Block Party: Synchronized Planning and Navigation Views for Neighbourhood Expeditions

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ABSTRACT
Mobile wayfinding and guide apps have become indispensable tools for navigating unfamiliar urban spaces. Such applications address targeted, "just-in-time" queries, but are not optimally designed for multi-point expeditions that can quickly build route and survey-level familiarity with a neighbourhood. We first conducted an experimental simulation involving a homebuying scenario to assess the usefulness of a popular mobile wayfinding and search application (Google Maps) for exploring a neighbourhood. We then designed a prototype application called Block Party that addresses a number of limitations of Google Maps for this purpose, and evaluated it in a second replica study. The results suggested that application designs that facilitate switching among distinct but synchronized navigation views such as Block Party might support more efficient usage and the selection of task-appropriate views, leading to better overall spatial awareness.

Author Keywords
Neighbourhood expeditions; itinerary planning; wayfinding; Google Maps; mobile guide

ACM Classification Keywords
H.5.2. Information interfaces and presentation: User Interfaces.

INTRODUCTION
Exploring unfamiliar urban neighbourhoods is a common activity for both locals and visitors to a city: homebuyers/renters might do this to build familiarity with a potential neighbourhood, local retailers when they are planning a new store location, new students when they arrive on campus, and tourists or professionals when they arrive at a new location for an extended stay. Exploring neighbourhoods close to home is also part of locative games like Pokémon Go.

Urban neighbourhoods can be difficult to penetrate. What may appear to an outsider as just another busy street is often the focal point of a community, who conduct a good portion their day-to-day lives within a set of city blocks. Services like daycares, schools, grocery stores, vets, fitness clubs, dog walkers are linked through physical proximity and community networks. It is not enough to become familiar with the physical space when exploring urban neighbourhoods; we also want to build an appreciation of the neighbourhood as *place*. The potential resident wants to sample their prospective day-to-day, the retailer wants to understand how the neighbourhood ebbs and flows and how to integrate with existing stores, and the visitor wants to experience the local culture.

Mobile applications provide a variety of data about neighbourhoods including local stores and reviews, attractions and places of interest, real estate listings and prices, local news and events, transit schedules, even crime statistics. Such apps often offer spatial views and some navigation support. In the case of tourism, some even support multi-point itineraries [26], but in a manner that is highly tailored for short tourist visits. Wayfinding apps such as Google Maps are optimized for targeted search and navigation from point A to B. Google Maps has only offered support for multi-point itineraries very recently, and there again is optimized for the navigation task, rather than for exploring an area and updating an itinerary *in situ.*

Some mobile recommender systems research does consider serendipitous exploration and adaptive itinerary planning [12]. For example, Magitti models user behavior and other contextual information to recommend leisure activities [6]. TramMate is a route planning tool which suggests routes based on contextual data, planned activities (e.g., appointments), and public transport system details [17]. Where these studies emphasize route planning algorithms and context inference, our work explores basic interface designs for *user-driven* planning and exploration, to support goal-driven *expeditions* (e.g., explore amenities near a potential home): this middle ground between strict planning and free exploration is underexplored in the literature.

While many mobile map and guide applications provide multiple spatial views, most mobile maps research has compared views rather than explore how they work together to support an activity. The intuition driving our work is that neighbourhood expeditions would benefit from a flexible Coordinated and Multiple Views (CMV) approach [33,40], involving several lightweight spatial views, each supporting different wayfinding and discovery tasks, and by making it

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simple to switch views while keeping them synchronized. To the best of our knowledge ours is the first work that considers how a CMV approach can be applied to support neighbourhood expeditions.

We conducted a field assessment of a widely-used mobile wayfinding tool (Google Maps) using a homebuying scenario, to establish a need for more targeted application designs for neighbourhood expeditions, and as a baseline comparison for our CMV approach. We found that views were often dictated or their selection impeded by design, support for multi-location itineraries was minimal, and that switching views required significant interaction with the app and sometimes restarts, interrupting the main task. We present a prototype application called *Block Party* we designed to address these limitations. Block Party provides synchronized views supporting navigation, orientation, and planning, single click transitions between views, and support for multi-point itineraries and in situ itinerary modifications. A replica field evaluation provides evidence that the synchronized view design promotes fewer, but more purposeful transitions, serendipitous and dynamic activity modifications, and better overall spatial awareness.

We contribute to the mobile guide and wayfinding research by addressing a gap in current wayfinding mobile apps specifically designed for people exploring a new neighbourhood. We challenge the sequential, point-to-point design assumptions embedded in widely used pedestrian wayfinding apps and demonstrate how a design based on coordinated multiple spatial views providing compatible detail can improve flexibility. This opens up new design opportunities for such apps. We provide evidence that the CMV approach encourages heightened spatial awareness, benefitting new residents and others who wish not only to get a flavor for a neighbourhood but also to know its layout.

RELATED WORK

Mobile Information Needs

Location and activity can impact a user's information needs, for both familiar and unfamiliar places [9,28,36]. Users often search for information related to their current location, for routes and directions, or to find places close to their final destinations [9,37].

Information needs for pedestrians are also different than those in vehicles. While drivers use turn-by-turn directions when navigating, pedestrians often need more route context such as instructions with visual landmarks (e.g., turn left at the library) [24]. Pedestrians are interested in points of interest (POIs) close to their current location, and they use mobile apps to find information about their environment while locating desired services [36].

In their classification of location-based services, Zipf and Jost [42] distinguish primary services (such as maps, navigation, and search support) from secondary services (e.g., mobile guide content, commerce features). Our study emphasizes primary services in support of neighbourhood expeditions, but secondary services would be integrated in implementations tailored for specific needs.

Spatial Cognition and Navigation

Spatial awareness affects how people build knowledge of the location of landmarks or POIs within the environment [10]. Work by Tversky [38] and others on spatial mental models suggests that people use landmarks to help identify locations and remember how to get back to them. In contrast to the pure landmark-route-survey (LRS) model [21], which suggests that survey knowledge is the ultimate organizing mental spatial representation, Tversky argues that both route and survey like descriptions are used when describing where landmarks are situated. Pedestrians in urban areas often use landmarks rather than street names, numbers and distances as navigational cues and apply specific details to landmarks (e.g., Starbucks instead of coffee shop) [22]. Kallioniemi and Turnuen [16] found that pedestrians chose landmarks that were unique, close to the route (e.g., within 200 metres) and could be clearly seen *en route* to help navigation.

In Block Party, we provide survey (map), route (map, list), and egocentric landmark-focused (AR) views, all of which highlight and connect the same set of POIs. By making it straightforward to switch between views, and by marking the same landmarks on each, we hope to reinforce spatial relationships and encourage the formation of useful spatial mental models.

Mobile Maps, Map Views and Navigation Guides

Much work has considered how people use maps on mobile devices. Agrawala and Stolte [1] identified readability, clarity, completeness, and conveniences as design goals for information displayed on electronic route maps. Navigation and interactions are also important when designing map-based mobile applications [5,7,15,29,30,31], as is presenting information that helps users find a route or search for a POI [5,15,34].

Partala et al. [27] compared three spatial views (road maps, satellite maps, and street images) for pedestrian navigation. Participants preferred road maps for navigation, and thought street images were effective for displaying landmarks but required more time to compare them with their environment. Goh et al. [13] compared three views (list, map, and augmented reality) for searching. Participants took a similar amount of time to perform searching tasks with all three views, but preferred the list view for presenting search results. The map view was slowest for general browsing tasks. Vatinnen et al. presented CityScene [39], an app using a street view form of navigation. It was found useful for pedestrians to browse and explore their surroundings and to confirm arrival at their destination. They recommend that image-based systems allow simple switching between navigation views.

Augmented reality can also be used to provide spatial views. Applications use AR for a variety of reasons, including supporting navigation (e.g., [32]), searching for POIs (e.g., Yelp), and providing museum tours (e.g., [34]). AR has been found to be more advantageous than the street view approach for driving by keeping the driver's attention on the road [23]. AR views need to consider contexts of use (e.g., task and information needs) to help reduce clutter and information overload [13]. Just-for-Us used augmented panoramic photographs to exploit cues (e.g., color of buildings) in the physical surroundings [18], and integrated these with complementary activity-specific views. Mulloni et al. provided seamless switching between egocentric AR and exocentric (top-down) map views to promote contextualization [25].

In addition to the easy transition between spatial views and the effective use of AR or image-based views, studies have identified the need for other features similar to those in Block Party. These include the ability to develop routes with multiple POIs, the ability to divert from the recommended route, and to personalize routes [3, 8, 19]. For example, Hornecker et al. [14] designed a serendipitous city guide that encouraged flexible, unexpected discovery while ensuring visitors would not be missing nearby places of interest with vibration alerts.

PRELIMINARY WORK

We began by interviewing 2 recent homebuyers and 2 real estate professionals, to build an understanding of the neighbourhood expedition activities that homebuyers undergo. This allowed us to derive scenarios for our study, and to design a first mobile application concept.

To explore how effective current tools were in helping people explore neighbourhoods, we ran a pilot study with 4 participants in Riverdale, a neighbourhood in Toronto, Canada. We asked participants to use Google Maps and other apps of their choice while they performed home-buying scenario tasks. Participants were asked to find a set of POIs in the neighbourhood and to build their own route involving a subset of the POIs before navigating. We also asked them to establish their location relative to a prospective home at certain stages. At the end of the study, we asked participants for feedback on the suitability of the preliminary app design for this and similar activities. Observational data and qualitative feedback were collected.

When first searching for POIs and planning routes, participants used Google Maps search (4 participants), Yelp (2), and a branded coffeeshop app (1). The star feature in Google Maps was useful to plan and to keep track of progress on a simple route. When mobile participants used Google Maps exclusively. The default Map View was helpful to find the closest POI (e.g., a nearby market). In addition, 3 tried the navigation support, and 4 used Street View at certain POIs and for short bursts, to reorient or identify places that were not easy to locate. Importantly, no single feature was sufficient to support all 4 participants when exploring Riverdale. Moreover, while multiple services and application features were used, it was up to the participants to integrate information coming from these different sources. These shortcomings for neighbourhood expedition warranted further study.

GOOGLE MAPS FIELD EVALUATION

Building on this initial work, we recruited 10 participants to explore two neighbourhoods using Google Maps. We were interested in further exploring: 1) which map view(s) benefit spatial awareness when on neighbourhood expeditions 2) when and why participants switch map views 3) the limitations of a point-to-point navigation app (i.e. Google Maps) for neighbourhood expeditions, and 4) impressions of our initial CMV-inspired prototype.

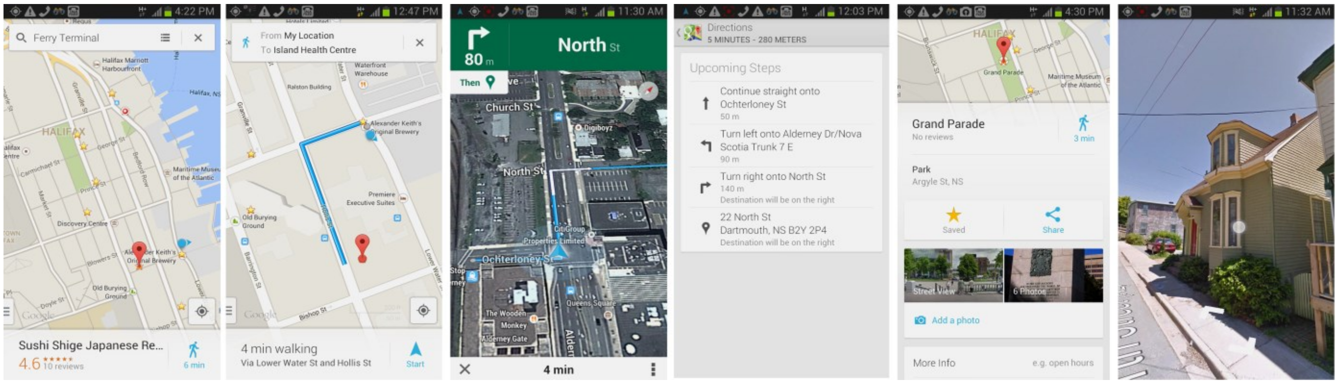
Setting and Tasks

Participants were told to imagine that they were looking to purchase a home, had identified two, and wanted to explore the neighbourhood each home was located in (the Waterfront and Downtown Dartmouth neighbourhoods of the city of Halifax, Canada). The Waterfront and Downtown Dartmouth are connected by ferry, and have condos or family style homes intermixed with restaurants, cafes, parks, etc. We selected a more familiar (Waterfront) and less familiar (Dartmouth) neighbourhood to explore the impact of familiarity on participant behaviour.

Individual participants conducted similar tasks at both locations including: locating POIs (search for a set of distinct places and service categories they are likely to visit near the potential home); route planning (build a multi-point itinerary visiting a subset of POIs); navigation (walk to each POI in the route); periodically noting the distance and orientation of their starting point or other key landmark; serendipitous discovery (making notes of interesting places encountered); and route modification (needing to change plans midway, or add a new POI). While the tasks do not span *all* neighbourhood expedition activities (e.g., attending local events, learning about a neighbourhood's history), they were designed to simulate the experience of discovering walkable urban neighbourhoods.

Map Views

Participants were introduced to all features of Google Maps and told they could use whichever features they wanted to complete the tasks. We divided the views into main categories (see Figure 1): Map (A, B), Navigation (C, D) and Street (E, F) views. The default Map view is a 2D top down map. Selecting a transportation icon (e.g., the walking man in A) displays a route to the selected destination (B). Clicking the "start" arrow transitions to Navigation view. The Satellite option can be selected for Map or Navigation based views (e.g., C). Step by step textual directions can also be selected from Navigation view (D). Voice guidance can be enabled during navigation. Clicking on a search result or a location from the Map brings up a hybrid view containing a smaller scale Map view, information about the location, and a clickable Street View snapshot (E). Street view shows a panoramic image of the buildings and other landmarks as you see on the street (F). The view can be



A. Map View B. Map with route C. Nav View (Satellite) D. Nav View (text) E. Map + Street F. Street View

Figure 1. Map, Navigation and Street views in Google Maps.

controlled using swiping gestures or can be synchronized with the phone's orientation sensors.

Study Process

Participants (6 male, 4 female) were recruited from the Dalhousie University community. Nine were between 18-35 years old and one was over 50. Participants' self-reported sense of direction was on average 4.6 out of 7 (SD=0.6) on the Santa Barbara Sense of Direction Questionnaire (SBSOD). All of the participants rented their current home. We asked for their familiarity with each neighbourhood on a scale of 1 to 5. Average familiarity was 3.6 out of 5 (SD=0.7) for Waterfront, 1.9 out of 5 (SD=0.7) for Dartmouth, thus participants were more familiar with Waterfront (Z=-2.86, p<.01). When finding their current residences, 9/10 used online sources and two used mobile maps. While we didn't recruit prospective home buyers, all participants were familiar with finding new accommodations. No participant lived in the neighbourhoods used in the study. Even in the Waterfront, most POIs were unfamiliar to the participants.

Prior to the study, participants gave consent and filled in the background and SBSOD questionnaires. Two researchers then met the participants at a meeting point and provided them with a Samsung Galaxy Note II smartphone. We demonstrated the features of Google Maps during a training session that involved walking to the location of their potential home using each view at different stages. We emphasized that the training session was not to suggest a "best" way to use the app, but to build familiarity with the features. Participants performed a set of tasks in each neighbourhood, using the ferry to travel between them. The study order was counterbalanced (5 participants started in Waterfront, 5 in Dartmouth). From the training session onward, we videotaped the participants, screen captured the smartphone, and took hand written observation notes.

Once at the starting point (prospective home), participants entered a planning phase. They were given a list of generic destinations (e.g., dentist, bank) to search for using Google Maps. When possible, we personalized the destinations to boost realism (e.g., visit their bank or favorite type of restaurant). Participants searched for matching POIs close to the house and starred them. One common destination was included so all participants would reach the same location at some point. Once a set of POIs was determined, participants planned a multi-point itinerary.

Participants conducted the neighbourhood expedition by going to each destination in the itinerary in sequence, identifying it to the facilitators on arrival before moving to the next POI. At three points we asked participants to stop and point in the direction of a landmark (e.g., the house). We also asked participants to look out for other places of interest to them, and to star them on the map. When participants arrived at the pre-set common destination, an itinerary change was initiated: we asked them to search for and to go to three specific destinations in turn. For example, for Waterfront the premise was that friends wanted to meet somewhere, but once the participant arrives the friends called and changed the meetup location. The participants were asked to visit a third location on the way to the new meetup point. Although wayfinding was a main activity in the tasks, we introduced several mechanisms to support exploratory goals: participants selected their own items and built their own multipoint itinerary; POIs used were customized in part by participants' preferences; an unexpected change to the itinerary was introduced; participants were asked to take note of interesting places encountered along and way and to periodically reflect on relative orientations and distances between POIs.

Participants completed a neighbourhood familiarity test to assess their spatial awareness and recollection of the area after exploring each neighbourhood. We also performed a post-study interview, asking participants to reflect on how they used the app. We then demonstrated our Block Party prototype and elicited their feedback on the design and its suitability for neighbourhood expeditions.

Data Analysis

Video and screen capture data were synchronized in Adobe Premiere, and played side by side for coding. One researcher annotated a subset of video data in a freeform way. All researchers then reviewed the annotations to arrive at a coding scheme. Using this the video was formally coded to determine when participants searched (e.g., at the beginning of a task, while navigating, etc.), which map views were used and when, when map view switches occurred, and when device rotation occurred in a first pass. Other interesting behaviours such as when participants were lost were annotated in a second pass. The interview data and the video analysis data were organized into major themes using an affinity diagramming approach.

Using the coded data, we also compiled proportions of time spent using each view across each participant and across each start/end point. We further split each start/end point into a *planning* phase (beginning when participants began to prepare to go to their next destination) and an *on-path* phase (from when participants began to walk to when they identified the destination, or gave up).

Results

Participants took around 2.5 hours to complete the field visits. Even though 8/10 participants used Google Maps for navigation in their daily lives, participants experienced a range of issues with switching views, multitasking, searching and route planning.

View Usage

Participants used different map views to accomplish different tasks. We measured the average time proportion participants spent on each view across tasks. During the planning phase, participants spent 90% of their time on Map, 4% on Navigation and 6% on Street View; while en route, they spent 56%, 40%, and 4% of time on Map, Navigation, and Street views, respectively; when asked to point in the direction of landmarks and estimate their distance, they used Map 97% of the time (the remaining 3% was Navigation View).

Map view was used almost exclusively when planning to go to the next destination, but once on-path usage was diverse: 6 participants mainly used the Navigation view (5 with voice guidance, 4 with Satellite view enabled), 3 used the Map view with the route on it, and 1 used Map Only most of the time.

Cost of Switching Views in a Sequential Workflow

Google Maps' application design assumed a sequential pattern of view access: target identification on Map view, followed by the route display, sometimes followed by Navigation mode. Street View can only be accessed from Map view. However, users have wide variations in view access flows. For example, when getting close to the destination, 9 participants switched to Street View from whichever view they were on to see what the destination point looked like. P3 commented: "*now I am having trouble using Street View when it is doing navigation*". When 8 participants had difficulty identifying the destinations, they switched to any other view (e.g., Map, Street, Navigation, Satellite) that might help them. Participants had to go through a series of redundant views (1-5 extra clicks) to find the target view that 3 of them closed the app to break away from the current flow. This observation suggests designs that facilitate easy, non-linear switches between different views might better suit the varying workflow of navigation tasks.

Many other unintended switches happened because the system did not behave consistently across different types of views. For example, operations such as searching, starring, accessing the name and distance information of starred locations can only be performed on the Map view. 5 participants had to switch from Navigation view back to Map view for these reasons. Allowing for synchronized operations on different views could improve this unnecessary switching.

Cost of Multitasking in a Sequential Workflow

We introduced additional tasks during navigation to simulate the variety of activities people might engage in during expedition such as pointing landmarks (e.g., where is my house in relation to where I am now), diversion tasks (e.g., have to go somewhere else first), and serendipitous discovery (e.g., star a restaurant to check up later). We observed that these tasks often interrupted the workflow of current navigation tasks. For example, while P2 and P4 were using the navigation view and they found places they were interested in (e.g., café), they weren't able to save or search it without going back to the Map view. Then they lost the current location and progress and had to start over. When asked to point to the direction of a landmark or estimate the distance, most of participants would go back to the Map, search for the place, retrieve and information and start again. Being able to multitasking without losing the current history or status could be useful for more complicated contexts than simple navigation tasks.

Spatial Awareness

The neighbourhood familiarity test was designed to assess participants' spatial knowledge acquired including route/ procedural (a sequence of points), landmark (a single point) and survey (spatial relation of at least two points) knowledge [2]. We asked participants to use paper, 2D maps to a) draw routes between two locations, b) to mark the locations of landmarks that they would have viewed while on route (e.g., a dentist office), and to mark where an image of a landmark (e.g., an image of corner flower shop) belonged on the map, c) to draw arrows from a marked landmark to the direction of an unmarked landmark (e.g, if you were standing at the starting house, what direction is the vet). On average participants drew 1.1/2 routes, marked 4.3/7 locations, labeled 2/10 images and drew 2.2/3 directions correctly across the neighbourhoods. We found there was a marginal difference for the labelling score ($Z=-1.845$, $p=0.065$), with lower scores in Dartmouth, which may be due to the lower familiarity in that neighbourhood.

Getting Lost, Reorienting, and Street View

Participants got lost (i.e. disoriented as to where they are or what direction they are heading) 3 times on average during the entire study. The main reasons were missing / poor signage (e.g., a dentistry inside a building), inaccurate or vague location data (e.g., a dry cleaner that has moved), and destinations that didn't match expectations (e.g., a museum looked like an ordinary house). The voice guidance reminder, the addresses, the GPS arrow and the map all helped participants to get back on track.

7/10 participants switched to Street View as a strategy for reorienting, but found it not helpful if it showed multiple buildings but not the exact destination (4 participants), the images are outdated to reflect the reality (3) or users were not familiar with the place (2). An AR view is similar to Street View in some ways, but provides real-time visuals and visible markers for a destination or other POI.

Star-based Route Planning

In terms of multi-stop route planning, the star feature was thought to be helpful in saving locations for future use and aiding spatial visualization. For example, P7 noted: "*You can visually see where all the points are and create a route*." However, no explicit itinerary for multiple stars led to extra checking the names of the stars and not remembering the itineraries. 5 participants suggested having a list of all saved points by name or number. Also some participants failed to plan an efficient itinerary that they had to backtrack or revise the planned route. 2 participants complained they couldn't "*letter*" or "*number*" the stars to create a route connecting all the different points to avoid backtrack. 3 participants wanted the application to show the optimal route "*in terms of time or of priority on my choice*" (P8).

BLOCK PARTY DESIGN

Using the outcomes of the prior two studies and the feedback provided by participants on our early prototypes, we designed Block Party to support: 1) easy switching among distinct views that support diverse tasks 2) synchronized data/operations among views. 3) a directory-based list of POIs. 4) explicit support of planning, creation, and modification of multi-point itineraries.

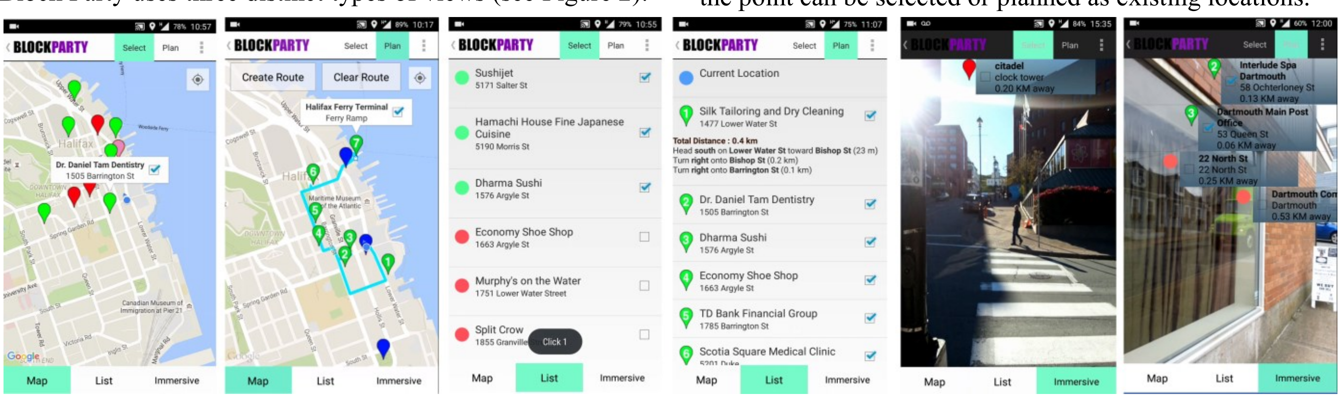
Coordinated Multiple Views

Block Party uses three distinct types of views (see Figure 2): Map, List and Immersive views toggled with the bottom menu to facilitate easy switch among different ways to view the data. Each view has a Select and a Plan+go mode toggled with the tab bar in the top right corner to *select* POIs from a number of potential locations and *plan* an order of visiting the selected POIs. The Map view is a top down 2D map display with points shown as markers (A) or numbered points connected with a highlighted route (B) to provide a big picture of the area. The List view displays location information (i.e., name & address) in a list (C) or ordered list of points with textual turn-by-turn directions between any two points (D) to support navigation from one point to another. To give a sense of where clusters of services are located and visualize relative location of the next destination, the Immersive view uses an augmented reality view with the camera stream and displays the name, address, and distance from the current location of a point in a box when the user holds their camera in the direction of the point (E), or multiple ordered points (F).

We maintained constant states across the three views such that when one location was selected in one view (e.g, Map), it was automatically selected in the other two views; when a particular order was planned for multiple points in one view, the data was updated for the other two views. The synchronized data was designed to support expedition tasks that might require multiple views at different stages. In Google Maps, same data (e.g., address) is often available in one view (e.g., Map) but not in another (e.g., Navigation).

Directory-based locations and Annotation

In addition to searching, we mocked up a directory-based location database to facilitate discovery of unfamiliar areas. Selecting a location and a category (see Figure 3, A) from the home page would generate a list of curated POIs in all three views. The services under each category are pre-defined by the researchers for the purpose of evaluating the prototype. When users find places of interests on the way, they can click on the Map view and type the name and description of the location in the popped up window (Figure3, C). A pink marker will be added to the map and the point can be selected or planned as existing locations.

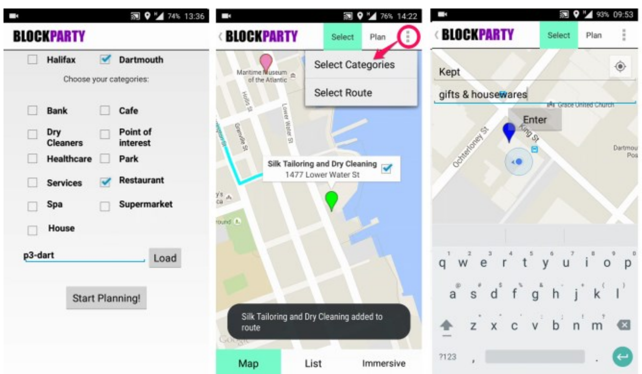


A. Map (select) B. Map (plan+go) C. List (select) D. List (plan+go) E. Immersive (select) F. Immersive (plan+go)

Figure 2. Map, List and Immersive views with both Select and Plan+go modes in Block Party.

Multi-point Route Planning

Once the user has selected a category (e.g., bank), a list of POIs shows on the Select mode of the Map view as red markers by default. By clicking on the wanted ones and select with checkmarks, the markers will change to green and appear in the Plan+go mode as blue markers. The user can keep selecting new POIs from other categories (Figure 3, B). All the selection history will be saved in the Plan+go mode as blue markers. As the user click each location in the Plan+go mode in a desired order, the markers are numbered in turn and an itinerary was created. Being able to transition between Select and Plan+go mode allows for checking, adding other locations (in Select Mode) without breaking the existing itinerary (in Plan+go Mode) thus the ability of performing multiple activities in expedition.



A.Categories B.Select categories C.Annotation

Figure 3. Location selection and annotation in Block Party.

Implementation

Block Party is an Android application using the phone's GPS, camera and orientation sensors, the Google Maps API and a third party augmented reality API. The multipoint route in the Map view was determined through calls to the Google Maps API.

By demonstrating the concept and prototype of Block Party in the preliminary and Google Maps studies, participants imagined the AR view would be beneficial for people who are poor at translating map and world orientations or easy to get lost. We considered all feedback and made a number of revisions such as adding select and plan+go modes to all views, and avoiding overlapping POIs in the AR view. We further evaluated Block Party through an adapted version of the Google Maps study.

BLOCK PARTY FIELD EVALUATION

We recruited 10 new participants for Block Party, and replicated the study design and analysis methodology of the Google Maps evaluation for comparison with the following differences: 1) the location database had a few different destinations (e.g., dry cleaners) that participants could choose from due to business changes since the prior study. Most POIs remained the same. 2) two images in the familiarity test were updated due to business changes or city renovation. 3) we logged the view usage data (e.g., view, mode, timestamp) and one researcher collated the data with video/screen capture and assigned the tasks participants performed on each view. All other differences in the study protocol result from the design differences between Google Maps and Block Party (e.g., directory selection vs. search, Block Party's annotation feature).

Recruitment

Participant demographics were similar to those of the previous study: participants (5 male, 5 female versus 6 male, 4 female) were recruited from the Dalhousie University community, between the ages 18-38 (Median = 26). Participants had average self-reported sense of direction, scoring 4.6 (SD=0.8) on the SBSOD Questionnaire, which was not different from the previous study (M=4.6, SD=0.6, p=.38). The average familiarity score was 3.8 (SD=0.4) with Waterfront and 2.7 (SD=0.9) with Dartmouth. As before, participants were more familiar with Waterfront (Z=-2.5, p=.013). 9 participants were students from a diverse background (e.g., health, art, law) and one was a professional. 8 participants rent and 2 own their current home/apartment. When finding their current residences, 9/10 participants used online sources, 4 used real estate agents/companies and 2 used mobile maps.

RESULTS

On average participants took 2 hours to complete the study, with mainly less time on wayfinding (e.g., search POIs, navigation, get lost) compared to the prior study (2.5h). Participants used diverse combinations of views both among different tasks and within the same task. With Block Party, participants made less switches during navigation, had less interruption when rerouting during expedition, and retained more route and direction knowledge than with Google Maps. Multi-stop itinerary planning was useful in neighbourhood expedition.

View Usage

We compared the proportion of total time participants spent on each view for each type of task between Google Maps and Block Party (see Figure 4).

While participants mainly relied on the Map View to plan an itinerary with Google Maps, those with Block Party behaved differently: 6 participants mainly used the Map whereas 4 participants used a combination of Map and List – List to select POIs among many options (rather than clicking each POI on the map to retrieve descriptions), and moving to Map to visually figure out an order.

For pointing to POIs, participants relied on directions of the arrow on the Map in Google Maps to orient themselves. With Block Party, most people chose a combination of Map and AR view, 8 people spent more than 70% of time on AR view as it's "*a lot easier*" (P1) to point and check distances information. Map was used to select POIs and sometimes as a means of confirmation or to roughly identify directions.

For navigation from between POIs, 6 participants spent more than 75% of their time on Map and the rest with AR or List view, 3 used equal or more time on List than Map, and 1 used Map mostly. A common pattern was to use the AR view to establish the general direction of the next POI before departing and then switching to Map or List. The AR view was also used to confirm that they were approaching their destination. With Google Maps, more participants used Navigation view. Using Map to get the lay of the land first, follow Navigation, and confirm with Street view when nearby the destination was typical.

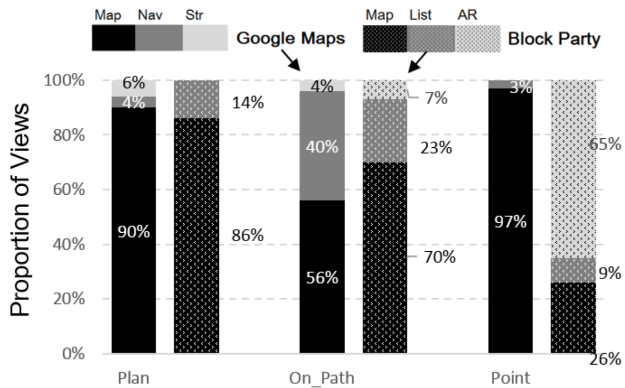


Figure 4. Proportion of view usage comparison on task type.

Coordinated Multiple Views & Easy Switching

In addition to participants switching views to begin a new subtask better supported by another view, there were also cases when participants switched views during a task. We summarized three main reasons for this.

Cross-checking information. 6 participants switched to AR view when they were disoriented, couldn't find or weren't sure about the destinations. 4 switched to others when the directions of List were confusing.

Serving complementary purposes. For example, for planning a route, List allowed users to look for specific names to pick while Map provided visualization of where all the locations are. For navigation, some used Map or AR to confirm being on the right track, and List for turn-by-turn directions. P1 said: "(with Map) *I couldn't know which direction I am to start with. Immersive complements that…It's almost like combining it*." For pointing a location, some participants first looked at the map to get a sense of "*whether it's in front of me or behind me*" (P8), and then switched to AR view for precise directions.

Extra information. Sometimes information in a different view can be easier to use or unique. For example, participants switched from Map to List to easily see addresses or the destination is on which side of the road.

As the walking phase saw the most diverse usage of views, we compared the total number of switches between Google Maps and Block Party when walking. We found across all the participants, the median number of switches using Google Maps is 33 and Block Party 13 during walking. Participants in two studies switched views for similar reasons, but the result shows Block Party might be able to reduce the number of switches required among different views with designs to support easy switch among coordinated views.

7 participants liked the concept of easily switching between different views. P8 commented: "*the list and the immersive were useful for different tasks, and it was nice if you could switch quickly between them*." Similarly, P4 noted: "*I really like how quickly it was to switch between map, list and immersion...I would flip them back and forth so frequently*." P6 found it less distracting if all the information is not on the same screen. However, people didn't necessarily like switching *per se* as it was extra interaction. For example, P5 liked "*the separation between everything and the immersive view, immersive being its own kind of thing*" but wanted map and list to be "*compact in one*", whereas P1 liked "*condensing*" list and immersive "*so that you just have to switch between two (views) instead of three*".

Multitasking Support & Rerouting

While participants saved 36 POIs in total (twice as many as the 18 POIs bookmarked using Google Maps) for future use and pointed to 12 POIs on the way, none of them have to abandon the current route to perform those tasks. For the 4 diversion tasks (e.g., go to somewhere outside the planned route), 6 participants recreated 2 routes on average: 1 rerouted every time a diversion happened and others only recreated a route when they were unsure of the destinations or the route looked complicated with lots of turns. 4 participants didn't recreate routes at all, as P5 said, "*so that we don't disturb our route*". Being able to add new locations to the map via Select mode without changing the history in the Plan+go mode supported flexible multitasking and easier returning to the current workflow. The cost being additional within-view switches and added complexity to use the interface. On average, participants transitioned between the Select and Plan+go mode within the same views 16 times across the study: 7 times in plan phase, 6 in walking and 3 in pointing. In a few cases, participants couldn't find the intended locations in one mode (e.g., Plan+go), which were supposed to appear in the other mode (e.g., Select) only.

Improved Spatial Awareness

On average participants drew 1.8/2 routes, drew 2.7/3 directions, marked 6/7 locations and labeled 4.3/10 images correctly with Block Party. Similarly, there were difference for the marking locations score (Z=-2.271, p=.023), with lower scores in the Dartmouth. Using Spearman's correlation test, participants with higher familiarity with the areas tend to rank higher on marking scores (r_s=.49, p=.03) and labeling scores (r_s=.56, p=.01) while self-reported sense of direction has non-significant correlation with test scores.

After adjusting the impact of the two changed images for labeling test (the average score for one image is higher than the original one), we compared the number of correct answers for the familiarity test between Google Maps and Block Party (see Figure 5). Mann-Whitney U tests indicated that participants performed better with Block Party than Google Maps on all the tests: route (Z=-2.4, p=.016), direction (Z=-1.98, p=.048), marking (Z=-2.56, p=.01) and labeling (Z=-2.74, p=.006). As the overall familiarity with both locations is slightly higher in the current study (3.3 vs 2.8, Z=-1.8, p=.073), we compared the test score in Waterfront only because the familiarity in both studies has no difference (3.6 vs 3.8, p=.335). The results were similar: all the test scores were higher than in the Google Maps study (p=.022, .053, .012 & .029). Ruling out the potential impact of the familiarity difference with the study locations, the results suggest Block Party might at least increase the route and direction awareness comparing to Google Maps.

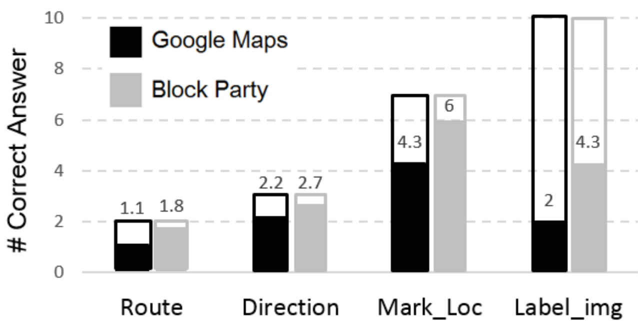


Figure 5. Familiarity test performance comparison.

Directory-based Location Selection and Annotations

6 participants thought the directory-based selection system was quite useful because of the recommendation of specific types of places (e.g., "this category gives me the whole picture of the city", P10), no prior knowledge assumed (e.g., "*I don't know how people call it [to search for it]*", P8), and limited selections in each category (e.g., "*you don't have to sift through much information, it's already curated*", P3). In general, participants wanted more fine-grained filters to narrow down their options such as displaying locations by distance (e.g., < 200 meters) or more specific categories (e.g., split different types of doctors). Other issues include missing categories and having to guess the categorization when selecting POIs.

9 participants saved serendipitous locations during their journeys that reflected diverse personal interests (e.g., shops, services, tourist attractions). The varied descriptions they used were general (e.g., "food", "restaurant") or specific (e.g., "pizza", "Lebanese", "dinner").

Multi-point Route Planning

All participants created highlighted multi-point routes. Participants cited their convenience ("*instead of having to go back, erase and type in the next stop*"-P5), efficiency ("*it was useful to…create a route that would go as much in a circle or square to save your time*"-P1), and support for in situ changes ("*especially if there is more than one place, it's very useful that I add it into the route…it would be easier for me to follow*"-P8).

DISCUSSION

General Feedback on Neighbourhood Expedition

Most participants had positive overall experience with Block Party. P4 thought it was a fun tour and commented: "*Just check on places and add to my itinerary. It's more of a tourist tool in my mind*." P2 liked how Block Party "*assumes you are walking…I'm here, what are things around me*". P5 found "*it was actually very entertaining…It had more options to use than just a map and directions*." Participants suggested features beyond planning and navigation for neighbourhood expeditions, including supporting in-situ experiences such as interactions with people, places, and events, providing recommendations for local establishments and services, and general descriptions of the neighbourhood itself.

Differences in View Usage and Familiarity Tests

Dünser et al. found a combination of Map and AR interface was preferred over single views because of more choices and no best view could suit varied situations [11]. Similarly, Block Party allow for more diversified usage of combinations of views. For example, when given the options, participants added List in planning and AR in pointing tasks instead of relying on a single view.

Participants using Block Party did better in all spatial awareness questions. Familiarity with the neighbourhood certainly played a role, but couldn't fully explain the difference. As users may often understand their data better if they can view it through different representations [33], the convenience to crosscheck, access complementary or additional information in our CMV design might have facilitated memory of route, direction etc. Another possible reason is that participants using Google Maps paid less attention due to less workload required by the forward-up navigation view [41] or more interrupted workflow dictated by Google Maps' design. Also Street View might require more time while AR was "*really fast*" (P8) in telling exactly where things were. Further investigations with stricter control and larger sample size would be useful.

Feedback on Spatial Views in Block Party

Map View was favoured by most participants. Combining survey, route, and landmark information facilitated understanding and recollection. As P8 said: "*When I see it on the map and I see it in reality, the two kinds of memories go together and it helps it stay in my mind*". In accordance with prior research, 3 participants had trouble figuring out directions with the north-up map orientation. 2 participants wanted to see distance information on the map in a manner similar to List and AR.

List View's instructions provided useful information such as street names, distance to the next turn, and which side of the road the destination will be on. However, 3 participants found it hard to orient using only the textual "west" or "east". Others felt they wanted more context ("*you have to know where streets are*", P2). ("*I feel in a vacuum because I just have street name, I don't know…what should be* *around me*.”, P7). One participant suggested adding a compass to show the relative direction of each street.

AR View received positive feedback from almost all participants. It was useful to get “*a general sense of direction*” (P1) to orient and confirm they were on the right track. It helped “*figure out where things are instinctively*” (P4). Half of the participants complained about instable location labels due to the signal fluctuation. 2 felt awkward holding the phone vertically while walking in public, and 2 mentioned that the view became cluttered with POIs at certain points. P4 suggested adding route detail (“*...paint the blue line down the road*.”), and P8 wanted access to more detail (e.g., names, pics, reviews) so she could “*stand on the street and scan*” her immediate environment.

Participants suggested that in addition to keeping views *synchronized*, they should be made as *consistent* as is reasonable. Several recommended providing estimated time and distance to a selected POI on all three views. Kjeldskov et al. found route planning information should be based on users' current time and location, and key information such as walking distance and travel time should be easily accessible [17], which are in line with our findings.

Getting Lost, Reorienting, and AR View

Participants got lost on average 2 times across the study using Block Party. The reasons were similar to the Google Maps study: poor signage, a moved business, issues with GPS updates and accuracy. From the human error side, the common cases were that participants went to the opposite direction or thought the destination was on the opposite side of the road. Participants used addresses/ distance information, Map, natural landscape such as water as reference, and the AR view to reorient themselves. But the error occurred mainly because of the difficulty of mental rotation and manipulation of the Map view. As P8 noted: “*to look at the map then transfer that to reality and know which direction to go would be hard for me, and it would take me a while that I really think it through*”. P10 said “*I tried to reverse directions in my mind*” but reversed left and right a couple of times.

Furthermore, during both studies 7 people reoriented the mobile phone, the map, and themselves at multiple points for various tasks: to make turning decisions, find directions, or mentally generate a route. This showed the mental rotation consumes significant cognitive resources and that people relied on physical rotation to facilitate comparison. Seager et al. showed that physical rotation is the most effective and preferred navigation assistance [35]. AR view is such an ego-centric view that saved users' work of mental rotation and had the additional benefit of translating the cartographic representations to the real world.

Limitations and Future Work

The current work is limited in terms of study design and interface design. For study design, while 10 participants in each study is a relatively small sample to compare the two designs, we combined quantitative and qualitative insights obtained through multiple test settings to strengthen our conclusions. In addition to homebuying scenario, other neighbourhood expedition scenarios should be considered in future work. For example, tourists might differ with home buyers in having less prior knowledge (e.g., of street names) and may get lost more easily. By leveraging the user's visual context, an AR view might be more useful than a List view in this case. The study tasks were designed around planned excursions with emphasis on navigation which do not represent a full picture of learning about a neighbourhood. However, this focus was derived from the limitations of the point to point design of Google Maps and used as inspiration for Block Party's design. While we identified a need for locative annotation and added this to Block Party, a full consideration of how annotation support integrates with locative information retrieval for neighbourhood expedition is left for future work.

For interface design, additional views (e.g., street view, ego-centric navigation views) could be integrated to complement the current design. A hybrid system with both searching and directory-based selection might be more useful. A more controlled comparison between coordinated synchronized views and a compact view which combines different views on one screen would be interesting. Community built itineraries and annotations can be further explored as a means to build neighbourhood awareness and community.

Aporta and Higgs distinguish technology that “physically and socially” engages from technology “that reduces engagement with experience of the land, people, and local knowledge” [4]. Leshed et al. [20] argue that GPS-based wayfinding apps can detach people from physical and social interactions, and suggest redesigning GPS interfaces with environmental engagement as goals. How mobile guides might be designed to help discover, understand and appreciate the physical world, and enhance social engagement with other pedestrians or social networks remains a key research challenge.

CONCLUSION

We presented the design and comparative field evaluation of an application called Block Party with a popular point-to-point navigation and search application (Google Maps) in support of neighbourhood expeditions. With a design emphasis on synchronized, lightweight spatial views, curated directory-based POIs and explicit support for multi-stop itinerary planning, Block Party was found to improve the efficiency of the wayfinding workflow, and better establish spatial awareness in the visited neighbourhoods.

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