Smartphone-Based Travel Experience Sampling and Behavior Intervention among Young Adults

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UbiActive: A Robust Smartphone-based Application

- Monitor respondents’ transportation routines
- Investigate travel-related health impacts
- Intervene against unhealthy travel behavior
UbiActive Prototype Development

FIGURE 1 Framework of UbiActive Application Prototype

- **Participants**
  - Focus on travel-related physical activity and well-being

- **Smartphone-based Monitoring**
  - Monitor travel behavior and collect correspondent data

- **Activity Monitoring**
  - Collect data from participants

- **Weekly Evaluation Report**
  - Evaluate participant performance

- **Survey Triggering**
  - Collect participant feedback

- **Programs**
  - Program I
    - Data Collection
  - Program II
    - Data Collection
  - Program III
    - Data Collection
  - Program IV
    - Data Collection

- **Server-based Inter-participant Comparison**
  - Evaluate data collected from smartphones, allowing inter-participant comparison

- **Smartphone-based Survey**
  - Collect information about travel experience

- **Smartphone-based Evaluation**
  - Evaluate data collected from both sensors and self-reported questionnaires
Sensor
- 3-dimensional accelerometer: sampling frequency is 1 Hz
- 3-dimensional magnetic sensor: sampling frequency is 1 Hz
- GPS: sampling frequency is every 30 seconds

Auto Tracing
- **Collected**: Location, movement time, speed, acceleration, and orientation
- **Derived**: Travel distance, duration, and mode of each trip, physical activity intensity and duration
Travel mode detection

FIGURE 2  Speed and Acceleration Output from Smartphone Measurement
UbiActive Program II: Smartphone-Based Experience Survey

- Trigger survey actions immediately after a trip is detected

- Collect self-reported travel experience
UbiActive Program II: Smartphone-Based Experience Survey

FIGURE 4 Screenshots of Smartphone-based Experience Survey
UbiActive Program III: Smartphone-Based Evaluation

• Summarize real-time collected data

• Provide daily reports to participants
  – Duration of physical activity
  – Duration of travel-related physical activity
  – Calories burned
  – Travel experience/well-being ratings

• Reports are scheduled at 11 pm

FIGURE 5 Daily Report Example
UbiActive Program IV: System Server-Based Inter-Participant Comparison

- Transfer data from smartphones to a remote system server
- Develop weekly inter-participant comparison reports
- Send weekly reports to participants at 10:30am on the following Monday
  - Total physical activity and travel-related physical activity
  - Three types of comparisons

FIGURE 6 Weekly Report Example
Test using Samsung Nexus S Google phone:

• **Network usage:** data size is less than 1 KB per day

• **Memory requirement:** collect around 7Mb of raw sensor data and statistics per day (150mb for 3 weeks)

• **Battery life:** around 12-15 hours without additional voice/text/data usage
Three-Week Field Study

• **Time:** October-November, 2012
• **Participants:**
  - 23 participants were recruited
  - 17 Participants completed the three-week study (10 received intervention)
### TABLE 3: Trip Information of a Participant on November 3, 2011 – Part I

<table>
<thead>
<tr>
<th>Trip #1</th>
<th>Trip #2</th>
<th>Trip #3</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Map of Trip #1" /></td>
<td><img src="image2" alt="Map of Trip #2" /></td>
<td><img src="image3" alt="Map of Trip #3" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Start Time</th>
<th>10:00am</th>
<th>12:00pm</th>
<th>4:30pm</th>
</tr>
</thead>
<tbody>
<tr>
<td>End Time</td>
<td>10:15am</td>
<td>12:30pm</td>
<td>5:15pm</td>
</tr>
<tr>
<td>Trip Purpose</td>
<td>School</td>
<td>Meal</td>
<td>Back Home</td>
</tr>
<tr>
<td>Mode</td>
<td>Walking – Bus - Walking</td>
<td>Walking</td>
<td>Walking – Bus - Walking</td>
</tr>
<tr>
<td>Companionship</td>
<td>Alone</td>
<td>Alone</td>
<td>Friends/Schoolmates/neighbors/Acquaintances</td>
</tr>
<tr>
<td>Secondary Activity</td>
<td>Doing Nothing</td>
<td>Doing Nothing</td>
<td>Talking/Conversation/Making Phone Call</td>
</tr>
<tr>
<td>Satisfaction of Trip</td>
<td>★★★★☆</td>
<td>★★★★☆</td>
<td>★★★★☆</td>
</tr>
<tr>
<td>Does this trip make you feel good?</td>
<td>★★★★☆</td>
<td>★★★★☆</td>
<td>★★★★☆</td>
</tr>
<tr>
<td>Do positive aspects outweigh the negative of the trip?</td>
<td>★★★★☆</td>
<td>★★★★☆</td>
<td>★★★★☆</td>
</tr>
<tr>
<td>In general, how happy were you during this trip?</td>
<td>★★★★☆</td>
<td>★★★★☆</td>
<td>★★★★☆</td>
</tr>
</tbody>
</table>
TABLE 4  Trip Information of a Participant on November 3, 2011 – Part II

<table>
<thead>
<tr>
<th>Trip #1</th>
<th>Trip #2</th>
<th>Trip #3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walking - Bus - Walking</td>
<td>Walking</td>
<td>Walking - Bus - Walking</td>
</tr>
<tr>
<td>Trip 1 - Speed</td>
<td>Trip 2 - Speed</td>
<td>Trip 3 - Speed</td>
</tr>
<tr>
<td>Speed (m/s)</td>
<td>Speed (m/s)</td>
<td>Speed (m/s)</td>
</tr>
<tr>
<td>Walking</td>
<td>Waiting</td>
<td>Walking</td>
</tr>
<tr>
<td>Walking</td>
<td>Waiting</td>
<td>Waiting</td>
</tr>
<tr>
<td>Walking</td>
<td>Waiting</td>
<td>Waiting</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Trip 1 - Acceleration</th>
<th>Trip 2 - Acceleration</th>
<th>Trip 3 - Acceleration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acceleration (m/s²)</td>
<td>Acceleration (m/s²)</td>
<td>Acceleration (m/s²)</td>
</tr>
<tr>
<td>Walking</td>
<td>Waiting</td>
<td>Walking</td>
</tr>
<tr>
<td>Walking</td>
<td>Waiting</td>
<td>Waiting</td>
</tr>
<tr>
<td>Walking</td>
<td>Waiting</td>
<td>Waiting</td>
</tr>
</tbody>
</table>
• **The null hypothesis:** the daily percentage of walking and biking trips in the first week is equal to the percentage in the third week

• **The alternative hypothesis:** the daily percentage in the first week is smaller than the third week

• **Test:** the Mann–Whitney U test (Mann and Whitney 1947)

<table>
<thead>
<tr>
<th>Percentage of walking and biking trips (%)</th>
<th>W-Statistic</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st week</td>
<td>587.0</td>
<td>0.8668</td>
</tr>
<tr>
<td>3rd week</td>
<td>501.5</td>
<td>0.5603</td>
</tr>
<tr>
<td>Intervention Group</td>
<td></td>
<td></td>
</tr>
<tr>
<td>48.39%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>51.06%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.67%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control Group</td>
<td></td>
<td></td>
</tr>
<tr>
<td>31.67%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>40.93%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.26%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

• No strong evidence to reject the null hypothesis

• Possible Reasons: small sample size, cold weather, etc.

• Evidence shows augmented awareness of travel behavior, travel-related physical activity, and travel-related well-being effects
Participation Experience

• High level of satisfaction: 13 of 17 (76%) participants reported having a “satisfied” overall experience

Study Design & UbiActive’s Performance

• Preference for phone-based survey rather than a pen-and-paper instrument
• Good design and layout of the phone-based survey and paper-version diary
• Room for improvement in UbiActive’s ability of trip detection
Compliance with Participation Requirement

- Low compliance rate of paper-version travel diary attributes to the low portability of a pen-and-paper instrument
- The most disruptive requirements to be timely battery charging, filling paper-version travel diary and keeping GPS setting always on

Privacy Issues

- Sixteen (98%) participants at least “somewhat agree” that they felt comfortable having smartphone detecting their general travel behavior
- All participants agreed that they felt confident the data collected by the smartphone would be handled in a way that protected their privacy
**UbiActive**

- An adaptive, smartphone-based application that enables auto tracing and context-aware experience sampling.
- Collect in situ information and interactive communication between users and researchers.
- Could be applied in various research settings, such as transportation, clinical trials, etc.

**Future improvement**

- Better trip detection
- Better energy expenditure estimation
- Reduced battery consumption for UbiActive
- Revised intervention designs that go beyond simple information sharing