People group content and representations in the system with elements in their physical surroundings based on iconic and symbolic similarity.	Does the user interface make use of representations that have similarities with corresponding objects in the physical surroundings? Does the user interface match elements in the surroundings, such as prominent signage, landmarks, and visual style of a place or area?

7. Conclusions

This article has addressed the issue of explaining how people perceive and make sense of mobile location-based services situated in context. Prompted by the finding from our research that people are extremely good at making sense from small and fragmented pieces of information when using location-based services, we have analysed empirical data from a user study of such a system in pursuit of explanations of this phenomenon. In response, we have suggested the application of Gestalt theory as an analytical perspective for describing and explaining the interplay between people, mobile devices, and context of use through five principles of perceptual organisation. Informed by qualitative findings from our use evaluation, we have shown how Gestalt principles can be applied to the user experience of location-based services as a way of explaining peoples' use of well functioning as well as problematic system design. In their use of location-based services, people are not just drawing conclusions from their mobile device or their surroundings alone; they are drawing from 'a larger canvas' to which both are contributing. As system designers of location-based services, we need to focus on this larger canvas when designing rather than merely focussing on the 'smaller canvas' of the mobile device.

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. Similarity describes the mechanism by which people are able to group graphical elements in the system with corresponding elements in the surroundings. Acknowledging the importance of context, the Gestalt viewpoint is that things are affected by where they are and by what surrounds them. Hence, applying a Gestalt theoretic perspective to the user experience of context-aware mobile computer systems captures, in essence, the cognitively perceived ensemble of technology and context, and provides a foundation for rules about how this relationship can be exploited in interaction design.

While Gestalt theory's principles of perceptual organisation might provide a useful umbrella theory for understanding, or a lens for characterising, aspects of the user experience of location-based services in a structured and systematic way, it is important to note that other concepts in the literature are dealing with the description and understanding of the observed characteristics of location-based services in use. Proximity is closely related to the concept of *location* itself. Closure is related to *salience* or *abstraction*. Symmetry is related to *alignment* and *egocentric frames of reference*. Continuity is related to *patterns of movement*. Similarity is related to *matching*. However, although each is useful for describing one particular aspect of the user experience of a location-based service, these concepts do not jointly make up a coherent whole within a common theoretical foundation, as is the case of the Gestalt principles of perceptual organisation. In contrast to the individual concepts outlined above, the Gestalt approach suggested in this article provides a broader framework and a way of thinking about the user perception of location-based services that explicitly promotes a holistic view on the ensemble of elements perceived by the users, that is, mobile devices as part of their context of use. It is our hope that applying a Gestalt theory perspective can add

successfully to the repertoire of concepts and theoretical foundations for understanding the user experience of location-based services.

This research is still ongoing and evolving. Motivated by the promising outcomes from the analysis of our empirical data presented in this article, we are in the process of collecting further empirical data to extend our analysis. From this research we aim to expand on the descriptions of Gestalt theory principles as experienced by people in relation to their use of location-based services. As a part of this, we are continuously elaborating on the framework presented in Table 1 towards the refinement of an established set of Gestalt-based design heuristics for the user experience of location-based services on mobile devices.

Acknowledgements

References

BBC, 2002. Mobile users unexcited by 3G [online]. BBC News. Available from: http://news.bbc.co.uk/1/hi/business/2050994.stm [Accessed 22 October 2008].

Behrens, R., 1984. *Design in the visual arts*. Englewood Cliffs: Prentice-Hall.

Benyon, D., Turner, P., and Turner, S., 2005. *Designing interactive systems*. Harlow: Addison-Wesley.

Beyer, H. and Holtzblatt, K., 1998. *Contextual design: defining customer-centred systems*. San Francisco: Morgan Kaufmann.

Borchers, J., *et al.*, 1996. Layout rules for graphical web documents. *Computer Graphics*, 20 (3), 415–426.

Buxton, B., 2007. *Sketching user experiences: getting the design right and the right design*. San Francisco: Morgan Kaufmann.

Chang, D. and Nesbitt, K., 2005. Developing Gestalt-based design guidelines for multi-sensory displays. *In*: F. Chen and J. Epps, eds. *Proceedings of the 2005 NICTA-HCSNet multimodal user interaction workshop*, *MMUI'05*, 13–14 September 2005, Sydney. Sydney: ACS, 9–16.

Costolo, D., 2005. Mobile operators seek incremental revenue from the mobile internet [online]. SYS-CON Media. Available from: http://wbt.sys-con.com/read/40977.htm [Accessed 22 October 2008].

Dix, A., *et al.*, 1998. *Human-computer interaction*. London: Prentice Hall Europe.

Dahlbäck, N., Jönsson, N., and Ahrenberg, L., 1993. Wizard of Oz studies: why and how. *In*: W.D. Gray, W.E. Hefley and D. Murray, eds. *Proceedings of the 1st international conference on intelligent user interfaces*, 4–7 January 1993, Orlando. New York: ACM, 193–200.

Dourish, P., 2004. What do we talk about when we talk about context? *Personal and Ubiquitous Computing*, 2004 (8), 19–30.

Ellis, W.D., 1938. *Source book of Gestalt psychology*. New York: Hartcourt, Brace and Co.

Ericsson, 2007. The 2006 Australian survey. Ericsson consumer and enterprise lab [online]. Ericsson. Available from: http://www.ericsson.com/au/ericsson/press/2006/Consumer_Lab_2007_public.pdf [Accessed 22 October 2008].

Forrester, 2006. Breaking the mobile internet's low adoption spell – best practices that will boost the mobile internet's appeal for content firms and consumers. Forrester Research. Available from: http://www.forrester.com/Research/Document/Excerpt/0,7211,39880,00.html [Accessed 2 March 2007].

Fithian, R., *et al.*, 2003. The design and evaluation of a mobile location-aware handheld event planner. *In*: L. Chittaro, ed. *Proceedings of the 5th international symposium on human-computer interaction with mobile devices and services*, *mobile HCI 2003*, 8–11 September 2003, Udine. Berlin: Springer, 145–160.

Flieder, K. and Mödritscher, F., 2006. Foundations of a pattern language based on Gestalt principles. *In*: R. Jeffries, ed. *CHI '06 extended abstracts on Human factors in computing systems*, 22–27 April 2006, Montreal. New York: ACM, 773–778.

Frøkjær, E. and Hornbæk, K., 2008. Metaphors of Human Thinking for Usability Inspection and Design. *Transactions on Computer-Human Interactions*, 24 (4), 1–33.

Frøkjær, E. and Hornbæk, K., 2002. Metaphors of human thinking in HCI: habit, stream of thought, awareness, utterance, and knowing. *In*: F. Vetere, L. Johnston and R. Kushinsky, eds. *Proceedings of the HF2002/OzCHI 2002 human factors conference*, 25–27 November 2002, Melbourne, Australia. Melbourne: HFESA and CHISIG, 964–971.

Gibson, J., 1979. *The ecological approach to visual perception*. New Jersey: Lawrence Erlbaum Associates.

Hinckley, K., *et al.*, 2005. Foreground and background interaction with sensor-enhanced mobile devices. *Transactions on Computer-Human Interaction*, 12 (1), 31–52.

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. *In*: C. Johnson, ed. *Proceedings of the first workshop on human computer interaction with mobile devices*, *Mobile HCI* 1998, 22 May 1998, Glasgow. Glasgow: University of Glasgow, Department of Computing Science. Available from: http://www.dcs.gla.ac.uk/~johnson/papers/mobile/HCIMD1.html [Accessed 17 November 2008].

Jones, Q., *et al.*, 2004. People-to-people-to-geographical-places: the P3 framework for location-based community systems. *Computer Supported Cooperative Work*, 2004 (13), 249–282.

Kaasinen, E., 2003. User needs for location-aware mobile services. *Personal and Ubiquitous Computing*, 2003 (7), 70–79.

Kjeldskov, J. and Paay, J., 2006. Public Pervasive Computing: making the Invisible Visible. *IEEE Computer*, 39 (9), 60–65.

Köhler, W., 1947. *Gestalt psychology: an introduction to new concepts in modern psychology*. New York: Liveright Publishing Corporation.

Lauesen, S., 2005. *User interface design: a software engineering perspective*. Harlow: Addison-Wesley.

Lee, I., Kim, J., and Kim, J., 2005. Use contexts for the mobile internet: a longitudinal study monitoring actual use of mobile internet services. *International Journal of Human Computer Studies*, 18 (3), 269–292.

McCullough, M., 2001. On typologies of situated interaction. *Human-Computer Interaction*, 16, 337–349.

Millen, D.R., 2000. Rapid ethnography: time deepening strategies for HCI field research. *In*: D. Boyarski and W.A. Kellogg, eds. *Proceedings of the 3rd conference on designing interactive systems*, *DIS 2000*, 17–19 August 2000, New York. New York: ACM, 280–286.

Mullet, K. and Sano, D., 1995. *Designing visual interfaces: communication oriented techniques*. Englewood Cliffs, NJ: Prentice Hall.

Nielsen, J. and Molich, R., 1990. Heuristic evaluation of user interfaces. *In*: J.C. Chew and J. Whiteside, eds. *Proceedings of the SIGCHI conference on human factors in computing systems*, *CHI 1990*, 1–5 April 1990, Seattle. New York: ACM, 249–256.

Norman, D., 1988. *The psychology of everyday things*. New York: Basic Books.

Norman, D., 1999. Affordance, conventions, and design. *Interactions*, 6 (3), 38–43.

Oviatt, S., *et al.*, 2003. Toward a theory of organized multimodal integration patterns during human-computer interaction. *In*: T. Darrell, M. Maybury and W. Wahlster, eds. *Proceedings of the 5th international conference on multimodal interfaces*, *ICMI'03*, 5–7 November 2003, Vancouver. New York: ACM, 44–51.

Paay, J. and Kjeldskov, J., 2008. Situated social interactions: a case study of public places in the city. *Computer-Supported Cooperative Work*, 17 (2–3), 275–290.

Preece, J., *et al.*, 1994. *Human-computer interaction*. Workingham: Addison-Wesley.

Raper, J., *et al.*, 2007. A critical evaluation of location based services and their potential. *Journal of Location Based Services*, 1 (1), 5–45.

Raubal, M., Miller, H.J., and Bridwell, S., 2004. User-centered time geography for location-based services. *Geografiska Annaler: Series B, Human Geography*, 86 (4), 245–265.

Raubal, M. and Winter, S., 2002. Enriching wayfinding instructions with local landmarks. *In*: G. Goos, J. Hartmanis and J. van Leeuwen, eds. *Proceedings of 2nd international geographic information science conference*, *GIScience 2002*, 25–28 September 2002, Boulder. Berlin: Springer, 243–259.

Roth, S., 1995. Visual literacy and the design of digital media. *Computer Graphics*, 29 (4), 45–47.

Sacher, H. and Loudon, G., 2002. Uncovering the new wireless interaction paradigm. *Interactions*, 9 (1), 17–23.

Sharp, H., Rogers, Y., and Preece, J., 2007. *Interaction design: beyond human-computer interaction*. 2nd ed. Chichester: John Wiley and Sons.

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.

Timpf, S., 2002. Ontologies of wayfinding: a traveler's perspective. *Networks and Spatial Economics*, 2 (1), 9–33.