

An iPad App for Recording Movement Paths and Associated Spatial Behaviors

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Abstract. This paper describes an iPad App, known as ‘PeopleWatcher’ created for the real-time recording of wayfinding behaviors in buildings/outdoor environments. Initially the paper reviews other spatial-temporal behavioral recording programs and compares their features to the PeopleWatcher App, which is introduced in the next section. The third section presents a pilot study in which the App was tested and discusses the resultant user feedback. It concludes that the iPad is a particularly useful device for behavioral observations in the field, but that further development, the inclusion of post-experiment data-analyses, could be beneficial for future versions of the App.

Keywords: iPad App, Wayfinding and navigation, Wayfinding task, Direct observation, Building usability

1 Introduction

Since the early 20th Century, researchers of human (and animal behavior) have sought ways to make their observations of behaviors more objective, accurate and less prone to error (particularly see Ittleson et al [16] who developed and popularized behavior mapping/tracking). In the field of spatial behavior, of which wayfinding and navigation research is one sub-category, observational accuracy is required in two dimensions, the accuracy of the spatial location and the precise time of the event being observed (in other words spatial-temporal accuracy). Objectivity can be achieved through the creation of precise definitions and classifications of potential behaviors in conjunction with sufficient training of researchers so that they are able to reliably recognize such events. However, the third requirement, the reduction of human-error in making those observations, is harder to achieve, especially when the environment being observed may be complex or noisy and the numbers of potential participants and different classes of behaviors are large. The cognitive load of an

observer, however well trained, might reach the point where human errors can easily occur². Although pen-and-paper methods partially facilitated making accurate and error-free observations, the recent development of mobile computing solutions has served to fill a need for making spatial-temporal observations in the field.

2 Precedents

2.1 Pre-digital and early computerized methods

This section will start by describing antecedents to the PeopleWatcher App (see figure 1 for a diagrammatic time-line representation of antecedent software), and will cover hand-based and computer-based methods formerly employed by researchers investigating wayfinding and navigational behavior in complex environments. This section will then focus on the small number of recent and contemporary software programs that most closely approximate PeopleWatcher with respect to their intended use and functionality.

The first means of recording wayfinding behavior were manual [16]: the participant would be accompanied by a researcher who could simply record (by drawing) their path onto a pre-prepared map attached to a clipboard. Task times could be recorded in parallel using a stopwatch. The primary form of data was the resultant paths or trajectories (which might later be transcribed or digitized for further analysis) and the associated task-durations times. The simple clipboard and stopwatch approach was remarkably robust and amenable to different settings. This ‘movement tracing’ method was also used extensively by space syntax researchers for observations of ‘natural movement’ where high-volumes of pedestrian paths were unobtrusively observed without the participant’s knowledge. These methods were documented in a handbook [13]. Often, wayfinding tasks will include a pointing task where, typically, a participant is instructed to point to specified locations. These were typically recorded either with a magnetic compass or with a circular dial and then transcribed manually. It is very easy to see how such basic methods continued to be used for a surprisingly long period of time, being both highly accessible, inexpensive yet relatively effective research tools. The problem with such hand-based methods, however, is that it is challenging to record any additional behavioral information other than paths, durations and compass directions.

In order to overcome these deficiencies, wayfinding researchers occasionally employed ‘Thinking Aloud Protocols’ [10, 23] in which the participant is instructed to verbalize their thoughts and to comment upon environmental features that have caught their attention. In order to record such a potentially rich dataset, there was a need to move from pure hand-based methods to some form of automated recording: initially audio, and later video recording. However, if recording audio alone, the concomitant problem of reconciling the traced-path and the precise location of a

² It could be argued that the cognitive abilities of a human observer will always prove to be a limiting factor in behavioral observations.

pertinent comment or remark arises. This can only be solved through the recording and ‘time-stamping’ of spatial events.

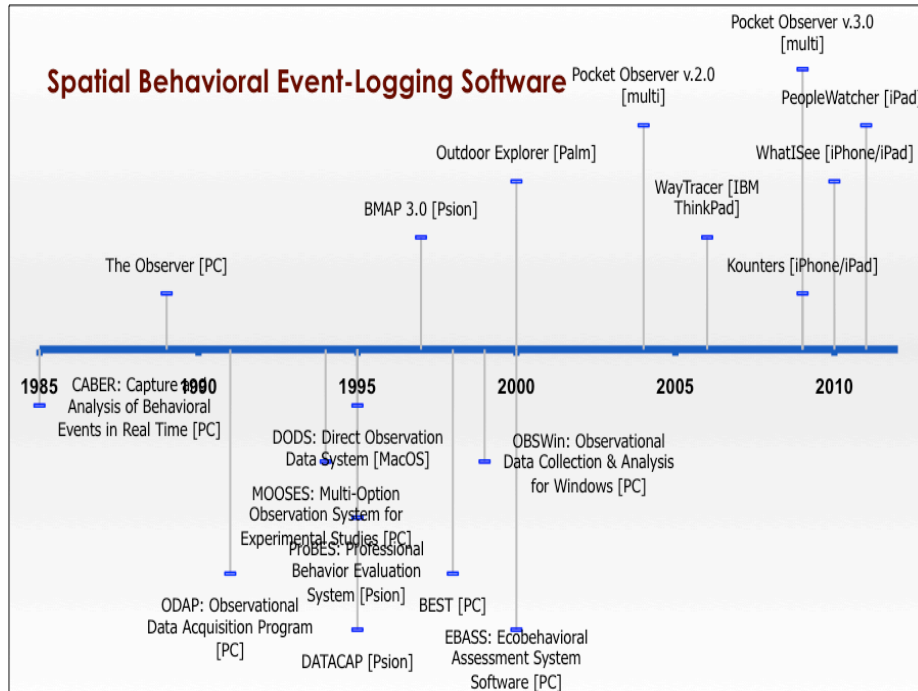


Figure 1 Timeline showing approximate release dates of known spatial-behavior event-logging software. Applications discussed in section 2 lie above the dateline.

Behavioral researchers were early adopters of computerized methods of behavioral data collection (see figure 1 above): for the most part software was developed within academic environments and rarely commercialized; therefore it is particularly difficult to research the precedents to PeopleWatcher. Most software consisted of the pre-definition of the types of ‘events’ to be observed, a means of identifying the observee and recording the associated time (and often location as well) of the events. Most behavioral researchers (which include human and animal behavioral researchers) were primarily interested in observing and recording natural behavior in the field and therefore there was also a strong, early impetus to explore mobile computing solutions for fieldwork. Previous reviews of early behavioral recording software include Farrell’s paper [12] and the papers by Kahng and Iwata [17, 18] where they review 15 programs for behavioral data collection, including a number of applications for handheld devices (Psion Series 3, Psion Organizer, Psion Workabout, Palm Pilot, and Apple Newton). One of programs they review is the Behavioral Evaluation Strategy and Taxonomy (BEST) software also reviewed in Sidener et al’s paper [29] and The

Observer software [1, 4, 8, 15, 24, 25]. The Observer software is particularly noteworthy for its longevity, dating back to the late 1980s [25], and is still available today; in the following sections we will begin by reviewing the current mobile solution, Pocket Observer, offered as part of The Observer suite of software solutions.

2.2 Pocket Observer

As mentioned above, The Observer suite of software dates back to the late 1980s (ibid), was produced by Noldus Information Technology and, very early in its development-history, versions for handheld computers were produced [15]. The original desktop version only supported live observations [25] but rapidly developed into supporting post-hoc analyses of video-based observations. In this respect, most of the software solutions provided as part of The Observer family can now be held to be extremely sophisticated video-coding software. However, in 2004 Noldus produced a new version for the handheld computing market, called Pocket Observer 2.0 [9] which ran on a large range of available handheld computers and permitted the time-stamped encoding of up to 250 different participants, 100 behavioral classes and 250 sub-behaviors (ibid). This was updated to Pocket Observer v.3.0 in 2009. Unlike its fully featured, video-based counterpart, Pocket Observer is intended for the collection of real-time data, rather than post-hoc video encoding. Given the mobile and small-screen nature of this version of the Observer suite, there was some criticism that the large number of available behavioral classes meant that scrolling to select the correct one was cumbersome and time-consuming and that, overall, there was a steep learning curve to learning to use the software (ibid). However, noteworthy features of the software is the ability to create codes/classes of new behaviors ‘on the fly’ if they are observed in the field, and the ability to store notes with individual instances of behavioral events. It should, however, be noted that Pocket Observer does not store the spatial location of any observed behavioral events (although, given the high number of available sub-classes of behaviors that can be defined, location-descriptors could be added as event-modifiers. See figure 2 for screenshots of Pocket Observer.

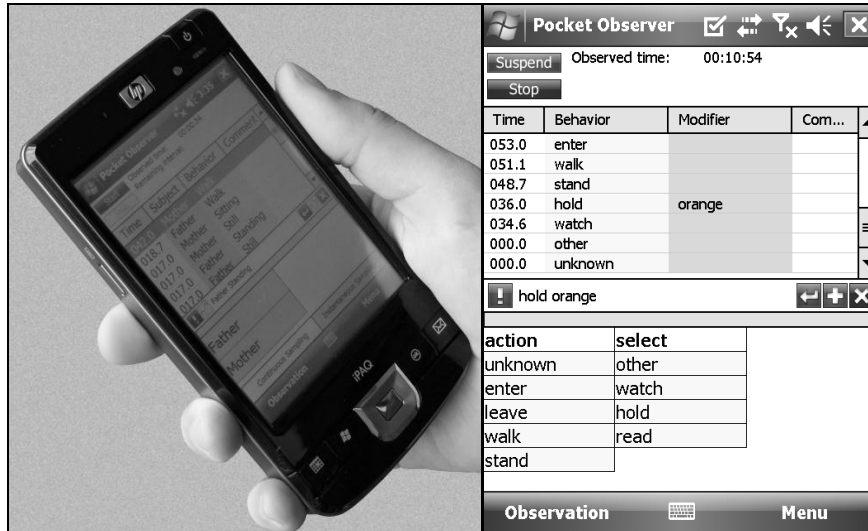
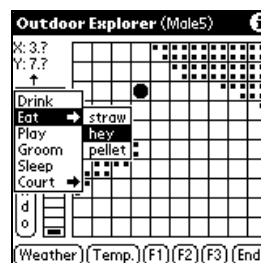


Figure 2 Pocket Observer software: screenshot on handheld device (left) and example of the data entry screen (right). Image source: Noldus Information Technology.

2.3 Outdoor Explorer

Outdoor Explorer was written by Lars Lewejohann at University of Muenster and appears to have been written for his own academic research circa 2000 [22]. It was written for any handheld computer running Palm OS. What is noteworthy about Outdoor Explorer is its early attempt to record not only the time and type of observed spatial behavior, but also its approximate locations (accurate to within 1m). This is achieved by superimposing an imaginary 10x10 grid upon the observation-setting: this can be edited to include features/boundaries (see figure 3). 15 behavioral classes with 15 behavior-modifiers can be user-customized. When a behavior is observed, it is recorded by tapping the grid-square in which the observee is located (this can be zoomed to a finer 10x10 sub-grid) and this location then linked to the associated behavior/sub-behavior and additional observations/notes.



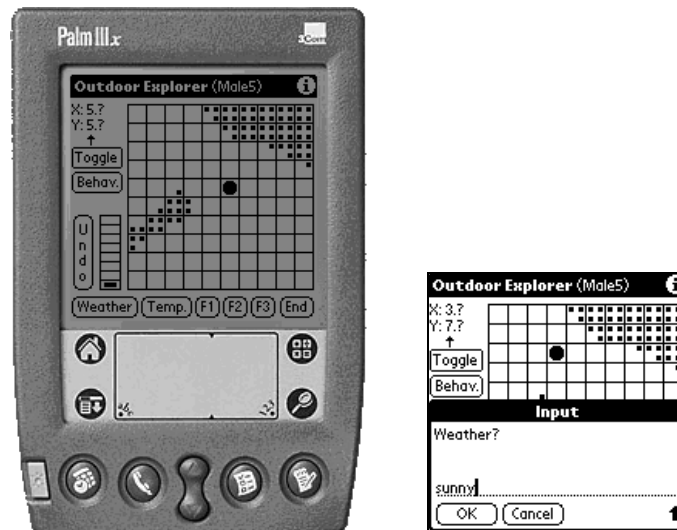
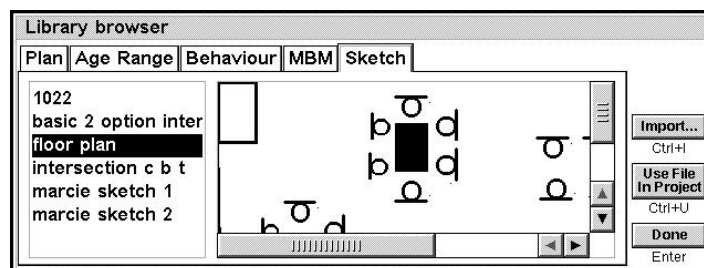


Figure 3 Palm interface to Outdoor Explorer software. Image source: [22]

2.4 BMAP

BMAP 3.0 was an application written for the Psion handheld computer for tracking, mapping and time-stamping behavioral events developed by Wener³ at the Polytechnic Institute of New York University [30–32]. It permitted the import of raster plans/maps as backgrounds and then, when the observer tapped onto a point on the map/plan, the program automatically recorded the location and time of the event and, if set up to include associated data, the tap could prompt a pop-up menu to record other data, such as participant attributes (participant gender or age-range, for example) and types or sub-types of behaviors.



³ The first distributable version of BMAP was programmed by Alex Wilbur under the guidance of Richard Wener [31].



Figure 4 Screenshots (top) showing BMAP’s floor-plan import facility and (bottom) showing the export data selection screen. Source: [30].

The fact that BMAP 3.0 could simultaneously record locations with event-classes, participant information and times is highly significant, and is the reason why it has been included in this review. However, BMAP was only able to record discrete locations of events: it had a “tracking module” but could not draw continuous lines. It was possible to ‘tap-tap-tap’ as a person progressed through a space (each tap recorded time and place⁴), which provided a reasonable facsimile for their continuous movement path⁵ [31]. BMAP was subsequently tested in several studies [3, 19, 11].

2.5 Kounters

There is a growing number of Apps that keep a tally of user-defined events; we have chosen to review one of the first to be released of these, Kounters. Kounters (currently version 1.3) is an iPhone App released on December 15, 2009 by iPinsoft. It is compatible with iPhone, iPod Touch, and iPad and requires iOS 3.1 or later. Kounters was never intended to serve as a spatial behavior event-logging App; rather it was designed as a generic ‘counting’ app but with the ability to simultaneously track a number of different ‘counters’. However, the reason why it is included in this review is that it is highly customizable and is surprisingly effective at logging wayfinding behavior. Figure 5 shows a screenshot of Kounters, adapted with custom-icons for gathering wayfinding data.

⁴ And as opposed to the Outdoor Explorer, the position records of BMAP were not snapped to a grid, and thus could be placed more precisely.

⁵ In subsequent analysis (outside the BMAP program environment) it was possible to smooth the sequence points into a continuous line, although this was never directly implemented in the BMAP software as the Psion Series 5 went out of production [31].

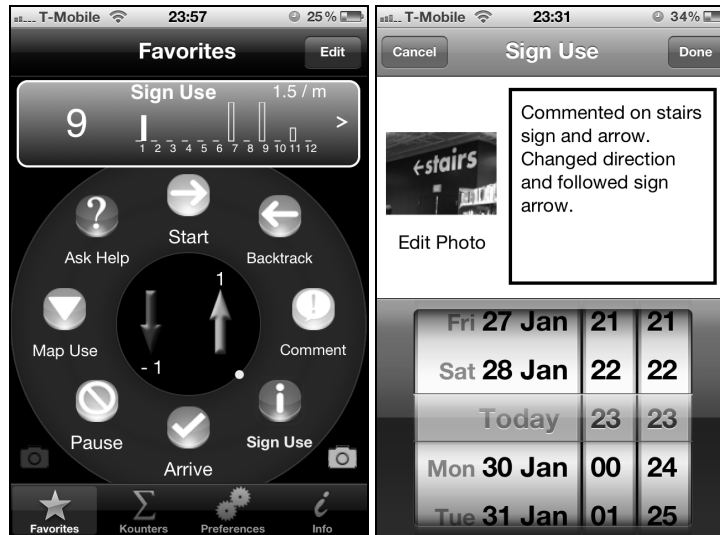


Figure 5 Screenshots of Kounters iPhone App, customized for wayfinding experiments. The rightmost screen shows the ability to link a photograph and observer-notes with a time-stamped event. Source: author's iPhone.

Eight events can be logged, and when the appropriate button is tapped⁶, that specific event can either be logged 'positively' or 'negatively' (Kounters permits a negative 'count' or reduction in the tally of recorded events), in which case the event is time-stamped, the total count incremented, and the results are displayed on a small bar chart above the event-buttons. Although not inherently 'spatial', Kounters has one feature that permits the linking of a time-stamped event to a spatial location: every event recorded can be linked to a photograph and observer-notes stored alongside the time-stamped event. This can be particularly useful if, for example, the participant explicitly uses signage. The rightmost screen of figure 5 shows an image and notes associated with a single time-stamped event. Furthermore, if a more precise location is required, it is possible to record the GPS location of the phone in the background, using a second App (there are currently several Apps that will perform this task) and then integrate the time-stamped event log with the GPS log. Furthermore the ability to location-stamp as well as time-stamp events is intended to be included in the next version of Kounters [26].

2.6 WayTracer

WayTracer was developed by KuhnMünch et al [20, 21] (DFG: SFB/TR8 Spatial Cognition, project I2-MapSpace). It is written in C++ with LINUX as an operating system and tested on an IBM ThinkPad X41 tablet PC using a pen-input interface

⁶ Events can also be recorded by shaking the iPhone or upon 'sensing' a noise instead of tapping the screen: this has the potential to be useful in certain experimental settings.

[21]. The functionality of WayTracer is considerable and we are only able to review a small proportion of its functionality in this review. WayTracer consists of a map screen with a series of pre-defined event buttons below it. See figure 6 below for a screenshot of the WayTracer interface.

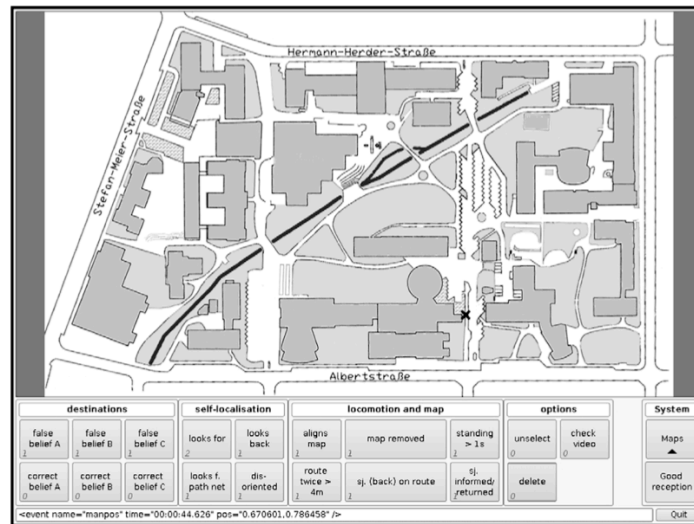


Figure 6 WayTracer’s event entry screen. Source: [20]

The position of the observer is automatically recorded through an attached, external GPS receiver. For indoor use or when GPS signals are not available, the locations of individual events can also be noted manually by pressing the button and then indicating the spatial location of that event (the event is time-stamped on the initial button-press). Event buttons can be configured and grouped by the user under titles of their choice. WayTracer permits switching between multiple maps rendering it useful for multi-floor buildings or large areas. In addition, system feedback on the status of buttons and the GPS signal's quality ease working with WayTracer.

WayTracer was tested extensively in several field experiments and projects within SFB/TR8 [21]; they report testing results of the first experiment in this series, amongst them a high observer agreement between well-trained experimenters of 0.92 (percentage agreement when allowing for a temporal offset of 3s). This indicates that the event-button/stylus interface together with the chosen method of data entry is well-suited for recording such spatio-temporal data and supports reports by Wener about the earlier Psion-based BMAP system [30, 32]. It was noted by Kuhn Münch & Strube [21] that in their tests the manual spatial input often proved more accurate than the accompanying GPS data. This is due to inherent imprecisions of GPS data when signal quality is diminished by the environment (e.g., street canyons). PeopleWatcher shares a significant number of these key functions of WayTracer, and it is officially credited that PeopleWatcher was developed using central design features of WayTracer.

2.7 WhatISee

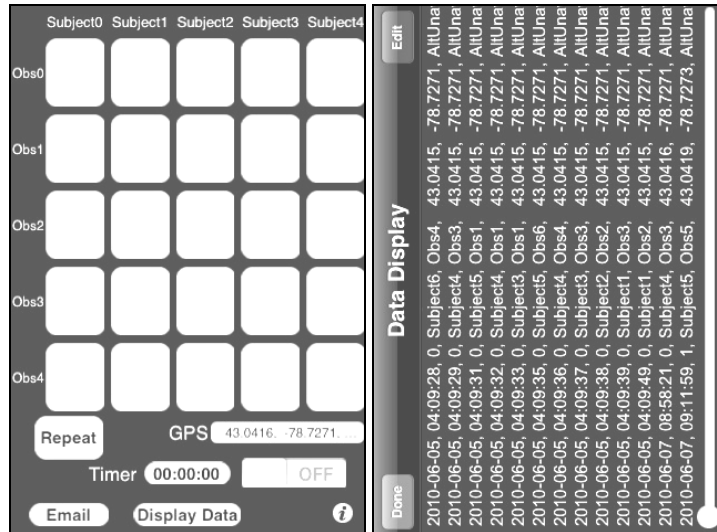


Figure 7 Two screenshots of the WhatISee App. Source Heuser.

WhatISee (currently version 2.0) is another iPhone App originally released on June 21, 2010 by Heuser. It is compatible with iPhone, iPod touch, and iPad and requires iOS 3.2 or later. WhatISee is a straightforward App with a simple interface. It does not display maps/plans of any kind, simply presents the experimenter with a matrix of different participants and potential actions/events (this array can be customized for the number of participants/actions and the associated labels can be edited). When an event is observed, by clicking in the correct cell in the matrix, the participant, event/action, time, date and elapsed time (since start of session) as well as location is recorded (see figure 7). The location is recorded by GPS that, unlike the Kounters iPhone App, is integrated into the App. Although a map interface is not provided, the resultant spatial locations of actions can be visualized easily on a map. The locations are obviously discrete locations (instances of discrete events) rather than a continuous path or track through an environment, but the strength of this simple App is its ability to track simultaneously the actions of multiple participants, something neither WayTracer nor PeopleWatcher is able to do.

⁷Table 1 Comparison of primary features of recent spatial behavioral recording software

| Software | Time-stamped events | Multi-classes of event | Discrete spatial locations of events | Continuous paths tracked | Parallel multi-participant logs | Audio transcript | Compass direction for pointing task |
|------------------|---------------------|------------------------|--------------------------------------|--------------------------|---------------------------------|------------------|-------------------------------------|
| BMAP | ✓ | ✓ | ✓ | (✓ ⁴) | ✓ | ✗ | ✗ |
| PeopleWatcher | ✓ | ✓ | ✓ | ✓ | ✗ | ✓ | ✓ |
| Kounters | ✓ | ✓ | (✓ ⁸) | ✗ | ✗ | ✗ | ✗ |
| Outdoor Explorer | ✓ | ✓ | ✓ | ✗ | ✓ | ✗ | ✗ |
| Pocket Observer | ✓ | ✓ | ✗ | ✗ | ✓ | ✗ | ✗ |
| Waytracer | ✓ | ✓ | ✓ | ✓ | ✗ | ✗ | ✗ |

3 The PeopleWatcher Approach

PeopleWatcher emerged out of a research program designed specifically conduct building-level⁸ (rather than urban-based) usability experiments. Our previous architectural work relied on a paper-based approach but this limited the amount of behavioral data that could be collected which was central to our research aims. We were aware of a number of previous digital approaches to mobile observation (Section 2) but the hardware required was quickly becoming dated (e.g the Psion) or often required complex installation and maintenance. One solution to these problems is the proper choice of the hardware platform, with an easy-to-use software environment. Thus, we were drawn to the iPhone and the iPad. The potential use of the iPad created many possibilities, the long battery life meant a number of experiments could be performed in a single period without pauses to recharge. The iPad is an off-the-shelf consumer-level product that reduces cost and minimizes the technical knowledge necessary to operate and maintain it. Given that one user group for the tool might be student research assistants we prioritized simplicity of use early in the design phase. Furthermore the computing power of the iPad is significantly higher than previous generations of hardware permitting more computing power to be used.

In terms of form-factor, the iPad is light and so less fatiguing to the experimenter during prolonged usage and is light enough to be easily carried in the hand without a need for straps or other supports. iPads are rapidly becoming a common sight in

⁷ Spatial location of events in Kounters (using GPS) to be included in the next version (Pinzon, 2012).

⁸ The focus on architectural usability immediately required an alternative to relying on GPS for recording the paths of participants as GPS is usually unavailable or inaccurate inside a building. It was clear that one primary requirement of any software solution was to be able to trace the path of a participant onto a plan, and to time-stamp the coordinate of the drawn route.

public so the presence of a participant accompanied by an experimenter holding an iPad does not arouse attention or attract interruption (which can invalidate a task). Experience with building evaluation has shown that building owners prefer that experimenters conduct themselves as discreetly to as possible and minimize disruption to a building's occupants.



Figure 8 Screenshots of the PeopleWatcher user interface, showing the 'Map Page' (left) and 'Analytic Page' demonstrating the superimposition of multiple paths (right).

Our original intention was to evaluate and utilize a number of pre-existing iPad applications⁹ and use them simultaneously, each performing a different, specialized task. The iPad hardware comes preinstalled with many useful elements: a multi-touch screen, digital compass, Wi-Fi connection, motion sensor, audio recorder, GPS

⁹ An event logger (Kounters), a GPS tracker (Location Tracking GPS), a compass (Compass or Direction Known), a drawing program (i.e. Sketches 2, Brushes or Sketch Memo) which would permit a floor-plan/map to be imported as a background image and then drawn upon/annotated and, finally, an audio recorder (Voice Memos))

receiver, Bluetooth, LED light and still/video camera, all within one single, small package which would eliminate the need for carrying and connecting several devices.

We encountered two problems with the ‘collection of Apps’ approach. First, it proved impossible to bundle them together into a single display. This meant that a user would need to have some Apps running in the background (i.e. the GPS tracker and audio recorder) whilst rapidly flipping between other Apps as required (i.e. toggling between the event logging and drawing App). This would clearly cause problems for the subsequent accuracy of recording observations and increasing the complexity of the user-interface. Second, this approach requires considerable technical skill to weave together the resultant, disparate data. The lack of a common ‘timeline’ or ‘timeframe’ or even coordinate system between different Apps prolongs the subsequent analysis phase. Our approach became the development of a single App that contained all of the functionality that we had found useful in the pre-existing Apps we had already evaluated, but to combine them in a single application which was simple and robust to use.

3.1 The ‘Home Page’ of PeopleWatcher’s Interface

This section of the paper will describe the primary features of the PeopleWatcher App. The PeopleWatcher app is designed following the standard IOS look and feel. It consists of a lower ‘control bar’ which has four buttons. ‘Home’, ‘Preferences’, ‘Map’ and ‘Analysis’. Each of these pages prescribes a different area of activity. The Home Page is the starting point for both the App and each experiment or experimental session. This page is where new participant records are entered and where the experiment-recording phase is initialized). In PeopleWatcher an ‘Experiment’ typically consists of an experimenter or observer discreetly following a participant. Each experimental session has only one participant¹⁰ but may consist of a number of differing wayfinding tasks. All the tasks for one participant are stored in a single file. The Home Page (functionally analogous to the XML-based ‘metadata’ configuration file used by Waytracer) simply provides an area for the experimenter to set-up a new experiment, initiate and ultimately end, the ‘recording’ phase. An area is also provided on the Home Page to allow the experimenter to record notes, which are subsequently appended to the text-based log-file. A label displaying the automatically assigned, individual participant-ID¹¹ is displayed on the Home Page, which permits the experimenter to use the participant ID to annotate manually collected information such as additional questionnaire data.

Once an experiment has been initiated the recording begins and each action or event is time-stamped¹² relative to the beginning of the experiment. The Home Page

¹⁰ In this respect PeopleWatcher differs from Pocket Observer, BMAP and Outdoor Explorer, which permit simultaneous observations of multiple participants.

¹¹ The automatic ID feature was intended to prevent a human error of assigning an ID number twice and hence overwriting valuable observational data.

¹² Time-stamping is relative, not absolute, as in many of the applications reviewed in the first section of this paper. This was intended to facilitate the easy comparison of the same task performed serially by different participants.

also provides the option for an audio recording track to be recorded in synchronization with the event log-file. This permits the experimenter to either simultaneously record audio notes or to directly record the participant's voice if employing a 'Thinking Aloud Protocol' [10].

Once the recording-phase is initiated, the experimenter typically switches over to the Map Page until the experiment is finished. Once the experiment is over the experimenter must return to the Home Page in order to 'stop' the recording at which point all the relevant data is output to log-files (see section 3.5).

3.2 The 'Map Page' of PeopleWatcher's Interface

The Map Page is the primary area for spatial behavior recording/encoding. The Map page screen is further divided into two sections: the upper 'map' section and the lower 'events' section. The map section displays the current floor level (for a multi-level building) and is a 'drawable' part of the screen, allowing the experimenter to manually trace the path¹³ of a participant onto the screen as they observe their progress through an environment. (See figure 8 for a screenshot of PeopleWatcher's Map Page.)

The coordinates of the participant's location are recorded in real-time. The lower half of the screen consists of a series of buttons permitting actions to be logged. The buttons are classified as changes in floor level (at which point the displayed map will be updated accordingly), as path events (starting a new task, pausing, backtracking, arriving at a false destination, becoming lost or giving up the task), the use of external aids (signage, maps, external views to the outside or equivalent invariant views, asking for help) and other log/action events (saving a compass direction in a pointing task, recording the location of a significant remark, if simultaneously recording an audio transcript and 'undo' which deletes any of the previously recorded actions). See figure 8 for a screenshot. Every time an event is logged a colored 'dot' on the traced-path is created: it is time-stamped and its location¹⁴ is noted in the log-file. The text-based log-files, annotated maps and any associated audio files are saved for subsequent retrieval.

To facilitate the use of other recording mechanisms (video, still cameras, paper notes) elapsed time is also displayed during the experiment. There are two timer displays, the first is the overall time which indicates the time from the beginning of

¹³ GPS data tracking can be recorded in conjunction with manual tracing for GPS-enabled iPads. However, since it was envisioned that this would be used primarily indoors, where GPS reception is typically poor or unavailable, the development of the App focused on the manual path entry mode. For discrete position entries (either GPS or manual) not to produce artifacts, the positions have to be recorded regularly, especially in curves and when participants repeat sections of the path. Whether recorded manually or by GPS, the main precondition for interpolation of a continuous path by connecting discrete positions hence is a sufficient frequency of position entries. PeopleWatcher overcomes this when users trace paths continuously by hand.

¹⁴ Since the path of the participant is already being drawn manually, the location of the observed action is held to be co-located with the last recorded position of the participant. The time of the event is held to be the point at which the event-button is pressed.

the overall experiment-session and coordinates with the times recorded in the log-file and the second timer indicates the elapsed time from when the ‘New Start’ (a new sub task) button is clicked. This permits notes to be taken relative to the start of the most recent sub-task: a feature that emerged from the first usability testing of PeopleWatcher.

3.3 The ‘Settings Page’ of PeopleWatcher’s Interface

The Settings Page is used infrequently: its purpose is to import and manage the image-files of maps representing the individual floors (or tiles of a larger map). The pages consist of an array of buttons which, when clicked, prompts the experimenter to upload an image from their photo library. Prior to setting up the experiment, the experimenter is expected to upload a maximum of nine floor plans from the iPad’s Photo Library. Experiments have shown that navigating (panning and zooming) a large-scale map is difficult in a mobile context [27] so images should cover the entire navigable area of a building’s floor-plan. Multiple-floor maps can also be adapted to complex single-floor settings, for example an airport, in which case the ‘floor’ images can be used to represent different adjacent zones at ‘zoomed-in’, higher resolutions.

If preparing for a multi-floor experiment, while preparing the floor plan images experience has shown it is useful to take care to ensure that the individual maps are vertically registered. That is to say, any vertical circulation elements such as the lift/elevators and the staircases should align between floors. On the Map Page, when a new floor plan is selected (as a participant moves from one floor to another) then the last point on the previous floor plan is registered (displayed as a dot) on the current floor plan. This acts as a visual prompt for the experimenter to rapidly reorient him/herself (on the new plan) while simultaneously observing participant-behavior during the often-important vertical transition of the participant. This registration between floor plans is also important to calculate inter-floor metrics from the log files. For example, if an experimenter calculates walking speed from the spatial data-stream and time then there will be an implicit assumption of scaling factor (from screen pixels to meters or feet) if the individual floors do not represent the same scale.

It is planned that for future versions of PeopleWatcher the Setting Page will also permit users to change the labels and icons of the individual buttons, for example customizing the events to be logged.

3.4 The ‘Analytic’ Page of PeopleWatcher’s Interface

Once a number of experiments with different participants have been completed it is usual to undertake some form of post-experiment analysis. This can be achieved in one of two ways. The Analytic Page is designed to provide an early-stage, rapid analysis in order to identify any possible experimental problems or areas for more in-depth research. The Analytic Page resembles the Map Page (see figure 8) and displays one of the available floor plans (user-selected from a radio button control). The analytic view merges all of the experimental tracks from each participant on the selected floor together. Each participant is assigned their own unique color facilitating

the identification of points/zones of commonality (similar routes taken or zones where multiple participants paused). This composite view permits the simple observation of emergent behavior events common to all participants. In addition, when placing two fingers on the screen on the map (on the Analytic Page) a line or ‘virtual gate’ is created between the two touch points. The system then counts the number of routes crossing this virtual threshold and displays the total in the bottom left-hand corner of the map (see [13] for more background on the ‘gate-counts’ observation method).

In future versions it is intended that the user will be able to draw a polygonal ‘zone’ onto the plan displayed in the Analytic Page and PeopleWatcher will calculate how many paths pass through this zone and enumerate the number of different events that take place within the selected area. For more sophisticated or specific analysis PeopleWatcher reports the observation data can be exported to the desktop environment (see section 3.5 for PeopleWatcher’s file format).

PeopleWatcher File Format

PeopleWatcher has the potential to generate a number of output files. The primary output file is the event log-file and this takes the form of a simple .csv (comma separated values) format. There are a separate event log-files for each participant and they are named as ‘PathXXX.csv’ where XXX is the participant number automatically generated and displayed on the home page when the ‘new experiment’ button was clicked. Accompanying each event file is a number of .pdf vector files: one for each floor/zone of the building. Each of these files contains a high resolution, vector version of the information displayed on the Map Page for participant XXX. This displays the participants’ recorded path along with dots representing the location of recorded events (such as pauses). The original map image-file is stored as a background for the vector path permitting the path to be viewed against its context (without the need to re-generate the path in third-party mapping software). If the experimenter has used the optional audio recording an additional file “AudioXXX.caf” is also saved.

The PeopleWatcher file format is designed to be open and simple enough to permit other tools to be written to facilitate the further processing of the data held. The text-based .csv format can be simply imported into packages from Excel to large SQL databases and is simple enough to be edited by hand in a simple text editor. The file is in the form: “event-type, floor, time, x-coordinate¹⁵, y-coordinate”.

¹⁵ The coordinate system is in pixels, relating to the image-display of the map, in the Map Page.

4 Pilot Testing the PeopleWatcher App

4.1 Procedure

The PeopleWatcher App was tested in the field in November 2011 as part of a genuine wayfinding experiment. Experiment participants, the majority of whom were attendees at the 52nd Annual Meeting of The Psychonomic Society, were invited to participate in a the experiment that took place in Seattle Public Library. 28 participants (13 M; 15 F) aged between 21 and 68 years (mean age of 35) presented themselves at the library's Fourth Avenue entrance, level 1, at pre-arranged time-slots, throughout a single day (Nov 3, 2011). All participants were, hitherto, unfamiliar with the building. They were tested individually. The tasks consisted of four separate wayfinding tasks: two took place within a single floor (levels 1 and 3) and therefore involved no vertical travel and two tasks involved navigating from one level to different level. Of the two 'within floors' tasks, one was intended to be relatively easy and one harder and this pattern was mirrored exactly by the 'between floors' tasks (L1 to L4; L5 to L7). The tasks (E='easy'; H='hard'; W='within floors'; B='between floors') were as follows:

- E&W: Starting from the Fourth Avenue entrance (L1) and finding the boys/girls restrooms in the Children's Center (L1);
- H&B: From the Story Hour Room (L1) and finding Meeting Room 6 (L4);
- H&W: From the far end of the Teen Center (adjacent to the staff-only meeting room) (L3) and finding a book (Sherlock Holmes by Arthur Conan Doyle) located in the Mystery Fiction section located behind the red staircase (L3);
- E&B: Starting in front of the Info Desk (L5) and finding the non-fiction DVDs located on level 7 of the Book Spiral (L7). Please refer to figure 9 for an illustration of the four routes. The tasks were designed to be 'chained', that is to say, once a participant had concluded one task in the sequence they were led, by one of the experimenters, to the starting location of the subsequent task, ready to begin again. In this way, four participants could be tested simultaneously, each beginning at one of the four separate starting points and being observed by one of four experimenters, and then moving in rotation between the tasks, so as not to inadvertently 'overlap' with one another.

It is clear from the description above, that the experiment set-up served to be a particularly challenging first test of the PeopleWatcher App. Not only were four participants being tested simultaneously (and therefore the four experimenters needed to use PeopleWatcher installed on four separate iPads) but the routes frequently involved changes in floor-level by different modes (stairs, escalators and elevators), a proportion of the tasks were intentionally designed to be spatially complex and, finally, the library staff requested that the experiment be conducted discreetly and not disturb the library's patrons. In addition to this, the four experimenters came from three different institutions, and had little or no familiarity of PeopleWatcher in advance of the experiment. Due to the nature of the event, only limited training in its use was possible (1-4 hours per observer): although all the PeopleWatcher users had

conducted similar experiments in the past, and therefore were familiar with general procedures for indoor navigation experiments.

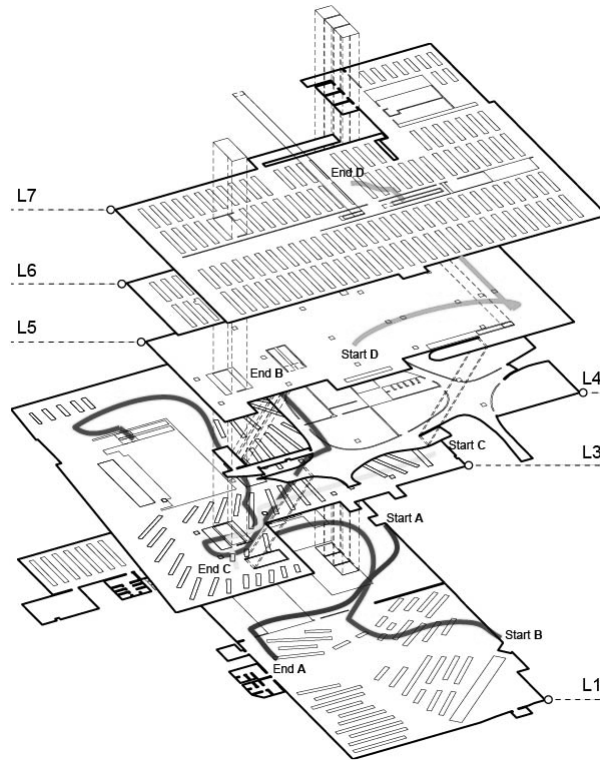


Figure 9 An illustration of part of Seattle Public Library (levels 1 to 7 only) showing the paths of the routes used as wayfinding tasks in PeopleWatcher's test-study.

PeopleWatcher enabled the experimenters to observe and record the path taken by the participants for each of the four tasks, whilst simultaneously logging actions or behaviors observed en route, such as pausing, using signs, backtracking etc. These actions were recorded and logged in real time, with the location and time of the behavior/action being recorded by the App and was subsequently downloadable as a single data-file. Such real-time, electronic collection of the data enabled the unusually rapid analysis¹⁶ of the participant data and constitutes one of the notable aspects of this study.

The detailed results of the experiment in the Seattle Public Library will be published separately [5]. But the available preliminary analysis [6, 7] already indicate that the data collected with PeopleWatcher is sensitive to systematic variations in the

¹⁶ The experiment was conducted at the beginning of the Annual Meeting of The Psychonomic Society; the results were presented at the end of the Annual Meeting.

wayfinding tasks and that it captures behavioral differences that can be traced to differences in psychometric tests like the SBSOD [14] and mental rotation [28]. In this test-study we concentrated on collecting trajectory data, pauses and sign use. For each of these measures significant statistical effects were obtained in line with study hypotheses, as well as significant correlations to individual difference measures¹⁷.

5 Usability Feedback

As evidenced in KuhnMünch and Strube’s paper [21], they found a high degree of inter-observer agreement when testing this aspect of WayTracer’s usability. Given the similarity of the user-interface of PeopleWatcher to WayTracer (they both utilize map- and button-pressing event-sampling user-inputs) we saw no reason to re-produce their inter-observer agreement study, as we would expect the results to be broadly comparable. Rather, we decided to focus on the overall usability of the App. Since one of the reasons for using the iPad (see section 3) was the perceived ease of use of the iPad plus accompanying benefits of its lightweight form, we wished to test whether PeopleWatcher did, as intended, result in an easy-to-use solution for gathering spatial behavior data.

Post-experiment, the four experimenters who took part in the Seattle Public Library study were asked to gauge the usability of the PeopleWatcher App by filling in a usability questionnaire based on System Usability Scale (SUS) and selecting descriptive words from a version of Microsoft’s Product Reaction Cards [2]. In addition to this, they were invited to make any other comments on the use of PeopleWatcher in an open question. This section of the paper will discuss the usability of the PeopleWatcher App based on the results of and feedback of the experiment and will discuss any implications for the automation of data gathering of human behavior in the future.

While the number of users in this field-test was low, the feedback does give an indication of the attention to usability that influenced the development of the App and the early results of this process. The SUS yields a single number representing a composite measure of the overall usability of the system. SUS cores have a range of 0 to 100 with the mode (of a number of commonly used industrial products and websites along with research projects) between 71-80. Our early system had a score of 71 putting it in the top 50th percentile or on a par with everyday products. One question that many users gave a low score for was ‘I need to learn a lot of things before I could get going with this app’ which may reflect either the experience of the users of conducting wayfinding experiments or may reflect the usability of application itself: this will be further investigated in future usability tests.

The Microsoft Product reaction cards highlighted the words ‘*Straightforward*’, and ‘*Valuable*’ with ‘*Unpredictable*’ as the only negative response¹⁸. Almost all of the responses to the open question concerned suggestions for additional functionality for

¹⁷ Gender differences have yet to be analyzed for this dataset and hence no conclusive results are currently available. It should however be stated that the ‘Note’ field located on the App’s ‘Home Page’ can be used to record gender data, if required as part of the experimental setup.

¹⁸ This needs further research to reveal the origins of this response.

future versions. Many of these suggestions have already been incorporated into the current version of PeopleWatcher. The only comment that did not specifically address future functionality requests, stated, “*Overall I thought it was easy to use and well suited for the task.*” The next stage of PeopleWatcher’s development will include further user-testing and continued use of the above methods to investigate its usability.

6 Conclusions

It is clear from the review of previous software solutions that behavioral researchers benefit from easy-to-use, mobile and discreet software solutions to gather real-time data in the field. We would also like to suggest that the iPad, with its many inbuilt-features and lightweight form, is ideally suited to this task. The aim of PeopleWatcher was to take advantage of as many of these inbuilt features as possible and to bring them together in a single, easy-to-use package. The Seattle Public Library study proved a challenging first test of the software. The App is currently in its second stage of development and is in the process of responding to the feedback from the study.

Future developments will focus on reliably concerning the hard- and software and enhancing the in-App data-analysis functionality. Further test-studies are planned and ongoing usability studies will form an integral part of this process. As part of this commitment to long term usability an off-the-shelf package called ‘Flurry’, which annotates the software and anonymously sends problems/errors to a central sever for later diagnosis, has been included in the current version of PeopleWatcher.

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