Opportunistic At-Glance Information Acquisition on Interactive Public Displays

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ABSTRACT
The interaction process with interactive public displays can be viewed as a set of interaction phases. In this paper we report a wizard-of-Oz study that explores the last two phases: 1) *subtle interaction*, where users can interact with the display through gestures or movement, and 2) *direct interaction*, when users interact with the display by directly manipulating it through *e.g.* a touch-screen interface. We investigate the effect of these two interaction phases on *at-glance information acquisition*, and demonstrate that the presentation of such at-glance information items can help shorten interaction times during the direct interaction phase.

Author Keywords
Information behavior; information encountering; public display; wizard-of-Oz; at-glance information acquisition.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION
Large digital displays have become a common sight in public urban spaces, where they are used for broadcasting information and commercial content. Displays can also provide interactive applications and contextually relevant information such as maps and service directories. While touchscreen-based user interfaces are prevalent, researchers have begun exploring so-called mid-air gestures [20] for enabling interactions with public displays at a distance. Such gesture-based interfaces are often perceived as playful and fun, and therefore can efficiently be used to entice people to begin interacting with a public display [16,17]. However, gestures are not best suited for tasks that require accurate pointing or selection, such as browsing information repositories or picking items from a list. Gestures are also ill suited for tasks that consume extended periods of time due to potential fatigue when holding arms in a raised position [6]. A hybrid model, where interaction begins with a mid-air gesture and continues on to direct interaction, has been proposed as a potentially beneficial solution (*e.g.* [8,16]).

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In this paper we explore the potential benefits of combining mid-air gestures and direct interaction into a fluid user experience that begins with the user noticing a display, followed by "unlocking" the interactive affordances of the display through a mid-air gesture, and possibly moving on to direct interaction through a touchscreen interface. The requirement to "unlock" a display has been utilized in *e.g.* the UBI-hotspots deployment in Oulu, Finland, where a "subtle interaction hint" is shown on the displays upon detecting the proximity of a potential user, and a touch event is required to access the interactive features of the displays [19]. Similarly, Kukka *et al.* [11] studied various "visual cues", effectively lock-screens covering interactive elements that required a user to first touch a display before being able to access the interactive content on the display.

We look at utilizing the short period of time – from the user "unlocking" a display with a gesture to potentially beginning direct interaction on the touchscreen interface – for conveying useful tidbits of information already before the user has reached the display. We call this *at-glance information acquisition*. We show that it can positively affect user experience by reducing task execution times and increasing task execution accuracy. We propose to use the interrelated concepts of *opportunistic discovery of information* [15] and *information encountering* [2] as theoretical lenses through which we can understand and explain the emergent concept of at-glance information acquisition.

ENCOUNTERING INFORMATION
Urban environments can be characterized as *information rich environments*, where the *information user* is required to gather and process multitudes of in-situ information items and make quick, often intuitive decisions based on this information [9,12]. While human information behavior researchers have historically focused more on active, problem-oriented and purposive information seeking behaviors, there has been growing interest in studying information behaviors that are more passive and opportunistic in nature [2,4,7,21] . This behavior has been termed *information encountering* (IE), and it is characterized as a "memorable experience of an unexpected discovery of useful or interesting information" [2]. Erdelez

[2,3] describes information encountering as an episode consisting of five separate stages (Figure 1). In the model, the primary task is interrupted by the serendipitous appearance of an information item, which leads the information user to pause this task to examine and capture the information, before returning to the primary task. Current cognitive theory suggests that a very short glance (only 100 ms in duration) can trigger awareness of a possible information item of interest [1,22]. Hence, public displays as highly visible visual elements in the environment are well suited for conveying information cues that may help facilitate serendipitous information encounters. Such experiences are abundant in today's information-intensive environment where user mobility facilitates the disappearance of traditional task-oriented silos in acquisition of information and people move efficiently among information that is relevant to their current situation [4].

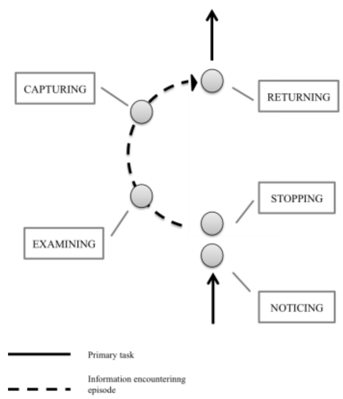

Figure 1. Information encountering event (adapted from [4])

De Bruijn has identified three main types of serendipitous information encounters: *opportunistic browsing* (OB), *involuntary browsing* (IB), and *search browsing* (SB) [1]. OB refers to a behavior that is intentional, but the user is unaware of any goal being pursued –"let's see what's there". IB, on the other hand, refers to *unintentional* behavior where the user's gaze fixates on an information item that may lead to the answer to a longstanding query. Finally, SB can already be considered as an intentional, goal-oriented activity and as such is very close to traditional information seeking behavior where the user has a clear information goal in mind, and has chosen the information repository to browse in attempt to satisfy the goal.

The behavior people often exhibit with public displays resembles OB in that a significant portion of usage is driven by curiosity [9]. With long-standing deployments of information displays, however, people will become familiar with the information affordances provided by these displays, and can choose to use them for goal-oriented information seeking [9,10]. In this case their behavior closely resembles SB. However, IB remains an under-utilized way of communicating information to passers-by. Providing such at-glance information on a public display is difficult for several reasons: in busy public settings, multitudes of visual stimuli compete for people's attention, and displays can easily disappear into the clutter of things. Further, as the prevalent use case of such public displays is still broadcast advertising, people have effectively become "blind" to content shown on displays. This phenomenon, often referred to as "display blindness", has been identified in previous work [18], and several studies have suggested methods to combat the issue (*e.g.* [11,19]).

STUDY

In order to explore the role of *involuntary browsing* for *at-glance information acquisition* on interactive public displays, we designed a study utilizing a hybrid model of interaction where a display shows a call-for-action to entice people to approach and begin interaction through a simple mid-air gesture to 'unlock' the display interface. After unlocking the screen, the user is presented with tidbits of information, suitable for at-glance consumption while moving towards the display (*involuntary browsing)*. After the user is within an arm's reach, s/he will be able to utilize the touch-screen interface for direct interaction, thus engaging in either *opportunistic browsing* or, if they are familiar with the display, *search browsing*. The purpose is to systematically study how the subtle interaction phase could be utilized to provide a user with important at-glance information before they move on to the direct interaction phase. The benefits of at-glance information acquisition are quantized with respect to task execution times and accuracy.

Study design and set-up

The experiment was conducted as a wizard-of-Oz study in a usability laboratory. The space was equipped with a large (46") full HD display with a touchscreen overlay installed on a wheeled stand (Figure 2). A video camera was set up to record interaction sessions. Two researchers were present at all times, the other serving as the experimenter interacting with test subjects and the other acting as the "wizard" controlling the system. The study included 8 different conditions in a 2x2x2 within-subjects factorial design, based on three independent variables: *unlocking mode*, *representation mode* and *information type* (Table 1).

Unlocking mode	Representation mode	Information type
gesture: display unlocked with a gesture	**text:** information represented as text	**time:** time of the day
touch: display unlocked with a touch	**graphic:** information represented graphically	**weather:** current weather information

Table 1. Study variables

We selected two simple information types for the study, namely *time* and *weather*. These two information types were selected because they are general enough to be of interest regardless of personal information preferences, and both can be processed within a brief period of time, *i.e.* are suitable for at-glance information acquisition. Initially, the display is in the "locked" state, where all menus are hidden and the user is presented with a call-for action in the form of a colorful picture and textual instructions to either "touch to continue" or "wave to continue" depending on the unlocking mode. After touching or waving, the display is "unlocked" and the main menu appears (Figure 2).

Figure 2. Unlocking the screen with a gesture (left); main menu (right)

The main menu consists of three sections: *time area*, *weather area* and *applications area*. The information items (time and weather) both have two representation modes: *graphical* and *text*. In graphical mode, time is represented as an analog clock, and weather is represented by an icon describing various weather conditions (*e.g.* sunny, cloudy, rainy). In text mode, the time is shown as text (hours and minutes), and weather is described in writing (*e.g.* "partly cloudy"). Both information items are generated randomly for each time the display is "unlocked". The application area consists of icons and names of various apps, such as 'alarm', 'calendar', 'music', *etc.*, and the icon grid is randomized for every session. One icon is titled 'questionnaire', and users were required to locate and launch the questionnaire application and input the information (time and weather) they gathered from the display. The other application icons are non-functional, and their purpose is to serve as visual distractors on the screen.

Participants, procedure, and data collection

A total of 18 people (10 male) with an average age of 24.5 (SD=2.6) years participated in the study. Participants were recruited from the university campus with a mixture of students, researchers, and staff members from different departments. The experimenter explained the task(s) to the participant, and all participants had a practice session with the display to familiarize themselves with the controls.

Participants completed the tasks for every condition in a randomized order to minimize learning effects. This meant that the participants had to, alternatively, acquire information regarding the weather or time in all the combinations of the other two independent variables (unlocking and representation mode), totaling 8 trials per participant. A participant always started at the 3.5-meter mark and then proceeded to move towards the display. In the *gesture* condition, participants could unlock the display at any time by performing a *wave* gesture. Participants were not informed on how or when to wave to the display, but were only informed that the software was able to recognize a waving gesture from any distance. In the *touch* condition, participant had to first touch the display to unlock it. Having unlocked the display, participant had to find and launch a "questionnaire" application, and submit either the weather or time information they acquired. We measured the time it took each participant to: 1) unlock the display either by waving or touching the screen, and 2) total time taken from the start of the 3.5-meter approach to launching the questionnaire application. The conditions of the study (unlocking mode, representation mode), the information that has been shown to the participant (time and weather), and his/her answers in the questionnaire application were stored in a database. After the experiment, participants were asked to fill in a questionnaire about their demographics, preferred unlocking and representation mode. They could also provide open-ended feedback and suggestions.

RESULTS

Time taken to launch questionnaire application

An ANOVA test showed that the unlocking mode had a significant effect on time taken to launch the questionnaire application, $F(1,17)=90.73$, $p<.01$. Unlocking the display with the wave gesture led to significantly faster time compared to touch (M=5.29s vs. 6.99s). Similarly, representation mode had a significant effect on time taken to launch the questionnaire $F(1,17)=26.63$, $p<.01$. Presenting the information in textual form led to significantly faster time when compared to graphical form (M=5.57s vs. 6.70s). As for the final independent variable, information type had a significant effect on time taken to launch the questionnaire application, $F(1,17)=13.19$, $p<.01$. Acquiring weather information was significantly faster than time information (M=5.83s vs. 6.46s).

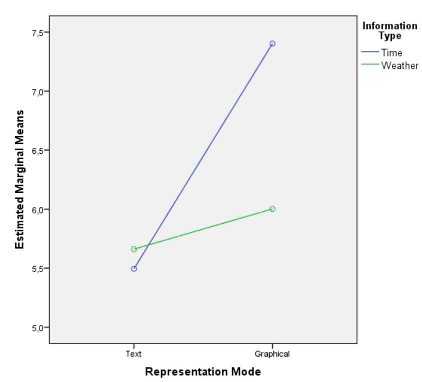

Figure 3. Estimated marginal means of the interaction effect between representation mode and information type.

In terms of interaction effects, only representation mode*information type was shown to be significant on time taken to launch the questionnaire application, $F(1,17)=15.06$, $p<.01$. With the textual representation mode, there was little difference in terms of time taken to launch the questionnaire application. However, the graphical representation of time information took significantly more time to process. Figure 3 describes the estimated marginal means of the interaction effect.

Questionnaire results

Results from the questionnaires are mostly in accordance with the statistical analysis done on time taken to launch the questionnaire application. All participants reported that for the time information they preferred textual form, which corresponds with the only observed significant interaction effect. For the weather information, participants were split evenly in terms of preference. This discrepancy was justified by some of the participants with the fact that they are not used to telling the time using analog clocks: "*I'm so used to the time representation of my mobile phone, that I just find it more difficult to tell time with an analog clock*".

Participants were also evenly split on what type of unlocking mode they preferred, even though quantitative results show that task completion time was faster in conditions with waving to unlock the display. Feedback from the participants suggests that this was mainly due to participants feeling self-conscious when having to wave to unlock the display: "*Waving arms just feels so weird, but it is better to get quick information. Personally, I prefer to just use touch*".

DISCUSSION

Studying information encountering in laboratory settings is always challenging, as the phenomenon is typically non-intentional and brief in duration. Opportunistic or serendipitous information encounters are difficult to stage and hard for users to recall and reflect upon in post-fact research designs. According to Erdelez [4], "*one plausible solution to studying opportunistic acquisition of information (OAI) in a research setting may be a design that exposes the participant to situations that may evoke OAI without him/her knowing that OAI is the object of study"*. For this reason, our participants were at no point made aware that the study was about information behavior. Instead, they were given to understand that the purpose of the study was to explore gestural user interfaces.

We intentionally selected two very atomic and common information items, namely time of the day and current weather conditions. The goal of this study was to see if the brief exposure to opportunistic information items could be utilized to enhance the use experience with an interactive public display. Specifically, we wanted to see if the option to utilize a mid-air gesture to unlock the display and expose the information items would reduce time taken to launch the questionnaire application when compared to unlocking the display by touching. It is noteworthy that we did not focus on information retention (*e.g.* recall) in this experiment.

The distinct elements of the information encountering model (Figure 1) were clearly present during the wave-to-unlock condition, thus suggesting that *involuntary browsing* was happening. The primary task given to participants was interrupted by the appearance of information items, which the participant then quickly examined, processed, and captured before returning to the primary task at hand (launching the questionnaire application on the display). This *at-glance* model of information acquisition clearly reduced task execution times, thus suggesting that *involuntary browsing* and *at-glance information acquisition* are feasible tools for the designers of public display services to help their users to opportunistically discover relevant information items which, in turn, can lead to reduced cognitive load and shorter task execution times. As such, *at-glance information acquisition* matches well with the well-known *audience funnel* model [14] as a type of transitive activity that spans phases 2 and 3 in the model (*viewing and reacting* and *subtle interaction*). At-glance information acquisition also adds the option to skip phase 4 (*direct interaction*) altogether, since it is possible that the user's information seeking goal has been satisfied without requiring additional interaction steps with the display.

Our results show that textual representations were better at reducing task completion times and easier for users to capture and process. This finding merits further study, as one might intuitively assume that graphically representing data would be better for at-glance consumption. Estimated marginal means (Figure 3) showed that reading a graphical representation of time information (analog clock) took much longer to process than the same information in textual form (digital clock). This is in line with previous research conducted with children [5], which has shown that already 1st graders are able to read and understand digital time information, whereas analog time information can be difficult to read and understand even for 5th graders. Similarly, Meeuwissen *et al. [13]* found that participants could verbalize time information quicker from digital clocks than analog ones. This would suggest that we are in fact seeing an effect specific to representations of time. However, the same effect was also apparent with weather information, but here the difference was far less pronounced.

CONCLUSION & FUTURE WORK

This study on *at-glance information acquisition* has been a "first thrust" effort to understand how public displays could be leveraged for delivering opportunistic and serendipitous information items to passers-by. By utilizing *information encountering* and *opportunistic information acquisition* as a theoretical lens, we have demonstrated that providing such at-glance information items may help improve the user experience of display interfaces through reduced task completion times.

A major limitation with this work is that we only considered two simple information items. In future work we will look at a more diverse set of information items, and run controlled studies to determine which types of information items are best suited for at-glance consumption on public displays. We will also look at how at-glance information acquisition can be utilized in interface design, *e.g.* how, when, and how many information items should be presented to an approaching user.

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