People and Computers XX – Engage

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Preface: Engage!

This volume contains the refereed papers to be presented at the 'HCI'06: Engage' conference at Queen Mary, University of London, 11–15 September 2006. 'HCI'06: Engage' is the 20^{th} annual British HCI Group conference.

It was a difficult task to select thirteen long papers from the 53 submitted (an acceptance rate of 1 in 4). Ten of the thirteen papers come from two European countries (UK and France) and the three remaining ones from North America and Japan. All the papers have been reviewed by independent peer reviewers and meta-reviewed by one of the Program Committee members. The three Technical Co-chairs considered all the reviews paper by paper and identified a first set of selected papers. Six papers were taken to the Program Committee for full discussion. The final decisions were taken by the Program Committee members and were always based on specific justified comments rather than scores.

The volume also contains seven refereed short papers. 84 short papers were submitted from which 36 have been accepted for presentation at the conference. The Programme Committee then selected seven short papers amongst the 36 accepted short papers to be included in this volume.

The papers reflect the exciting and evolving nature of human–computer interaction (HCI), a multidisciplinary and crucial research field for computing technologies. We nevertheless note the very low proportion of industry-only authored papers, and we need to consider new ways of engaging industry people in the HCI conference.

An innovation this year has been to introduce themes. We wanted to engage the HCI conference with six core themes:

1. *At the Periphery* – how can ambiance engage? Disappearing technologies – such as ubicomp, mixed media, and ambient intelligence – still engage us even though we cannot directly interact with them.

2. *Enthralling Experiences* – what draws people in? Performance, aesthetics, emotion, and creativity: powerful engagement can be a means or an end.

3. *Connecting with Others* – what happens around and through technology? Interacting with colleagues and friends is helped and hindered by the connecting technology.

4. *Interactions for Me* – what improves my experience? Technology can be dehumanising but it can also improve working and social life enormously.

5. *Interactions in the Wild* – how does technology breach boundaries? The borders between management, chaos and control change as interactions leave the desktop and go mobile.

6. *Mind, Body, and Spirit* – how does diversity impact? People are different so interactions should span age, ability, culture and gender.

Our goal was not to limit the topics of interest for the conference. Indeed the six proposed themes capture some of the established favourite ideas in the HCI field but also suggest new collaborations and approaches for opening the conference to new communities. Moreover the proposed themes are not independent but intertwined: they did not define a preset structure for the technical program that would have influenced the selection of papers. It is consequently natural that the papers could fit into several themes. We organized the papers along the six themes trying to encourage interesting relationships going beyond the contribution of any single paper.

Under the theme 'At the Periphery', one paper concerns cross-modal ambient displays combining a public ambient display with a personal cross-modal display. The second addresses the difficult question of evaluating systems for everyday life such as computational jewellery. The systems studied in the two papers are used in a mobile context that also contribute to the theme 'Interactions in the wild'.

The theme 'Enthralling Experiences' brings together five papers. One paper studies the olfactory interactive design for engaging game play. A further two focus on aesthetic and hedonic qualities as complementary to usability for enthralling experiences. A fourth paper studies the effects of pre-existing mood and music in connection with involvement while the last paper is dedicated to interface affect and familiarity in the context of a learning environment.

'Connecting with Others' encompasses studies on computer-supported collaborative work (CSCW). One paper considers how to enable both collocated and remote participants to engage in collaborative work simultaneously while a second focuses on the design of a mobile collaborative system for crime scene investigation. This last paper also focuses on shared awareness in a mobile context ('Interactions in the Wild').

'Interactions for Me' brings together two papers on new interaction techniques for target acquisition, one for pen-based interaction and one based on perspective view. A third paper under this theme focuses on the effect of motivation on procedural errors. Finally a fourth paper is dedicated to a particular application domain, e-shopping, exploring the usefulness of interactive animations.

'Interactions in the Wild' brings together three papers addressing the design and development of augmented reality and mobile systems. One paper is dedicated to the development of an augmented surgery system by focusing on output multimodal interaction. Three papers focus on the design of mobile systems, including location discovery tasks on mobile devices, a real time bus information system, and awareness/access to mobile services.

Finally a conference on HCI would not be complete without a session dedicated to the diversity of users. The theme 'Mind, Body, and Spirit' includes two different points of view on this. First, one paper highlights the impact of cognitive/visual style of users for evaluating visualization techniques and in particular the PieTree. Second, two papers address the challenge of visually impaired users: one paper is dedicated to accessibility as well as usability of websites while the second focuses on constructing bar graphs using a force feedback device for visually impaired users.

We hope that the themes and the collated papers will engage the reader in an exciting book that provides a valuable stimulating source of information for researchers and practitioners in HCI. The editors are grateful for the help given by the conference committee members and the vast team of reviewers who gave their time and energy to creating an engaging conference and book on HCI!

Nick Bryan-Kinns, Ann Blandford, Paul Curzon & Laurence Nigay

June 2006.

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At the Periphery

Crossmodal Ambient Displays

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Ambient displays have for some time been proposed as a means of providing situated information to users in public spaces in a manner that minimizes the invasive nature of traditional displays, and reduces the distraction caused to bystanders. We explicitly address these shortcomings and present a novel information display framework called a crossmodal ambient display. CrossFlow is a crossmodal ambient display prototype for indoor navigation, that exploits aspects of crossmodal cognition in providing users with the facility to decode temporally multiplexed information in an animated ambient display. We describe a number of benefits of crossmodal ambient displays relating to both privacy and performance. Initial user studies have demonstrated that, compared to traditional navigation aids such as maps, crossmodal displays have the potential to significantly enhance the navigation performance of users whilst at the same time leading to a reduction on the cognitive load imposed by tasks such as navigation.

Keywords: ambient displays, crossmodal cognition, crossmodal displays.

1 Introduction

Ambient displays have been a topic of investigation in ubiquitous HCI for a number of reasons. In part they have been the result of a growing need and desire to situate computer interfaces in the everyday environments of users. As such they have been a response to observations as to the recent increase in the density of information displays in public spaces such as shopping malls, airports, and any environment in which a number of organizations compete to attract the attention of users to their products and services. Indeed, as the number of information and service providers in a public space increases there is often a disproportionately large rise in the density and heterogeneity of public displays.

Ambient displays are one proposal for an information display framework that can address the visual clutter and resulting detrimental impact that heterogeneous public displays place on the occupants of a space. In essence they are embedded in their environment, often utilizing unused physical and visual aspects of everyday objects in the provision of an information channel that is easily ignored. The recent popularity of ambient displays also reflects a rise in interest in notions of user experience, and in particular, the aesthetics of the user interface and the links between user interface design and traditional art and design. Portrayals of ambient displays such as informative art try to leverage aspects of everyday objects and artistic genres as a means of embedding dynamic information in our everyday environment.

However, ubiquitous computing remains committed to the paradigm of the handheld computing device, and the provision of information in a manner that is personalized to the user and to the user's location. Many issues arise as a result of the constraint of requiring a traditional interface on a handheld device. Some of these are technical, such that providing personalized and spatially contextualized information to users requires reliable and fine-grained tracking of user positions in a space. Positional tracking in indoor environments remains a significant technical challenge and has significant implications in terms of the privacy and security of users.

The provision of information through a handheld display can also undermine the broader goal of situating information services in users' physical environments. As the rise of mobile phone usage readily demonstrates, interaction with a personal computing device often leads to a degree of disconnection from one's environment as cognitive resources are turned inwards towards our personal information and communication space. Our goal is to address the shortcomings of both traditional ambient displays, which to date have not been capable of supporting tasks which require both highly situated and personalized information provision (such as indoor navigation), through their integration with handheld devices. As such we aim to bridge the divide between personal computing in the form of handheld computing and display devices and developments in situated and ambient displays.

We briefly summarize work in the fields of ambient and peripheral displays in Section 2 and introduce our notion of a crossmodal ambient display and its underlying cognitive motivation in Section 3. We describe the prototype crossmodal ambient navigation system in Section 4, and the results of a preliminary user study in Section 5.

2 Ambient Displays

Peripheral displays aim to deliver information to users effectively and efficiently without demanding their full attention. Ambient displays extend this notion beyond the desktop or head-mounted configuration of traditional peripheral displays, by embedding aesthetically pleasing display in a user's everyday environment, either through specialized display technologies (e.g. floor lights), projection, or by dynamically controlling properties of familiar objects such as fountains and mobiles. Furthermore, an ambient display is embedded in an environment in a manner that is not inherently tailored to any particular user. To date, most ambient displays convey general information (e.g. news, stock values, weather, traffic congestion and human activity) for groups of users, though a small number of examples support personalized mappings [Prante et al. 2004; Vogel & Balakrishnan 2004].

Ambient display research has involved the of a number of prototypes that aim to utilize highly aesthetic and peripheral, representations. For example, InfoCanvas [Plaue et al. 2004], Informative Art [Redström et al. 2000] and AROMA [Pedersen & Sokoler 1997], each incorporates abstract design elements, motivated by different styles of visual art, to represent information. With a greater emphasis on the aesthetics of everyday design, the Active Wallpaper, Water Lamp, and Pinwheels [Wisneski et al. 1998] artefacts all attempt to map information changes (e.g. weather, stock values) to system state changes in a 'calm' and 'subtle' manner, with a view to minimizing the attentional demands placed on a user engaged in some other task in an environment.

The majority of peripheral displays are visual in character. Visual peripheral displays developers have a sophisticated understanding of the nature of visual cognition and aim to present information in a timely manner which appropriately matches the time-sharing strategies utilied when users are performing two related tasks simultaneously. However, when the dual or multiple tasks become too demanding, the visual channel is easy overloaded and errors increase. Audio Aura [Mynatt et al. 1998], ambientROOM [Ishii et al. 1998], and AROMA [Pedersen & Sokoler 1997] have explored auditory and/or olfactory, multimodal ambient displays to exploit other perceptual channels. A key aspect of our proposal in the use coordinated modalities to achieve effective personalized use of an ambient display.

3 Cognition and Crossmodal Ambient Displays

3.1 Crossmodal Cognition

Psychological research into attention, over many decades, has demonstrated that an information processing bottleneck (i.e. one-at-a-time processing) and an attendant limitation in the information processing capability of humans in multiple task conditions. However, overwhelming evidence demonstrates that some information from unattended sources ultimately reaches higher stages of processing [Luck & Vecera 2002], which presents the possibility for people to receive information in a manner that that does not require their full attention. More recently, empirical research in cognitive neuroscience has given rise to the notion of crossmodal attention, a term used to refer to capacities and effects involved in the process of coordinating (or 'matching') the information received through multiple perceptual modalities [Driver & Spence 1998a]. Recent studies reveal extensive crossmodal links in attention across the various modalities (e.g. audition, vision, touch and proprioception). With respect to ambient display design, it has been demonstrated that some crossmodal integration can arise preattentively [Driver & Spence 1998b].

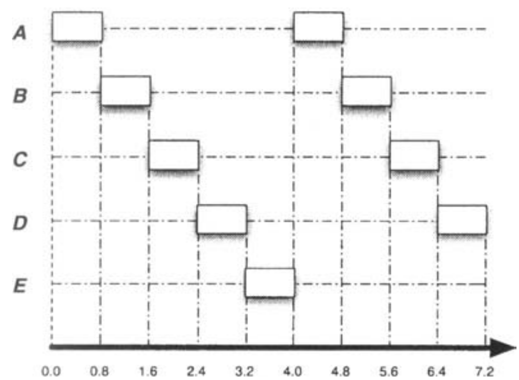


Figure 1: Temporal multiplexing of the crossmodal cues.

While empirical programs of research address the precise mechanisms of crossmodal integration, and in particular crossmodal spatial attention, our goal is to incorporate these insights in the development of new ambient display techniques. As we demonstrate in Sections 4 and 5, the crossmodal ambience framework integrates a public ambient display and a personal crossmodal display cue. This facilitates the anonymous access of publicly displayed information, without resorting to the tracking technologies, and personal visual displays, that are so characteristic of many ubiquitous computing designs.

3.2 Crossmodal Ambient Displays

In a crossmodal ambient display, information (which may contain both public and private components) is displayed throughout the whole physical extent of a shared information space. In contrast to a conventional ambient display, the crossmodal ambient display temporally cycles through information of potential interest to users in a space. Thus, in the case of our indoor navigation application, directions to different locations in the space (including exits) are projected on the floor of an environment one-at-a-time on a fixed time cycle. For example, in time-slot 1, directions to destination A are displayed at all locations in the physical space, in time-slot 2, directions to destination B are displayed, and so on until the directions to destination A are repeated (see Figure 1).

The user identifies (or decodes) which time-slot in the cycle is relevant to their own request for directions through the utilization of a crossmodal cue (e.g. a sound or vibration) issued by the personal mobile computing device. That is, either in response the user's request for directions, or on entry to the physical space, the user's device communicates with the ambient display infrastructure to establish the schedule of time-slots when the different directions will be displayed. In other words, the personal mobile device displays private information cues, that only individual users can perceive, that allow users to decode the ambiently displayed public and/or personal information.

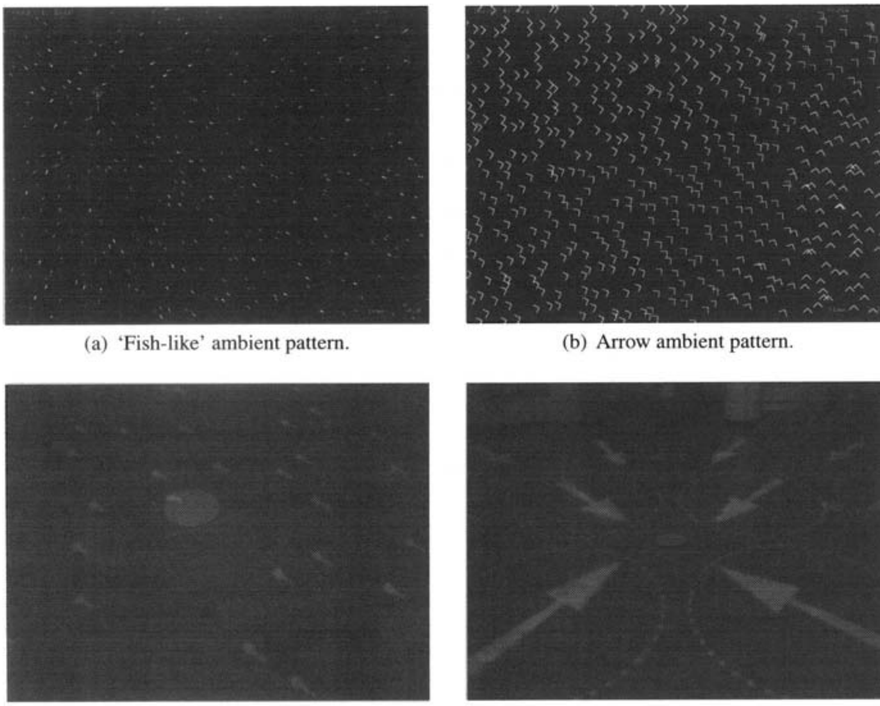
Note that the directions displayed at a location depend on the direction of the destination from that location. Again we can contrast this with traditional handheld notions of navigation, whereby there is a requirement to track the position of a user and present directions salient to the specific location of the user. We can contrast these two configurations in terms of the multiplexing of information displayed. In traditional mobile device applications, incorporating tracking, information is spatially multiplexed. That is, the position of a user is known and information specialized to the location of the user is displayed on the user's device. In the crossmodal scenario information is temporally multiplexed and information relevant to a location is displayed at all locations (in our case through projection on the floor of the environment) at a specific time.

Unlike traditional mobile configurations (e.g. a hand-held visual display with tracking) the information is clearly displayed in a manner that is visually accessible to any occupant of that space. Whilst this might be criticized as potentially undermining a user's privacy, crossmodal ambient displays address the problem of privacy by anonymizing the user. The crossmodal cue (e.g. the vibration or sound) that the user is provided with (to indicate in which time-slot their information is being displayed) is hidden from other occupants of the space. In addition, other, redundant, information may be projected in the unused time-slots with a view to making the personal information (e.g. in this case the directions the user is requesting) less discoverable. Furthermore, since the user only requests the schedule of the time-slots for an environment the ambient display infrastructure has no more detailed information as to which time-slot (i.e. which directions) the user wants access to.

We explored our design idea through a crossmodal ambient display prototype named CrossFlow, for indoor navigation, and evaluated it in a dual task experiment with nine participants. In accordance with our design hypothesis as to the use of a cognitively well founded coordination of modalities, we found that the participants had significantly higher performance when using CrossFlow for indoor navigation as compared to a traditional map. Furthermore, users of CrossFlow also performed better in terms of performance of the primary task of the dual task paradigm, implying that it had significantly lower attentional requirements. These results have implications for the design and evaluation of novel navigation tools, information displays and multimodal user interfaces.

4 Indoor Navigation with CrossFlow

As modern architectural spaces increase in their size and complexity, wayfinding in unfamiliar indoor environments also becomes more challenging. Conventional handheld maps, as well as stationary signs such as poster maps, landmarks and directional signs, need users to know their locations and the locations of destinations in order to formulate their navigation plans. Recent mobile computing proposals and products mostly propose that the user either pays full attention to a personal display (typically a small screen on a handheld device) or that they listen to verbal instructions. In the former case users must continuously refer to both their location and the location of their destination, both on the electronic map and in the physical environment, which may cause interruptions of the navigation task and may even provoke dangerous situations [Kray et al. 2005].



(a) 'Fish-like' ambient pattern.

(b) Arrow ambient pattern.

(c) 'Fish-like' floor projection.

(d) Influence arrows.

Figure 2: Ambient display designs and the influence arrow design tool.

Furthermore, in real world navigation tasks, people often have multiple other tasks to undertake whilst they are finding their way to a particular destination in the environment (e.g. taking care of children, transporting luggage, making a phone call, or simply just thinking about a problem as they move from one location to another). Few navigation systems aim to support multiple task handling during navigation.

CrossFlow is a prototype indoor navigation system, based on our notion of a crossmodal ambient display design, and embodies our framework for integrating public ambient displays and personal cues across modalities. The prototype is designed for use by a user with a mobile phone inside large unfamiliar buildings. The time-multiplexing technique described in Section 4 prompts users as to which directions correspond to their destination of interest. Advantages of such an indoor navigation system include: low cost, no requirement for sensing or tracking of the users, and the maintenance of user privacy.

4.1 Ambient Display Design

CrossFlow uses aesthetically pleasing ambient displays combined with a crossmodal cue on a user's personal mobile device to provide direction information. The ambient display for directions was designed to be as peripheral and calm as possible. Figure 2 includes two examples of the raw display, Figure 2a shows an animated 'fish-like' pattern, the elements of which orientate themselves and flow in the direction of the destination, and Figure 2b an arrow-like pattern that does not translate but animates between different directions. Once projected, the elements of the design (i.e. individual fish or arrows) are approximately the size of a hand, and have a visual intensity that integrates with the floor giving the appearance of a sparkling carpet. Figure 2c shows a close-up of the projection on the floor of the experimental region.

At any point in time, and at every location in the space, directions are displayed for a user to follow in order to reach a particular destination. Thus in Figure 2a the flowlines configure themselves to form paths (around any attendant obstacles) towards the crosshair indicating the location of the destination. The pattern changes every 800ms, during each time-slot all elements in the projected display have the appearance of swimming towards the same destination along the designed paths. Similarly, for the design in Figure 2b the entire arrow set points along the designed paths to the same destination. During the next time-slot, the elements undergo an animated transition in configuring themselves for the next destination.

The configuration of the pattern is achieved using configuration files to set parameters that control the design, size, density, and dynamic properties of the individual elements (rate of movement and visual persistence), and the duration and number of time-slots of the display. Influence arrows are used to interactively configure the direction of motion during each time-slot. Figure 2d shows a set of influence arrows which a designer interactively manipulates to control the direction of flow at locations in the environment. Influence arrows give the designer the flexibility to specify local flow tendencies for the pattern, which are aggregated for the final pattern. Thus a designer will configure the influence arrows to steer the flow around obstacles and away from sites that are not intended to lie on the path to a destination. Influence arrows may be interactively added, scaled, and rotated to attain the desired pattern of flow, and a key press binds the configuration to a time-slot. In Figure 2 we can see that a convergent pattern has been specified where all flow is directly towards the location of a white disc placed on the floor.

4.2 Crossmodal Cues

The second element of a crossmodal ambient display is the design of the crossmodal cue on the personal device. A personal mobile device, in this instance a Microsoft smart phone, issues a crossmodal cue in the form of one or both of:

1. a vibration for the duration of the corresponding time-slot; and
2. an audible high pitch sound coordinated with the onset of the time-slot.

We have yet to study empirically the impact of the different cues on the effectiveness of the display and in our initial evaluation we use both modalities simultaneously.

The crossmodal cue causes the user to pay attention to the directions shown by the public ambient display in the corresponding time-slot and induces a subtle switch of the user's attention. The personal mobile device connects to a central server to synchronize the time-slots at the beginning of navigation and to receive the schedule of time-slots and their mappings to the numerical keys of the navigation interface on the mobile device (which simply asks the user to press the number corresponding to the destination required). When the user selects a new destination the personal mobile device presents a cue in a different time-slot corresponding to the display of directions to the new destination.

5 Preliminary User Study

We ran a preliminary study to explore the effectiveness and efficiency of the crossmodal ambient display system as a personal navigation tool. The goal of the study was to inform our understanding of crossmodal ambient displays, in particular:

- To determine if the use of a crossmodal ambient display system can improve human performance for a navigation task in comparison to the use of a standard map.
- Provide an understanding of the impact of the use of a crossmodal ambient display on the performance of primary task during navigation.
- Explore the notion of ambiance through the measurement of subjective reports of mental workload.

5.1 Study Design

The study used a within subject design. We utilized one independent variable, type of task and navigation tool used, with two levels of treatment:

1. navigation using a map in a dual-task condition (answering arithmetic questions and navigating); and
2. navigation using CrossFlow in a dual-task condition (answering arithmetic questions and navigating).

We also measured user performance on the primary task (answering arithmetic questions) in the absence of navigation. The dependent variables included time of completion, time taken per arithmetic question, accuracy undertaking primary task, navigation errors, and perceived mental workload.

The 9 subjects, both male and female, were aged between 20 and 30 years old and had no discernible visual or physical impairments. The mathematical ability of each participant was elicited through a screening questionnaire prior to the study. An initial evaluation of performance on arithmetic questions yielded a mean time per question of 4.0 seconds and a mean accuracy of 97%.

The primary task involved answering a set of arithmetic questions posed one-by-one by the experimenter whilst the subject undertook the navigation task. Each subject was videoed and their responses for the questions were recorded during the experiment by the experimenter. The secondary navigation task was for the subject to find 5 targets (out of 15 targets displayed) with the aid of either a map or CrossFlow. Around the experimental area there were 15 containers positioned at different locations within the projected image. 5 out of the 15 containers held navigational information for the user.

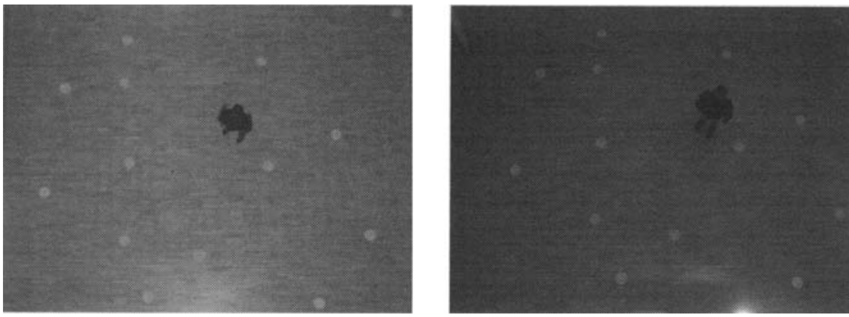


Figure 3: Map and CrossFlow conditions.

In the case of the map, the subject was given the name of the first target container, and subsequent target containers contained the name of the next destination. In the CrossFlow condition, the containers provided the number to be entered into the phone for the next target. The 10 containers that were not valid destinations contained the statement 'this is an incorrect location'. The use of these 'distracter' targets was with a view to adding a degree of real world complexity and ambiguity for both the map and CrossFlow conditions. As the experiment was conducted in a relatively small space, as compared to an airport, it was necessary to have a significantly denser array of locations for the user to navigate between (see Section 6 for a discussion of this aspect of the experimental design).

5.2 Procedure

In an initial phase, each subject answered 18 arithmetic questions as a briefing task. The briefing task was intended to evaluate the baseline performance of each user with regards to the primary task. Subjects were asked to try to answer all the arithmetic questions correctly, and no time limit was enforced. On completion of the briefing task each subject navigated in the experimental area (10.0×6.5 meters) to find 5 targets out of the 15 targets under both conditions. Figure 3 shows the experimental area with a sample distribution of the targets used in the two conditions. The order of presentation of the conditions for each subject was randomized, as was the set of destinations used for a subject.

Condition 1 was undertaken with the aid of a simple map and subjects gave spoken answers to the arithmetic questions posed by the experimenter. On finding a target, the subject read the name of the next target from the container and continued. The subjects were told that answering the arithmetic questions was the primary task which would not stop until all designated 5 targets were found. No time requirement was placed on the subjects. In the second condition, the primary task was the same, and navigation task was completed with the CrossFlow system. Each subject used a SPV E200 smart phone and the five 800ms time-slots, corresponding to the five destinations, cycled every 4 seconds and utilized both an auditory and vibration cue as described in the previous section. On discovery of each target, the subject selected the number of the next target on the keypad of the phone.

Condition	Map	CrossFlow
Total time (secs)	133	80
Time per question (secs)	8.5	6.1
Questions correct (%)	84	98
Navigation errors	1.2	0.4
NASA-TLX score	79	60

Table 1: Mean performance measures for the map and crossmodal ambient display conditions (9 subjects).

Five measures were collected:

1. the completion time for the navigation task in each condition;
2. the time spent answering each of the arithmetic questions in the briefing phase and in the two conditions;
3. the accuracy of arithmetic question answers;
4. the number of navigation errors; and
5. a subjective measurement of mental workload using the NASA Task Load Index (NASA-TLX) [Hart & Staveland 1988].

5.3 Results

Our hypotheses were supported in terms of primary and secondary task performance, total completion time, and the subjective reports of mental workload. The descriptive statistics reveal that in contrast with a map the use of CrossFlow resulted in better performance in all aspects. Table 1 presents the mean measures for the two conditions.

5.3.1 Comparison of Primary Task Performance

The performance for the primary task was compared across the briefing task, and the two dual-task conditions: navigating using the map and navigating using the crossmodal ambient display system. Two aspects of the performance on the primary task were considered:

- time taken to answer arithmetic questions; and
- the percentage of correctly answered questions.

With respect the time taken, a one-way repeated measures ANOVA revealed very significant differences between performance without and with the navigation task ($F(2,16) = 42.28$, $p < 0.001$). A post hoc paired samples t-test further show that the average time taken to answer an arithmetic question in the dual-task condition decreased very significantly from using the map to using CrossFlow, $t(8) = 6.60$, $p < 0.001$. The mean time when using CrossFlow was 28% quicker than when using the map.

To compare accuracy, a one-way repeated measures ANOVA revealed that the differences were significant between conditions ($F(2,16) = 4.89$, $p = 0.022$). A post hoc two-tailed paired samples t-test shows that the difference of the accuracy of processing arithmetic questions was only marginally significant between the map and CrossFlow conditions, $t(8) = -2.26$, $p = 0.054$, with the mean accuracy using CrossFlow being 17% higher than for the map.

5.3.2 Comparison of Secondary Task Performance

The performance on the secondary (navigation) task was compared for the map and CrossFlow condition according to two criteria:

- total time spent finding 5 destinations (total time in the dual-task condition); and
- number of navigation errors in discovering the 5 destinations.

Navigation errors were recorded formally when subjects addressed the wrong location, i.e. subjects incorrectly identified a distracter location as the next destination and when users returned to a previous prior destination in order to ascertain the location of the next target. In the map condition subjects averaged 1.2 navigational errors and for CrossFlow the average was 0.4. In is apparent that for such a small scale experiment (both in terms of the spatial scale of the navigation problem and the number of subjects) few conclusions can be drawn from such a low error rate.

As for the total time taken, a paired samples t-test showed that the total time spent on the whole experiment in the dual-task condition decreased significantly from using the map to using CrossFlow, $t(8) = 3.457$, $p = 0.009$.

5.3.3 Comparison of Judgements of Mental Workload

A paired samples t-test was conducted on the subjective judgements of the subjects in each of the two conditions using the NASA-TLX rating of mental workload. The results show a significant reduction in the perceived mental workload when using CrossFlow as compared to the map, $t(8) = 6.24$, $p < 0.001$.

5.4 Discussion

The experiment compared the effectiveness of CrossFlow with a traditional map for navigating an indoor environment. The results indicated that subjects using CrossFlow performed better on both the primary (arithmetic question answering) and secondary (navigation) tasks. This can be explained in terms of the ambient nature of CrossFlow as supported by the NASA-TLX reports, and we observe that the attention bottleneck effect is apparent for subjects in the map condition.

Although the experiment supports the utility of the crossmodal ambient display system, informal observations of subject behaviour should be incorporated in future design iterations of both the system design and the experimental design. For example, subjects tended to pause more with the crossmodal ambient display system in order to gradually hone in on the correct target, as shown by the projected images. One of the subjects paused for a particularly long time as he struggled to find the next target, which was actually right beneath his feet. This situation can in the main be attributed to the artificially small spatial scales over which subjects had to move and as such is a shortcomings of the experimental design. However, a truly flexible ambient display design would take account of the local configuration, including the proximity of destinations to each other, and mediate against the state of confusion that this subject found himself in.

Another artefact of the small experimental area is that the dense array of destinations meant that the directions indicated by the display appeared vaguer than would have been the case in a larger area with larger targets. In a number of cases a subject needed to step out of the experimental area in order to gain some perspective on the display and find the next target. Finally, the aesthetics of the experience was not addressed in the experimental set-up, though informal subject feedback received after the study revealed that subjects felt at ease with the system and most found CrossFlow fun to use and helpful.

6 Conclusion

We have proposed an interaction framework which aims to bridge the gap between ambient displays and personal mobile HCI through exploiting aspects of crossmodal cognition. We utilized this framework in the construction of CrossFlow, a crossmodal ambient display prototype for indoor navigation, and demonstrated a significant increase in the navigation performance of users of CrossFlow over the users of a map. Based on our empirical studies there is significant support for both the utility and desirability of crossmodal ambient displays. Evaluation of the prototype has shown that crossmodal ambient displays can support faster, more accurate and less cognitively demanding navigation than a traditional map.

Serious notice must be taken of the physical configuration of our preliminary evaluation and its ecological validity. In the real world, navigation tasks take place over significantly larger distances, and landmark identification is a significantly smaller component (in terms of time taken) of the navigation task than in our experimental set-up. Furthermore, people do not generally navigate while performing mental arithmetic and the spaces they occupy are usually populated by other people undertaking a range or activities. We intend to address these observations in a multi-user study on a larger spatial scale.

The small distances involved in our preliminary study are potentially detrimental for CrossFlow, as the shorter the distances are between the destinations, the greater the impact of the user having to wait for the time-slot corresponding to the next destination. In the worse case users will have to wait 4 seconds for the full cycle of directions, and this time is comparable to the time required to move between destinations. However, this is clearly going to be less time that users will typically require to identify a destination on a map and to decide upon appropriate landmarks by which to navigate.

One final bone of contention is the very classification of CrossFlow as an ambient display. In traditional terms, few ambient displays support explicit tasks such as navigation, and even fewer provide even the low level of interaction afforded by CrossFlow (selection of a destination). Our position is not only to consider ambiance in relation to the user – indeed no display is ambient when a user attends to it – but instead consider the incidental bystander's view of the display. We feel it is unlikely that such a person would associate the calm and somewhat aesthetic nature of the display with traditional information systems. Indeed though it remains to be demonstrated, we feel that bystanders would struggle even to identify which occupants of the space are using the system and which are not (especially if a user uses the vibration of a phone in their pocket as the crossmodal cue). From the perspective of the bystander CrossFlow is highly ambient.

The use of crossmodal perception to index temporally multiplexed information has significant potential for applications other the navigation. Although the requirement for floor projection (in this configuration) is onerous, this is outweighed by the fact that there is no need for tracking, which is particularly difficult for in-door environments. We also see potential for crossmodal displays (ambient or otherwise) to address the public-private divide through the display of public, but anonymized, information.

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Plotting Affect and Premises for Use in Aesthetic Interaction Design: Towards Evaluation for the Everyday

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This short paper presents an experimental approach to the difficulty of evaluating interactive systems as artefacts for everyday life. The problem arises from the event-like nature of the user-centred evaluation session, as distinct from 'being' or the 'ongoing flow' of daily life, and from the dynamic complexity of the lifeworlds of users in human centred design approaches. In analysing the data from a recent project investigating the aesthetic and utilitarian figurations of a wireless system of computational jewellery, it was found that the participants made references to a range of notional lifeworlds, and that the premises for use attached to these varied in type. An overview of the evaluation procedure, including pre and post task sessions with the user group, is given, and the results from the project discussed.

Keywords: user experience, lifeworlds, premises for use, designing for the everyday, meaning making, evaluation, wearable computing, computational jewellery.

1 Introduction

Over the past two years, the first author has been engaged in the concept design and realization of a suite of wirelessly networked jewellery for a friendship group. This was developed as part of her doctoral program looking at user experience with Wearable Computers for 'the everyday', and at Contemporary Craft as a rich metaphorical resource for this and other design disciplines [Kettley & Smyth 2004; Kettley 2005]. The Wearable Computing community has been interested for some time in mainstream markets [DeVaul et al. 2001; Starner 2001; Watier 2003] but