Abstract

This paper details the development and deployment of an online seven day travel/activity diary and companion smartphone app in Sydney, Australia. The diary employs several innovative features to simplify data entry, while the app generates maps to assist recall. Based on 847 participants, 76% complete all seven days, 16,361 of 16,386 recorded trips are provided with complete details, trip entry times average two minutes/trip and three-quarters of trips entered within 24 hours of being made. Over half the participants download the app with strong indications this improves the accuracy of trip reporting.

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Keywords: Online travel diary; smartphone app; participant recall

1. Introduction

Designers of travel surveys are continually searching for approaches to improve the quality of data collected, encourage participation and reduce participant burden, while keeping costs down (Stopher and Greaves, 2007). New technologies have played, and will continue to play, an increasingly important role in achieving this goal, both in terms of providing new opportunities for interacting with participants and (passively) collecting location data. Building on this, there is growing interest in using smartphones because of the options they provide for participant...
interaction, tracking (GPS, Wi-Fi, mobile network location, Bluetooth), and pragmatically, their increasing proliferation within the population (for instance, two-thirds of Australians now own a smartphone). This has manifested in several efforts to design surveys using smartphone capabilities (Abdulazim et al., 2013; Fan et al., 2013). However, diaries will remain crucial to many applications and, for this reason, methods that make use of smartphones to improve the diary experience rather than simply replace them are of particular interest.

Within this framework, the current paper details the development and deployment of an online travel/activity diary and companion smartphone app, designed to support a major study of travel in inner-city Sydney, Australia. Briefly, the aim of the study is to investigate changes in travel behaviour and health indicators of residents before and after the construction of a major piece of cycling infrastructure (Rissel et al., 2013). The diary, designed to run for seven days, employs several innovative features to simplify the process of data entry, and improve participant recall and completeness of travel data. These features include auto-fills, prompting for public transport access mode, and the ability to save and recall favourite trips. The smartphone app uses Wi-Fi and network location capabilities of participants’ own phones to passively record their travel during the survey period. These positioning methods do not drain the phone battery as much as GPS, and are therefore appropriate for 24 hour use over seven days. The location data is used to generate daily travel maps, which the participant can view while completing the online diary, as well as to verify trip details reported in the diary.

Pilot testing of an earlier version of the diary on 37 participants produced a largely positive reaction with 89% of participants completing all seven days of the diary and 75% of participants indicating no issues once they become accustomed to how it worked (Greaves et al., 2014). Trip entry times averaged around two minutes per trip, with 75% of trips entered within 24 hours of being made and 96% of trips provided with complete details. This version of the diary did not include the smartphone app; rather, participants carried a small GPS device with them, the data from which was found to be less complete and of lower quality than that recorded in the diary. However, it emerged that those carrying the GPS device appeared to be more diligent in recording travel information in the diary, supporting findings that have been reported elsewhere (Stopher and Greaves, 2010).

Following pilot testing, an updated diary and smartphone app were developed and deployed for the main wave of the fieldwork. The current paper reports on the findings from 847 participants recruited into the first wave of the study during the Australian spring of 2013. The large sample provides a robust opportunity to gauge participant comprehension and interaction with the diary and app, reaction and burden, and completeness of data provided and observe how this varies by key demographic indicators. Following this, we assess the impacts of the app on levels of reporting, by comparing key trip metrics from the diary for those who installed the app versus those who did not. Finally, we draw conclusions about the merits of the approach, providing guidance for survey designers considering similar approaches in the future.

2. Literature Review

Travel diaries have been used extensively to collect the individual and household travel data required for a range of planning applications (Elango et al., 2007; Transport Data Centre, 2009), as well as more targeted studies of travel behavior (Hensher and Reyes, 2000). While much has been written about the design of ‘good’ diaries, the principles suggested by Kenyon (2006) capture the essentials: namely that the diary should be quick and intuitive to complete, have a shallow learning curve, and prompt participants for the required information at every stage. Despite continuing improvements in design, diary surveys continue to be plagued by declining response rates, errors caused by misinterpretation, skewing towards more literate population cohorts, etc. (Richardson et al., 1995). These problems become accentuated for multi-day diaries, with evidence suggesting increasing rates of activities and trip details being forgotten, or inadvertently telescoped to the wrong day (Stopher and Greaves, 2010).

In theory, the migration from a paper-based to web-based environment provides greater potential to address these issues, while at the same time engaging participants through user-friendly interfaces underpinned by logic that minimises the input time required and potential for error. In practice, some of these advantages have been eroded by the tendency to replicate paper-based diaries in an online environment and to over-estimate the ability/willingness of participants to complete the instrument. For instance, Theriault et al. (2013) developed a web-based version of a paper diary to study car share behaviour in Quebec over one week. While the survey employed many innovations, the number of fields on one page, 96 in total, was overwhelming, with just over one-third of participants completing
all seven days. Other approaches have focused on enhancing the user interface and logic to both engage and retain participants. For instance, Bourbonnais & Moreney (2013) detail an activity/travel diary designed to replace an established CATI survey in the Quebec region. The diary uses an interactive approach to take participants through each activity, with an online map to help respondents find addresses. An initial survey using this diary saw 60% of participants completing the diary. Further improvements to a standard travel diary have been made by Ali and Lui (2011), using GIS software to enable participants to enter locations by entering the beginning of the name of a location or intersection, and then selecting the location from a list of matches.

Of particular interest given the objectives of the current study is the reliable reporting of short walking and cycling trips, either on their own (e.g., to the local corner shop) or incidental to access/egress other modes of transport, particularly public transport. In general, these trips are captured inadequately from travel diary surveys (Clifton and Muhs, 2012). Web-based diaries provide the potential to capture these trips, by prompting participants when certain types of trips (or absence of trips) are reported (Clark and Scott, 2013). For example, a study conducted on students in Virginia, United States prompted respondents to both confirm and explain why they had made only one trip during a day (Son et al., 2012). Additional questions were asked on the total number of trips made, which could then be corroborated against reported trips. Another, sometimes overlooked, advantage of conducting surveys in an online environment is the ability to manage the survey process while the survey is ongoing. This ranges from checking response rates, communicating with participants, dealing with queries and automating the reminder process for completing the diary, particularly for multi-day diaries (Ali and Lui, 2011; Cottrill et al., 2013). Although potentially problematic for long-duration travel studies, email reminders can be sent periodically to remind respondents to complete the diary, potentially reducing non-response rates in a manner that is less intrusive than repeated telephone calls.

A further benefit of online diaries is the potential to incorporate automated data collection capabilities to assist participant recall of travel. To date, this ‘prompting’ has largely used Global Positioning System (GPS) data, which are processed into trips that are then played back to participants, who verify/edit the trips themselves and provide additional information about each trip (Cottrill et al., 2013). An important issue here is the timeliness with which data are processed into trips and played back to participants, particularly for multi-day diaries, as participants may become confused between days. Evidence suggests this is manageable over several weeks for car travel, where the processing challenges are relatively simple and data can be played back within hours (Greaves et al., 2010). However, the challenges for person-based GPS travel are much greater, due to pragmatic issues around relying on people to keep devices with them and charged, and higher rates of spurious data making trip identification more challenging (Stopher and Greaves, 2010).

To date, GPS data captured in this manner has largely involved customised devices, which, pragmatic issues aside, involve a capital cost coupled with delivery and retrieval costs. A potential alternative is to develop an app, which performs a similar tracking function, that can be downloaded onto a smartphone/mobile device, with data communicated to a web-based interface for viewing (Hudson et al., 2012; Abdulazim et al., 2013; Cottrill et al., 2013; Fan et al., 2013). This has the financial advantage of being able to widely deploy the app at little marginal cost and, assuming this is the participant’s own smartphone, the pragmatic advantage that the participant is more likely to keep the phone with them and charged (Cottrill et al., 2013). Admittedly, several challenges remain here around battery drain being seriously accentuated when using location tracking sensors on the smartphone, and ethical issues around the use of a participant’s device. However, we argue here that both these problems appear surmountable in the near future. This is partly due to improvements in technology improving the efficiency of GPS and other location sensors, but also due to societal changes in which privacy is becoming less of a concern (Lindqvist et al., 2011).

3. Survey Design

3.1. Web-based Travel Diary

The specifications for the online diary were that it needed to be straight-forward and quick to complete, flexible in terms of when/where it could be completed, and (most importantly) capture incidental walking and cycling activity. Following pilot testing and subsequent modifications, the final diary worked as follows. The initial screen
asked for home and work (where applicable) details including address information. Participants then completed the diary for the previous day with the option of completing their travel up to the current day/time if desired. For each day, participants were asked about the activity in which they first participated. Subsequently, participants entered basic details (origin, destination, departure time, arrival time) for the trip to access that activity (Figure 1). Following this, participants were asked for details of the modes of transport used for that trip in the order in which they used them via a drag and drop interface (Figure 2). To capture incidental walking and cycling, participants were prompted for the access/egress mode where applicable, using a prompt, e.g., “How did you get to the train?” Additional information was collected for bus, train, light rail walking and bicycling segments. Finally, a summary of the trip was provided and participants were prompted to record anywhere else they had travelled that day. Following completion of all the trips for a particular day, a summary of all the trips was shown and participants were asked to confirm that details were correct before advancing to the next day of the diary. Data were written to the database at the completion of every step and re-entering the diary would return the participant to where they left off previously.

Figure 1: Activity Screen.
The diary encompassed several key features designed to reduce completion times and improve data quality. Tips and a page-specific help section could be accessed on every page of the diary. Many fields included auto-completion functionality enabling participants to type in part of the origin and destination place names, which brought up the most relevant known places. These included schools, shopping centres and train stations (among others) in the study area, as well as the origins and destinations of trips they had already entered. Furthermore, the diary was designed to pre-fill fields where the answer was already known or highly likely to be known. For instance, a trip’s origin was automatically set to the destination of the previous trip, and the departure time was automatically set to the arrival time of the previous trip. Similarly, if the trip activity was ‘returned home’, the home location was pre-set as the destination. In an effort to further reduce burden, repetitive trips could be saved as favourites and recalled for future trips – in this case, all the fields apart from arrival and departure times were automatically filled in, implying that participants only had to confirm that the other information was correct before continuing. At the completion of a day, if the last trip did not end at home, participants were prompted to confirm that this was correct. A summary of the day’s trips were shown on the right hand side of every page (Figure 1) enabling participants to see, at a glance, the information they had already entered and – if necessary – modify, delete or add trips. Finally, for participants that elected to take the smartphone app (detailed in a later section), a map showing recorded travel for the day could be displayed or hidden by clicking on a navigation link at the top of the page.

To access the diary, participants were provided with a unique URL that contained a hashed identifier preventing participants from guessing the identifier associated with other participants and thereby gaining access to another person’s diary. The diary URL could be accessed through a study website, and a direct link to the diary was provided in daily reminder emails avoiding the need to remember a username and password. The diary worked for all popular computer browsers (Microsoft Internet Explorer, Mozilla Firefox, Google Chrome and Apple Safari) in addition to iPad, iPhone and Android devices.
3.2. Reminder System

The pilot study demonstrated that email reminders were crucial to participants both beginning and subsequently completing all seven days of the diary. The system worked as follows. First, participants were sent a ‘heads-up’ email on the Friday before their diary period started, notifying them that their diary period would begin on the following Monday and reminding them to install the app. On the Tuesday, a ‘diary start’ reminder was sent, asking them to complete their travel diary for the previous day, and providing a direct hyperlink to their diary. This same email was sent daily until they started the diary. Once they began the diary, a ‘diary reminder’ email was sent on days where they had not completed the diary for the previous day, until they had completed all seven days. These emails were set to go out at 11 a.m. each day, the rationale being that in addition to people being more likely to respond to emails in the late morning (Experian, 2013), this provided time to generate a list of recipients that could be sent out early enough for people to complete their diary before they forgot.

3.3. Optional Smartphone App

The purpose of the optional smartphone app was two-fold. First, as a means to assist participant recall of their travel (Figure 3) as they completed the diary and second, as a means of verifying/correcting data collected by the diary (Clifton and Muhs, 2012). Further, it was conjectured that, based on the results of the pilot and elsewhere, carrying the smartphone could increase the diligence with which participants completed the diary (Stopher and Greaves, 2010).

![Example Smartphone Trace to Assist with Recall](image)

The app needed to have as little negative effect on the participant’s everyday use of their smartphone. Initial testing showed that, despite the obvious appeal, using a smartphone’s built-in GPS capabilities seriously compromised battery life. Instead, the use of network and Wi-Fi location (location calculated using telecommunications towers and Wi-Fi respectively) was thought to provide a better balance between battery life and the need to collect location data of sufficient quality for the purposes of the study. To test this assumption two versions of the app were developed, one using GPS and the other using Wi-Fi/network location. The two versions were otherwise identical. The two apps were used by the researchers for a number of weeks and the data were subsequently compared. Testing of the app using both GPS and network/Wi-Fi location showed that network/Wi-Fi location provided sufficiently accurate positions in urban areas whilst limiting the effect on battery life.
Additionally, data from network/Wi-Fi location were often of better quality than GPS in the heavily built-up study area, due to reduced susceptibility to the urban canyon effect on signal degradation. As an additional confirmation, in the main study some participants used the smartphone app and carried a dedicated GPS tracking device with similar results (Ellison et al., 2014).

Versions of the app were developed for both the Google Android and Apple iOS operating systems; it is worth noting that, in the case of Apple, the app had to go through a stringent process of testing and approval before being released but the Android version did not. The app was made available to participants using the Google Play Store and the iTunes App Store, and could be found either through a search or by following the direct links provided in the welcome emails sent to participants. Once participants had installed the app, they were prompted to enter their name and an activation code that had been e-mailed to them. The activation code was required to ensure that the user of the app was a participant of the study, and to link their app to their diary. Prior to activation, the app continued to record the participants’ travel and allowed them to view their maps, but they were unable to access their diary from the app until activation was successful. Given respondents did not always enter the correct activation code, the app was designed so that it could be manually activated by the University of Sydney research team if required. In practice this was required for only a small number of participants.

The app was deliberately designed to be simple to use, providing only a small amount of information about their participation in the study (start and end dates in particular), as well as buttons to view their maps and go to their diary. Crucially, once the app was installed, it recorded participants’ travel and uploaded it to the University of Sydney’s server in the background, and automatically started when users started their smartphone. This meant that participants did not need to actively use the app, but were still able to view their travel in the app itself or in the diary. Two days after the completion of a participant’s seven day study period, the app automatically stopped recording their travel.

3.4. Survey Management

Among the advantages of working in an online environment was the ability to employ an efficient survey management system. Building on the experiences gained in the pilot survey, a management interface was developed, which was only accessible to the University of Sydney research team. This enabled them to check the general status of each participant, including the last time they accessed the travel diary or last time any smartphone data were uploaded, and view trips and associated smartphone data.

4. Fieldwork

4.1. Survey Recruitment

The survey period ran from September to December 2013, which marks the spring period in Sydney. In line with the wider objectives of the study, participants were recruited from a geographic area encompassing new planned bicycle infrastructure (intervention area), and a neighbouring area of similar demographics with no new planned bicycle infrastructure (control area); these are shown in Figure 4. In addition to residing in these areas and indicating they planned to stay there for at least one year, recruits needed to be aged 18-55 and capable of riding a bicycle. Those who met these criteria first completed an online questionnaire covering health, quality of life, and general travel-related questions, before going on to complete the second phase, the seven-day diary. Given the specificity of the geographic area, the sample itself, and the demands of the survey, despite the offer of a $50 AUD incentive, recruitment proved challenging, with a variety of methods (online sources, telephone, face-to-face intercept) required to achieve the final sample of 847 participants completing the questionnaire phase of the study.
Of the 847 participants completing the questionnaire, 754 (89%) started the diary with 641 (76%) completing all seven days. The age/gender breakdown by intervention and control areas is shown in Table 1.

Table 1. Diary Completion Rates.

<table>
<thead>
<tr>
<th></th>
<th>Intervention Area</th>
<th>Control Area</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
<td>Male</td>
</tr>
<tr>
<td>18-34</td>
<td>89</td>
<td>99</td>
<td>121</td>
</tr>
<tr>
<td>35-55</td>
<td>121</td>
<td>87</td>
<td>95</td>
</tr>
<tr>
<td>No. completing questionnaire</td>
<td>89%</td>
<td>91%</td>
<td>88%</td>
</tr>
<tr>
<td>% starting diary</td>
<td>80%</td>
<td>91%</td>
<td>88%</td>
</tr>
<tr>
<td>% completing all 7 days of diary</td>
<td>64%</td>
<td>77%</td>
<td>69%</td>
</tr>
</tbody>
</table>

Exit surveys completed at the end of the diary period suggested that overall most participants had enjoyed the survey, with 90% indicating they would be willing to complete the survey again in 12 months time. In terms of the diary, 75% of participants indicated they generally had no issues once they became accustomed to how it worked, with negative reaction generally focused around functionality issues, such as browser type/version and speed, and
the device used to access the diary. Usage information showed that PCs were used to input 48% of trips, Macs
(23%), iPads (9%), iPhones (14%), and Android devices (6%), with several participants using more than one type of
device during the survey period. With almost one third of trips being entered using mobile devices, the need to make
the interface mobile-device friendly was an important aspect in the design.

Of particular interest was gauging participant usage of the survey, including when they accessed the diary, how
long it took to complete, and the time-lag between when trips were made and when they were recorded in the diary.
Access times for the diary revealed a similar pattern to the pilot survey, with a peak of activity around 11 a.m.,
coinciding with the sending of the daily email reminders, and a relatively sustained pattern of access throughout the
afternoon and evening (Figure 5). Completion times, an indication of burden and diligence, showed the majority of
trips were completed in less than two minutes, translating to around 10 minutes per day (Figure 6). Again, there was
a tendency for completion times to come down as participants became more familiar with the diary over the seven
day period.

![Figure 5: Session Start Times for Completing the Online Travel Diary.](image-url)
4.3. Data Quality Indicators

As discussed previously, the online diary incorporated many features designed to improve the quality and completeness of data, while aiming to minimise participant burden. Of the 641 participants who completed the diary, 33 were excluded. The most common reasons for exclusions were living outside the study area and having a large number of mismatched origins and destinations, typically representing a missing return trip. The following analysis is conducted on the 608 participants remaining, who recorded a total of 15,620 trips.

Data Cleaning

Although the diary was designed with built-in logic partly to reduce participant errors, some data cleaning was nonetheless necessary. To assist in this process, a number of rules were used to flag trips and legs/segments for verification. This included mismatched origins and destinations, unlikely trip times or segment durations, and otherwise valid trips that occurred outside Sydney. Overall, 366 trips and 55 trip segments were modified. Of the 15,620 trips, 96 trips were removed and a further 504 trips were imputed and added to the dataset leaving a total of 16,028 trips for analysis. The largest data cleaning task was identifying locations that were the same, but had been identified as separate locations due to minor spelling differences. In all, 11% (932) of locations were duplicates, while 14% had additional information added (primarily linking to the pre-fill database) or required some degree of correction (usually spelling).

Trip Segments

A key feature of the diary was the drag and drop interface for travel mode, designed to capture the different travel segments. In an effort to capture incidental travel, this included the prompting of participants for travel required to access or egress other modes of travel, something which is often overlooked/forgotten by participants in recall surveys (Clifton and Muhs, 2012). Of the 3,300 (21%) trips involving travel by more than one mode, comprising a total of 9,814 segments, 2,393 required access/egress, resulting in 4,931 access and egress segments. Of these 2,393

† 32 participants were excluded due to the diary, one due to the questionnaire.
trips, 536 (22%) required prompting for the access segment (350 trips) and/or the egress segment (394 trips), highlighting the importance of the prompting.

**Modify/Delete/Insert Trips**
Participants were provided with the capability of editing their trip information subsequent to final submission for each day. In all, 385 trips (3%) were inserted, 699 trips (5%) were deleted, while 2,032 trips (13%) were modified/corrected. This indicates both a relatively high level of diligence and the importance of being able to go back and change information.

**Provision of Address Information**
Self-reported address information is generally of mixed quality from travel surveys, because other than home, work, school and possibly one or two other frequently visited locations, participants generally struggle to recall information to the specificity required. In this diary, participants were required to provide a place name, while street name and suburb were optional. The main feature designed to improve the veracity of address information was the auto-fill functionality tied to databases of commonly-visited locations. In total, 62% of locations were provided with a street name while 98% included the suburb. Overall, 7,390 unique locations were provided (counted as once per participant), which equated to around 12 unique locations per participant, of which 1,005 (14%) came from the pre-filled database.

**Favourite Trips**
The ‘favourite trip’ functionality was designed to reduce the time burden of inputting repetitive trips. In all, 1,000 trips were set as favourite trips with an additional 1,359 trips based on a favourite trip. These were primarily commuting and returning home trips with the remainder split among a variety of activities. An interesting question is how many trips were repetitive that used (and did not use) the favourite trip function. Of 6,872 repeated trips covering 2,132 origin-destination pairs, 31% covering 754 origin-destination pairs were entered using the favourite trip function.

**Time Lag for Trip Completion**
Assessing the time lag between when travel was made and when it was recorded in the diary provides insights into diligence and potentially the reliability of data. 65 percent of trips were recorded within 24 hours of being made and 87% were entered within 48 hours, suggesting a generally high level of diligence. Interestingly, around half of trips were entered on the actual day they were made, again suggesting generally high levels of diligence.

**4.4. Smartphone vs. Non-smartphone Users**
The optional smartphone app (discussed in Section 3.3) was used by approximately 45 percent of diary participants. Since the pilot had revealed higher trip rates for those carrying a GPS device (Greaves et al., 2014), it was of interest to see if there was a difference in the diligence of participants and, as a consequence, in the quantity and quality of the diary data. The 276 participants that used the app were further subdivided by those that looked at the maps (164 participants) and those that did not (112 participants), shown in Figure 7.
Data quality was measured using the number of (valid) trips entered by participants and the number of trips that required correcting as part of the data cleaning process. Diligence was measured by the time lag between when a trip occurred and when it was entered into the diary. The time spent entering each trip was also used as a measure of diligence.

Comparisons were between the ‘No app’ and ‘App’ participants, and between the ‘Looked at’ and ‘Did not look [at maps]’ participants. Since, conceptually, those participants that installed the app but did not look at the maps would have had access to the same information as those participants that did not install the app, ‘Did not look’ participants were also compared to ‘No app’ participants.

The results indicate that users of the smartphone app that looked at the map (i.e., the 164 participants in the ‘Looked at’ category) reported the highest number of trips (average of 29.0 trips), compared to 27.1 trips for the ‘Did not look’ group and 24.8 trips for non-smartphone users. This suggests that merely installing the app is associated with higher trip reporting rates. It is possible that this is a consequence of frequent travellers being more likely to install the app, but this appears unlikely given that it is consistent with prior research using GPS devices (Stopher and Greaves, 2010).

Table 2 provides a summary of data quality and participant diligence measures. In terms of the number of trips recorded and trip completion speed, there was evidently no statistically significant difference between smartphone users that looked at the maps and those that did not. However, an interesting finding is that, while the ‘Looked at maps’ group exhibited fewer errors per 100 trips compared to the ‘No App’ group, the ‘Did not look’ group had higher error rates. One possible explanation for this is that smartphone users that did not look at the map were more likely to record trips for which they were unsure of the details and would, therefore, record a greater number of spontaneous or infrequent trips.
Table 2: Measures of Data Quality and Participant Diligence.

<table>
<thead>
<tr>
<th></th>
<th>All</th>
<th>No App</th>
<th>App</th>
<th>Did not look at maps</th>
<th>Looked at maps</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of participants</td>
<td>608</td>
<td>332</td>
<td>276</td>
<td>112</td>
<td>164</td>
</tr>
<tr>
<td>7-day trip rate</td>
<td>26.3</td>
<td>24.8&lt;sup&gt;c&lt;/sup&gt;</td>
<td>28.2&lt;sup&gt;c&lt;/sup&gt;</td>
<td>27.1&lt;sup&gt;d&lt;/sup&gt;</td>
<td>29.0</td>
</tr>
<tr>
<td>Participants with no errors (%)</td>
<td>56.6</td>
<td>57.8</td>
<td>55.1</td>
<td>52.7</td>
<td>56.7</td>
</tr>
<tr>
<td>Errors per 100 trips</td>
<td>3.31</td>
<td>3.28</td>
<td>3.34</td>
<td>3.89</td>
<td>2.99</td>
</tr>
<tr>
<td>Trip completion speed (s)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>111</td>
<td>98&lt;sup&gt;c&lt;/sup&gt;</td>
<td>125&lt;sup&gt;c&lt;/sup&gt;</td>
<td>123&lt;sup&gt;d&lt;/sup&gt;</td>
<td>127</td>
</tr>
<tr>
<td>Time lag (hours)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>17.3</td>
<td>17.6</td>
<td>16.9</td>
<td>18.0</td>
<td>16.1</td>
</tr>
</tbody>
</table>

<sup>a</sup> Excludes outliers.

<sup>b</sup> Represents the lag between the arrival time at the destination and the time the trip was entered in the diary; excludes outliers.

<sup>c</sup> Difference between ‘App’ and ‘No App’ is significant at the $p = .05$ level.

<sup>d</sup> Difference between ‘No App’ and ‘Did not look at maps’ is significant at the $p = .05$ level.

5. Conclusions

This paper details the development and deployment of an online travel/activity diary and companion smartphone app, designed to support a longitudinal investigation of travel in inner-city Sydney. The diary employs several innovative features designed to simplify data entry, while ensuring the quality and completeness of information provided is not compromised. The app takes advantage of the growing proliferation of smartphones in society to provide a low-cost method to assist participant recall of their travel, without placing undue demands on battery life, as well as to provide an independent source of verification of trip details reported in the diary. Building on a successful pilot, the survey was rolled out to 847 participants, of which 641 (76%) completed all seven days, with all but 25 of the 16,386 trips recorded provided with complete details. Three quarters of participants indicated they had no issues with the diary once they became familiar with it, and 90% indicated they would be willing to complete the study again in 12 months’ time. Evidently, the use of daily email reminders, while potentially annoying, was crucial in ensuring timely completion, as was keeping the trip entry times to a reasonable level, in this case around two minutes per trip.

The smartphone app proved popular, with over half the diary participants downloading it. Evidently, installing the app improved both the recall of trips and, in general, the accuracy of trip reporting, although this did depend on the extent to which people actually viewed the maps while completing the diary. Those not installing the app cited a range of reasons for not doing so, including not owning a smartphone, technical issues, and not seeing the value in this, e.g., “I don’t need it as I know where I’ve been”. Battery drain was cited as an issue by some, but it appeared more prevalent in Android models and was highly variable, suggesting that factors other than the operating system may be at play, e.g., interaction with other apps. Clearly, while there are intuitive advantages in using a participant’s own device, it does raise issues about designing an app that will work with the myriad of smartphone models available, and take into account different usage patterns.

Although the story was generally positive, there was clearly a significant minority of people for whom the task was too burdensome. This was more the case among prevalent the younger age-brackets and for males compared to females. One possible reason for this is that the survey did require a degree of commitment and patience (particularly if there were any technical issues affecting page loading times, which happened occasionally), and it may reflect greater intolerance within these particular demographic segments. The largest hurdle was getting participants started on the diary and completing their first day. Of those participants that completed the first day or two, very few failed to complete all seven days. In terms of the technical aspects, although extensive testing was conducted, some participants experienced issues which required assistance to be provided.

In terms of wider implications for the travel survey community, while diaries have received some criticism in recent years, the online environment provides opportunities for re-thinking and re-invention. These opportunities include enhanced capabilities to overcome many of the perceived deficiencies of traditional diaries, integration with smartphones (and other data collection technologies) to make the process more engaging, and access to an
increasing number of people as potential participants become less receptive to conventional survey approaches. In addition, web technology allows researchers to gain a better understanding of how, when and where participants complete travel diaries, enhancing the ability to improve the quality of the diary interface and crucially the quality of data collected.

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