Participant Experience Using GPS Devices in a Food Environment and Nutrition Study

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**ABSTRACT**

Global Positioning Systems (GPS) have emerged as potentially useful tools for research on the spatial contexts of food purchases and consumption, but limited studies have assessed users’ experiences using GPS to track diet behaviors in free-living settings. This was a pilot study conducted in Seattle, Washington, in the fall of 2011. Ten university students (8 female, 2 male, mean age = 27.9, SD = 4.8) tracked their food purchases and consumption over 3 days using a Wintec WBT 202 GPS device and traditional paper-based methods. We compared the frequency of reports using these methods and assessed the participants’ experiences via interviews and product evaluation questionnaires. For most participants, the GPS method captured more records than the paper-based methods. Users appreciated the device’s compact size and the simplicity of its design but frequently complained about the device’s short battery life, problems carrying the device, difficulty maintaining satellite connections, and problems remembering to use the device. This study highlights the importance of investigating participant experiences with technologies before deploying them on a larger scale. A number of key characteristics should be considered in the development of such devices to optimize the user’s experience without sacrificing accuracy of the data collected.

**KEYWORDS**

GPS; food environment; obesity; user experience; food purchases; diet

**Background**

Researchers concerned with the potential influence of the environment on eating behaviors have faced challenges collecting accurate measures of where individuals access food, and there is growing recognition of a need to move from place-centric to person-oriented approaches.\(^1\)–\(^9\) Past methods have made assumptions about where people access food based on where they live, work, or go to school. The limitations of these assumptions are now accepted, and there is growing recognition of the need to collect exposure measures that account for individual mobility patterns.\(^6\)\(^,\)\(^10\)–\(^15\) Global
Positioning Systems (GPS) technology, traditionally used by physical activity researchers,\textsuperscript{16–18} has the potential to provide such information. By measuring where individuals buy and eat food, researchers may be able to gain a better understanding of how individuals interact with their environment,\textsuperscript{17,19–23} which could inform policy related to food access.

Previous work has focused on the accuracy of GPS devices.\textsuperscript{20,24–26} However, limited studies have assessed participant experience using these devices, particularly in the context of nutrition-related research.\textsuperscript{27} GPS provides 2 types of data: tracks and waypoints. Tracks are a set of points that show a person’s path while the GPS device is turned on, and waypoints are specific points that the user has selected. The advantage of this latter feature is that it can be used to identify relevant points (such as where a person accesses food) from the thousands of other GPS points in a data set. However, the only study to assess users’ experiences with GPS in the context of nutrition research did not use the waypoint feature,\textsuperscript{28} so questions remain about how feasible this application is in wide-scale nutrition research.

The purpose of this study was to assess participants’ experiences using the GPS waypoint feature to measure where individuals bought and consumed food. Additionally, we compared the frequency of food purchases or consumption events that were recorded using traditional paper-based methods to those recorded by using the waypoint feature of GPS devices. This information was part of a small pilot study to identify challenges and benefits of using this type of technology in behavioral research.

For this project, we used the Wintec WBT 202 GPS device (Wintec Co. Ltd., Taiwan). We chose to use this device based on cost (around $125), battery life (28 hours of continuous operation), weight (55 g), and accuracy (2.5 m). Wintec GPS devices have been used in previous epidemiological studies\textsuperscript{29} and several animal studies (grazing\textsuperscript{30} and travel patterns\textsuperscript{31,32}) and have been found to have similar performance to other GPS personal data logging instruments.\textsuperscript{33} Another benefit of the device is the simplicity of its interface (aside side from a status LED and a few buttons, the device can simply be turned on and will automatically collect positions until it is turned off), which makes it an attractive option for use with research participants.

**Methods**

Over the course of 3 days, we collected both qualitative and quantitative data from a convenience sample of 10 students. Our inclusion criteria required participants to be university students at the time of the study’s initiation, willing and able to use a GPS devices for 3 days, and capable of charging the device overnight. All research procedures received approval from the local Institutional Review Board (University of Washington) and we obtained
verbal and written informed consent from each participant. Participants were compensated $100 for completing the study.

After providing verbal and written consent, participants met one-on-one with one study researcher. They completed a simple questionnaire asking for information about their demographics, health status, home address, and previous experience using a GPS device. Additionally, their height and weight was measured. Following this, participants were given detailed verbal and written instructions asking them to track the locations and times of their food purchasing and food consumption behaviors for 3 days (one weekend day, 2 weekdays) using 2 methods.

The first method of tracking eating behaviors involved using a Wintec WBT-202 GPS device.

Participants were asked to push a button on the GPS device to create a record of their immediate location (known as a waypoint) every time that they purchased or ate food over the course of 3 days. The researcher showed participants how to turn on the device, obtain satellite power, mark food purchasing or consumption points, charge the device and turn it off (available in the Appendix). Participants were asked to keep the device on at all times. Because our study spanned multiple days, participants were also asked to charge the device via a standard USB connection overnight. At the same time that participants were tracking their food purchases and consumption with the GPS device, they were asked to track them using paper-based records.

Paper-based methods included use of a travel log in which users tracked their locations and activities by selecting one of 24 common activity codes, including “eating/preparing meals/dining out/drive-through” and “food shopping.” Participants tracked their food consumption using a food record. Detailed instructions were provided on how to describe foods completely, estimate portion sizes, and contextual information (date, time, and location). They were also asked to collect receipts from all food purchases and to ensure that the receipt contained the name of the store/restaurant where the food was purchased and the date and to provide this information if it was not available.

**GPS data processing**

GPS data were downloaded using proprietary software provided by the Wintec manufacturer. The output format from the GPS logger was as .TES files, which were converted into KMZ (to view tracks and waypoints in Google Earth) and GPX (GPS exchange formats). To ensure the anonymity of study participants, we replaced all identifiers with a numerical code and deleted the data from the devices. We used the software program R (R Core Team, Vienna, Austria) and an add-on package that allowed interaction with
the Google Maps API (Google, Mountain View, CA) to geocode each participant’s home address and the location of waypoints to provide a visual image of each participant’s tracks and waypoints. We analyzed the frequency of occasions when food was purchased or consumed and the locations at which such events were recorded in the participants travel diary. For each subject, we compared the frequency of occasions that were recorded by the GPS device to those that were reported in the diary and stratified to whether the event occurred at home or outside of home.

**Participant perceptions and feedback**

Qualitative interviews were conducted with participants in order to collect information about experiences tracking their food purchases and consumption using the GPS devices. Interview design and analysis was informed by Kvale and Brinkmann’s criteria for qualitative interviews and Albert and Tullis’s recommendations for measuring user experience. The interviews were administered by one researcher and lasted approximately 45 minutes. The interview focused on the participants’ interactions with the GPS device in order to reveal their perceptions about its effectiveness (their ability to complete the study tasks of tracking events, charging the device, etc), efficiency (the amount of effort required to complete the task), or satisfaction (the degree to which the participant was happy with his or her experience while performing the task). The interview provided structure but could also be adjusted based on the study participants’ responses, with the purpose of identifying participant’s experience with the devices. Responses were recorded and transcribed. The same researcher who conducted the interviews was responsible for coding responses and identifying key themes. Because of the small sample size, no specialized software was used for coding.

Participants also completed a usability questionnaire that consisted of questions related to themes of usability and satisfaction, such as system usefulness (8 questions), information quality (7 questions), interface quality (3 questions), and overall satisfaction (1 question). The instrument captured responses using a 7-point Likert scale. Examples included, “Overall I am satisfied with how easy it is to use this system” and “I felt comfortable using this system.”

**Results**

**Participant characteristics**

All 10 of the recruited participants completed the study protocol and their characteristics are described in Table 1. Eight of the 10 participants were female and 9 out of 10 were under 30 years of age (mean = 27.9, SD = 4.8).
Six of the participants had used a GPS device before, either as a stand-alone device (n = 2) or by using a smart phone with GPS capability (n = 4). None of the participants were obese; 9 fell within a healthy body mass index range (18.5–24.9) and one was overweight (25–29.9).

**Tracking food purchases or consumption: GPS waypoint versus paper diary**

Only one study participant reported an equal number of events when food was purchased or consumed in both the GPS and diary. There were an average of 14.4 (SD = 4.6) events reported in the GPS and 9.4 (SD = 3.2) in the travel diary. In all but one instance (when the participant could not get satellite reception at home), the GPS device caught more events than the diary. The biggest difference was more than 5-fold; one participant reported only 4 events in the travel diary and 21 in the GPS device. The participant interview highlighted that these differences may have been due to misclassification of events in the diary. When the data were stratified according to location (at home or away from home), the GPS device caught more events than the travel diary at both locations. Outside of home, the GPS device caught an average of 4.9 events (SD = 2.3) and the travel diary caught 4.2 events (SD = 2.4). At home, the GPS device caught an average of 8.9 events (SD = 4.0) and the travel diary caught an average of 5.2 (SD = 1.8; Table 2).

**User experience**

We identified several recurring themes in the reports of participant experience with the devices that point to important areas that should guide future eating behavior research using GPS.
We summarize these themes below, with representative comments included in Table 3. Participants appreciated the small size and the simple interface of the device. However, 3 participants reported problems turning the device on or off and an additional 2 participants reported accidentally turning the device off during the day. Additional barriers to use included the short battery life of the device and its requirement to be charged every night. Four of the participants reported having problems knowing where to put the GPS when they were not carrying a purse or did not have pockets in their clothing.

The most common technical complaint related to acquiring and maintaining satellite reception, reported by 8 of the 10 subjects. These problems included unexpected signal loss or deciphering whether or not the device was actually connected to the satellite. This ambiguity created some anxiety for the participants.

The problem that participants identified most frequently was not remembering to use the device daily. Six participants reported forgetting to bring their device with them at least once over the 3-day period. Four participants reported difficulty remembering to use the waypoint feature.

**Discussion**

Our results suggest that the Wintec WBT 202 GPS device may provide acceptable user experiences and may be suitable for deployment in a larger-scale study of nutrition-related behaviors among some population groups, provided that a few modifications are made to improve the user’s experience. Though participants were satisfied by the device’s simplicity and small size, they also reported difficulty acquiring satellite reception, keeping the device sufficiently charged, remembering to bring and use the device on a daily basis,
Table 3. Themes and representative quotations related to user experience with the Wintec GPS device in a neighborhood food environment study among college students in Seattle, Washington (N = 10).

| Themes                        | Subthemes and representative quotes                                                                                                                                 |
|-------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Flagging food consumption     | Problems remembering to flag                                                                                                                                         |
| points                        | “Sometimes it was hard to see the green light when flagging, especially outside in the sun. On the first day, I don’t think I actually saw the green light when starting my track. I figured it had started since I pushed the ‘flag’ button.” |
|                               | “[The thing that I liked least about this device was] remembering to push the button for meals. Uncertain if it collected/registered my entry [flag push at meals].” |
|                               | “[The most difficult task] was remembering to press the flag button with every meal and food purchase. I’m a bit forgetful.” |
|                               | “[The most difficult task] was remembering to ‘flag’ eating events.”                                                                                                  |
| Success flagging              |                                                                                                                                                                    |
|                               | “Flagging” eating events was easy IF I remembered to do so.”                                                                                                       |
|                               | “[The easiest task to carry out was] pressing the flag for sit-down meals.”                                                                                           |
|                               | “[The easiest task to carry out was] … flagging when I eat.”                                                                                                        |
|                               | “Placing a marker at food-consumption points was very easy.”                                                                                                         |
|                               | “[The easiest task to carry out was] flagging the location of eating.”                                                                                                |
|                               | “I liked the simplicity of pushing just one button.”                                                                                                                  |
| Carrying the device           | Problems remembering to carry the device                                                                                                                          |
|                               | “[The most difficult task was] remembering to bring the device with me, especially if I switched bags/purses/backpacks.”                                              |
|                               | “The device was easy, it was remembering to carry it and flag snacks as they are more grab-and-go than meals.”                                                        |
|                               | “The tool itself is simple, but remembering to bring it with me was harder than I expected and remembering to ‘flag’ my eating events was also difficult.”            |
|                               | “The device is not burdensome to carry IF I remembered to carry it (I forgot on 2 occasions in 3 days).”                                                             |
|                               | ”I really had to be conscientious to complete the tasks. For example, one evening running out the door I switched bags and forgot to take the GPS. I often forgot to flag eating events or did so late.” |
|                               | “[In terms of satisfaction with the device], it was more an issue of remembering to bring the system or ‘flag’ the times I ate but the system itself was very straight forward.” |
|                               | ”Problems carrying the device                                                                                                                                       |
|                               | “[The thing I liked least about the device was] carrying it when not carrying a bag (ie, walking the dog) because I had to have pockets and even then they are tight pockets and I was worried the device would turn off.” |
|                               | “[The thing I liked least about the device was] there was no clip to attach to me.”                                                                               |
|                               | “[The thing I liked least about the device was] it was a stand-alone device. No hip attachment—I may have remembered it if I could put it on/wear it.”                    |
|                               | “[The most difficult task was] finding a spot to carry the device.”                                                                                            |
| Problems carrying the device  | Recommendations to add an attachment to the device                                                                                                                |
|                               | “[The one thing I would tell the designers to change is] maybe it could have an attachment which would allow it to attach to pants—sometimes I went places without pockets/purse or was going to go but ended up changing my clothes so I would have a pocket.” |
|                               | “[The one thing I would tell the designers to change is] add a handle or wrist strap.”                                                                           |
|                               | “[The one thing I would tell the designers to change is] add a belt clip.”                                                                                          |
| Battery life                  | Recommendations to increase battery life                                                                                                                          |

(Continued)
remembering to carry it with them when leaving home, and remembering to push the “flag” button when purchasing or eating food to engage the waypoint feature. To address these problems, we suggest that frequent use of reminders will be important in future studies using technologies in this way (see below for further suggestions).

To the best of our knowledge, this was the first study to assess users’ experiences with the waypoint feature of the Wintec WBT 202 device for tracking dietary behavior. Our sample size was limited to 10 students due to resource constraints. There is little published guidance concerning how large a pilot study should be, but health and user experience researchers

| Themes                        | Subthemes and representative quotes                                                                 |
|-------------------------------|--------------------------------------------------------------------------------------------------------|
| Satellite reception           | “I wish the device had longer battery life.” "[The one thing I would tell the designers to change] is longer battery life.” “Battery life is poor.” |
|                               | Problems with satellite reception                                                                     |
|                               | “Sometimes, unexpectedly, I would lose the signal.” “No service in some buildings.”                   |
|                               | “The flashing light indicating receiving (sending signal did not flash while on the E level [basement level] at work).” “The satellite signal stopped blinking on various occasions and I did not know that affected the ‘flag’ function.” |
|                               | “Getting it started was a bit shaky, as my apartment did not get good reception, so I wasn’t sure if it worked at first.” “The satellite wasn’t always blinking and when pressing the flag during these times the light would turn yellow instead of green so I wasn’t sure it recorded it.” |
| Charging the device           | Confusion about turning device on or off to charge                                                     |
|                               | “I guess the only thing I was a little unclear on was whether we are to charge the device when it was ‘on or off’ I figured it was when it was ‘off.’” Success charging it overnight |
|                               | “[The easiest task was] plugging [the device] in at night and turning it on in the morning.”          |
| Size of the device            | “[The thing I liked most about this device was] small size.”                                            |
|                               | “[The thing I liked most about this device was] small, lightweight”                                     |
|                               | “[The thing I liked most about this device was] the size, portability”                                 |
|                               | “[The thing I liked most about this device was] it was compact”                                        |
|                               | “[The thing I liked most about this device was] size was small and its simplicity”                     |
| Turning the device on/off     | “[The most difficult task was] figuring out how to turn it off/on.”                                    |
|                               | “The device seemed susceptible to inadvertent triggers when carried in a pocket, so the most difficult task was avoiding false flags/shut downs while getting into cars or carrying bags.” |
|                               | “On my first day of tracking, the device shut off while in my pocket. I wasn’t sure how long it had been off, so I cancelled that day’s tracking.” |
| Sound                         | “A sound feature might help in case lights malfunction.”                                               |
| Incorporating device into     | “[The thing I liked most about this device was] no beeps or sounds.”                                   |
| mobile phone                  | “[The thing I would tell the designers to change is to] incorporate the technology into a device that users already regularly carry; eg, a cell phone.” |
|                               | “[It] might be nice to incorporate this into a phone or everyday device.”                              |
argue that smaller sample sizes of 8 or 10 participants can still be meaningful. We deemed that our sample size was adequate for providing us with information about the feasibility of using this technology in a larger study, but it did not allow for statistical testing.

Our findings have poor generalizability due to the fact that our sample was relatively young and educated, suggesting that they may be more technologically proficient. As such, the findings from this pilot may not inform research projects involving individuals of a lower socioeconomic position (eg, lower education levels). This is a major limitation, especially given that poor nutrition is associated with lower socioeconomic status, so it is crucial for research studies involving food access and nutrition to effectively engage these groups. More research with a larger and more socioeconomically diverse population is needed to understand how user experience with the devices and, therefore, the feasibility of deploying them in larger-scale nutrition studies can be established. A recent study by Duncan et al evaluated the feasibility of integrating GPS devices into research about obesity and hypertension risk factors among a large sample of low-income housing residents and found that nearly all participants \( (n = 112, 98.2\%) \) delivered at least an hour of GPS data; qualitative interviews suggested that participants found the protocol to be acceptable, leading the authors to conclude that GPS devices may be used in research with low-income populations. Similarly, Zenk found the use of GPS to be feasible among a racially and ethnically diverse sample of lower socioeconomic position.

Our population was young and this is likely to have influenced their experience interacting with the devices. Al Mahmud et al found that satisfaction with GPS devices varied between young and old participants, so future studies should assess usability among a wider age range of participants.

We followed participants for 3 days because we wanted to capture their behavior on both a weekend and a weekday but did not have the resources to track participants for a full week. The 3-day study period was adequate for the purposes of assessing user experience, but it was not long enough to provide an understanding of the participants’ overall activity space for food purchases and consumption.

We observed high user participation rates, which may have been influenced by the large incentive ($100 following completion of the study). Research studies with smaller or no incentives may not experience the same level of user participation.

This project did not assess the quality of the GPS data (eg, the amount of signal loss), and there was an implicit assumption that the user’s experience mattered because it would improve adherence to study protocols and improve data quality. Future projects would benefit from establishing the degree to which a positive user experience with the device is associated with
data quality. Future studies involving GPS must also acknowledge biases that may be introduced when data is put into a spatial context.19

**Specific recommendations for future projects**

Here are some of the lessons we learned in this pilot study using the Wintec WBT 202 GPS device to track food habits among a small sample of college students.

*Help participants remember to use the device with prompts*

The most frequently reported challenge was not a technical issue but, rather, problems that participants encountered remembering to use the device. This suggests that as new technology is integrated into health research, it will be important to incorporate the use of prompts (ie, text reminders, signals after no activity, etc).

*Make all instructions clear—and pilot these instructions*

Participants reported that even a relatively simple task (eg, turning a device on or off) could be problematic. This highlights the need for participants to be given clear step-by-step instructions for all tasks—even those that may seem simple to the researcher. Within our study, because the task of turning the device on and off seemed so straightforward, it did not occur to us that it needed to be made explicit. This underscores the need to pilot new technology before rolling it out in larger data collection efforts in order to identify problems that would otherwise not be anticipated.

*Develop longer battery life or make it convenient to charge the device*

Participants were dissatisfied with the short battery life of the GPS device. A longer battery life would reduce participant burden and enable participants to focus on tasks most critical to the research rather than worrying about ensuring that their device was charged. Alternatively, giving participants portable chargers would allow them to charge their device at convenient intervals. Future work should consider ways to lengthen battery life without increasing the bulk of the devices.

*Have a protocol established for predictable problems*

A common problem was inconsistent satellite coverage, which led to participant frustration and wide variation in the amount of GPS data collected from each participant. Given that this is a well-documented problem, our study would have benefited from going into more detail about what to do in this instance. Establishing clear steps for mitigating the problem (eg, attenuating device when it is first turned on) will improve both the quality of the data and the user’s experience.
**Make the device easy to carry**

Participants appreciated that the device was compact and lightweight, but because the device had no clip or strap, they were required to carry the device in a pocket (where accidental flags/shutdowns were likely) or in a bag (where they were likely to forget about it and fail to catch all occasions when food was purchased or consumed). Several participants recommended that the device have a strap or clip that makes it easier to carry or to integrate it with a device they are already using like a mobile phone, although this may make it even more important to include reminders to use the technology as the study requires it to be used.

**Conclusion**

GPS technology may bring important improvements to research about the environmental correlates of dietary behavior. Among 8 of the 10 participants in our study, the GPS waypoint feature caught more events when food was purchased or consumed than the traditional travel diaries. In addition, the GPS devices provided more detailed information that can be layered with GIS to create novel individual-level measures of the food environment.\(^{13,22}\)

Despite this promise, questions remain how to effectively incorporate these devices into larger-scale research, how to ensure privacy of individuals once the data are collected, and how to extract meaning from these large and complex temporal–spatial data sets. Future projects will require cross-disciplinary collaboration and may benefit from drawing on work in time–geography.\(^{11}\)

As GPS technology becomes more present in consumer devices such as mobile phones, researchers should also continue exploring ways to leverage their existence and ubiquity in the field for this type of research. For example, if a mobile phone application were developed, the paper food diary could be digitized, which would spare users the inconvenience of carrying numerous paper instruments and decrease respondent burden. Additionally, methods of geolocation via triangulated Bluetooth–Wi-Fi or cellular tower signals could provide an important means of filling the data gaps of GPS and therefore quell some of the anxiety that participants experienced when they lost satellite reception.

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