A novel approach to evaluating mobile smartphone screen time: feasibility and preliminary findings

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Abstract

Background

Increasingly high levels of smartphone ownership and use pose the potential for addictive behaviors and negative health outcomes, particularly among younger populations. Previous methodologies to understand mobile screen time have relied on self-report survey or ecological momentary assessment (EMA). Self-report is subject to bias and unreliability, while EMA can be burdensome to participants. New methodology is needed to advance the understanding of mobile screen time.

Objective

The objective of this study was to test the feasibility of a novel methodology to record and evaluate mobile smartphone screen time and use: Battery Use Screenshot (BUS).

Methods

The Battery Use Screenshot (BUS) approach, defined for this study as uploading a mobile phone screenshot of a specific page within a smartphone, was utilized within an online cross-sectional survey of adolescents aged 12 to 15 years old through the survey platform Qualtrics. Participants were asked to provide a screenshot of their battery use page, a feature within smartphones, to upload within the online survey. Feasibility was assessed by smartphone ownership and response rate to BUS upload request. Data availability was evaluated as applications (apps) per BUS, completeness of data within screenshot, and five most used applications based on battery use percentage.

Results

Among those surveyed, 309 (26.7%) indicated ownership of their smartphone. A total of 105 screenshots were evaluated. For data availability, screenshots contained an average of 10.2 (SD=2.0) apps per screenshot and over half (55%) had complete data available. The most common apps included safari and home/lock screen.

Conclusion

Findings describe BUS as a novel approach for real-time data collection focused on mobile smartphone screen time among young adolescents. Though feasibility showed some challenges in upload capacity of young teens, data availability was generally strong across this large data set. This data from screenshots have the potential to provide key insights into precise mobile smartphone screen use and time spent per mobile application. Future studies could explore the use of the BUS methodology to correlate mobile smartphone screen time with health outcomes.

Keywords: smartphone, youth, applications (apps), screenshot
Introduction

Smartphones and their vast functionalities have become an integral part of individual's lives today [1]. In the US alone, smartphone ownership has increased to 77%, with younger populations being among the highest percentage to own a smartphone (92%) [2]. Globally, similar trends are seen in smartphone ownership, including among emerging economies [3]. Among adolescent smartphone owners, 64% report “everyday use” in a recent survey [4]. As ownership and accessibility to mobile smartphones become ubiquitous so does the need for research into the implications, such as positive and negative health consequences. Recent research suggests high screen media usage is associated with poor sleep and diminished academic performance among adolescents and adults [5-7]. Thus, accurate and feasible methodologies to study mobile screen time are necessary to further understand these relationships.

Previous methodologies to understand mobile screen time have typically relied on traditional self-report and cross-sectional research design [5-9]. However, self-report is vulnerable to systematic and confounding bias [10]. Previous work has shown conflicting results related to media use time with the use of self-report. Some studies have found self-report application (app) usage to underestimate app and smartphone usage [11]. On the other hand, studies have also found self-report by participants to overestimate online time [12, 13]. These inconsistencies have led some researchers to suggest that self-reported smartphone use be interpreted with caution [14].

Another approach to evaluate mobile media use is Ecological Momentary Assessment (EMA). In these approaches, participants are typically contacted multiple times per day to report their real-time screen use [15, 16]. While this approach improves upon self-report biases, such as recall bias, this approach can be highly burdensome to participants [17]. In addition, these methodologies often fail to
obtain large-scale and representative samples due to costs to researchers to provide the compensation necessary to attract participants [18]. Thus, new methodology is needed to advance the assessment of mobile screen time that improves accuracy compared to self-report, but is also not burdensome to participants.

One possible approach to understanding mobile smartphone screen time while limiting participant burden is to leverage passive tracking that smartphones are programmed for via battery use reporting. Most smartphones, such as iPhones, track battery use per application and phone function (e.g. Home and Lock Screen). A majority of smartphones will then report this battery use by time, including both active on-screen and background use. The “battery use” function and display thus serves as an indicator for real-time app and smartphone activity.

In this research protocol, we present preliminary findings of the Battery Use Screenshot (BUS) approach among young adolescents. The objective of this study was to test the feasibility of the BUS approach to obtain and evaluate mobile smartphone screen time data.

**Methods**

**Design**

The BUS approach was defined for this study as the upload of a mobile phone screenshot of the “Battery Use” page within the participant’s smartphone. To assess the feasibility of the BUS approach the present study was designed as a cross-sectional online survey of 12 to 15-year-old adolescents. We collected data between June and July 2017 using the Qualtrics survey platform. The study was approved by the University of Washington Institutional Review Board.

Participants and Recruitment
Youth who were between the ages of 12 and 15 years old and who could read English were eligible to complete the survey. As described in previous studies [19], Qualtrics draws upon previously established age panels within their online database allowing for targeted recruitment. Eligibility was assessed prior to beginning the online informed consent process. Once informed consent by a parent was obtained, participants could begin the survey. Compensation was provided to participants through Qualtrics for survey completion.

Data collection process

Variables

Phone ownership: Participants were asked whether or not they currently had a smartphone capable of taking a screenshot. Participants were also asked to indicate whether the phone was their own, their parent’s smartphone, or that they did not own a smartphone.

Demographics: Age, gender, and race/ethnicity were assessed.

Screenshot Upload

Participants were provided an example battery use screenshot within the survey (Figure 1) and then asked to create their own screenshot from the phone they currently used, if they had one. Instructions included first asking the participant to go to the “Settings” section of their smartphone and clicking the “Battery” option. Once in the “Battery” section participants were asked to locate the “battery usage” data displayed. For iPhones, participants were asked to click both the “Last x days” and the clock symbol in the right-hand corner to display both on-screen and background activity for each application listed. Participants were asked to compare their display to the example provided to ensure the correct data was viewable. Participants were then asked to screenshot this display by holding down the home and power button at the same time to capture the image. Once the screenshot was captured, participants were asked to upload the image, as a .jpg or .png, to a file dropbox within the survey.
Analysis

Descriptive statistics were used to analyze feasibility and data availability. The most commonly used apps were determined based on frequency among evaluated screenshots. Analysis focused on iPhone screenshots because of inconsistency among android platforms in the display of battery usage. Screenshots were excluded if they contained anything other than the battery use page from a personal phone.

Outcomes

Feasibility: Measures to assess feasibility included a survey question asking about personal smartphone ownership and response rate to BUS upload request.

Data availability: To characterize data availability, content analysis assessed applications per screenshot and completeness of screenshot including, display of “on-screen” and “background” time and displayed percentage of battery use per application. The five most commonly used applications among
evaluated screenshots were assessed. The most used applications for each screenshot were defined based on displayed battery use percentage.

**Results**

Figure 2. Protocols Results Flowchart.

- Total survey responses
  - $n = 1,156$

  - Responses excluded:
    - Respondents who indicated screenshot was taken from parents' phone ($n = 163$)
    - Respondents who indicated they did not have phone to take screenshot ($n = 630$)

- Respondents who indicated screenshot was taken from personal phone
  - $n = 309$

- Screenshot image of battery use attached in survey
  - $n = 151$

  - Excluded:
    - Screenshots from Android battery use ($n = 36$)
    - Screenshots that were exact copy of survey example screenshot ($n = 3$)
    - Non-battery use screenshot/photo ($n = 8$)

- Screenshots of battery use from iPhones
  - $n = 105$
Results

A total of 1,156 adolescents with an average age of 13.6 (SD= 10.9) responded to the survey. The overall survey sample was 49.4% female and 72% Caucasian. Among the sample of participants for which screenshots were evaluated, 52.3% were female and 75.4% were Caucasian. Full demographics for both populations can be seen in Table 1.

Table 1. Demographics

<table>
<thead>
<tr>
<th></th>
<th>Total survey sample</th>
<th>Sample screenshots evaluated</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n= 1156</td>
<td>n =151</td>
</tr>
<tr>
<td>Age</td>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
</tr>
<tr>
<td></td>
<td>13.6 (1.09)</td>
<td>13.7 (1.05)</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td>N (%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>N (%)</td>
</tr>
<tr>
<td>Female</td>
<td>572 (49.4)</td>
<td>79 (52.3)</td>
</tr>
<tr>
<td>Male</td>
<td>573 (49.5)</td>
<td>69 (45.6)</td>
</tr>
<tr>
<td>Female to Male</td>
<td>4 (0.3)</td>
<td>2 (1.2)</td>
</tr>
<tr>
<td>Transgender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male to Female</td>
<td>0 (0.0)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>Transgender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not Sure</td>
<td>3 (0.2%)</td>
<td>1 (0.6)</td>
</tr>
<tr>
<td>Race/Ethnicity</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White/Caucasian</td>
<td>842 (72)</td>
<td>114 (75.4)</td>
</tr>
<tr>
<td>Black/African American</td>
<td>80 (6.9)</td>
<td>12 (7.9)</td>
</tr>
<tr>
<td>Hispanic/Latino</td>
<td>101 (8.7)</td>
<td>12 (7.9)</td>
</tr>
<tr>
<td>Asian</td>
<td>56 (4.8)</td>
<td>6 (3.9)</td>
</tr>
<tr>
<td>American Indian/</td>
<td>8 (0.6)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Alaska Native</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Native Hawaiian/Pacific Islander</td>
<td>4 (0.3)</td>
<td>1 (0.6)</td>
</tr>
</tbody>
</table>
More than one race & 41 (3.5) & 4 (2.6) \\
Other & 10 (0.8) & 2 (1.3)

**Feasibility**

Among the overall survey sample, 309 indicated they had their own phone (26.7%). Among these adolescents, 151 (48.8%) completed the BUS upload request. See Figure 2.

**Data availability**

A total of 105 iPhone screenshots, received as .jpg or .png images, were used for the evaluation of data availability. Each screenshot contained an average of 10.2 applications (SD=2.00). More than half (55%) contained complete data availability, indicating successful implementation of instructions provided. Complete screenshots allowed for the ability to view the applications used, battery use percentage per application, and total minutes or hours of usage in both "background" and "on screen" (Figure 1).

**Most commonly used applications**

Figure 3 shows the frequency of the most common apps to appear in the five most used applications among analyzed screenshots. Safari, an internet search engine, was the most common app among screenshots; 47% of screenshots included Safari within the five most used applications.

**Figure 3. Most Common Apps among Analyzed Screenshots**
Discussion

The present study protocol describes a novel BUS approach to test feasibility, data availability and most common apps among a young adolescent population. The inclusion of the BUS approach within an online survey adds the capacity to assess mobile smartphone screen time that is accessible for both participants and researchers in a highly technological environment. Battery use is automatically monitored by the operating systems of most smartphones [20] and thus reduces both the bias of self-report, as well as burden on participants to record real-time smartphone and application use. Compared to EMA, this methodology can improve the capacity to deliver real-time data, as well as allow for data collection from larger online samples than typical EMA approaches [21].

The feasibility of our approach was mixed with both strengths and challenges. Among those participants who did upload a screenshot, the images provided clear data that could be viewed, stored in a de-identified manner, and categorized for further analysis. Our challenges in feasibility may be explained by the rates of phone ownership in our young adolescent sample. Among adolescents with their own phone, approximately half of young adolescents were willing or able to upload a screenshot. It is possible that a study population of older adolescents and adults may have higher phone ownership and better understanding and capacity to upload a screenshot. An additional explanation for this challenge may be the survey platform Qualtrics, which allows users to take surveys on both mobile phone and desktop computers. Participants that used a desktop computer to complete the survey may have experienced an additional burden in uploading a screenshot from a different device, which may have contributed to the overall feasibility of the present study.
The data availability from the BUS approach was strong, over half of screenshots analyzed contained complete data including the display of "on-screen" vs "background" time per application. One possible reason for cases of incomplete data may be that participants had an older iOS operating system, as the battery usage feature is only available on iOS 9 and newer operating systems [22]. This should be taken into consideration in future studies utilizing this methodology. In addition, this study relied on a single screenshot, which may not have captured total app usage. To strengthen overall data availability, future studies could require as many screenshots necessary to provide the full range of apps used by the participant.

While our study illustrates both strengths and challenges to the proposed research protocol, it serves as a valuable starting point for considering how to advance data collection methods to understand mobile smartphone screen time and media use. Studies have concluded that smartphone applications can be beneficial in monitoring and evaluating patients [23-25], as well as increasing adherence to medical interventions [26, 27]. The BUS approach offers the ability to take these studies further in understanding real-time use and overall time spent on apps as a factor that could contribute to health outcomes.

The BUS approach may also be combined with a variety of research methodologies including online cross-sectional surveys, as was done in the current study, or used as a tool for monitoring smartphone app use longitudinally. In a previous pilot study conducted using BUS, older adolescent iPhone users were asked to submit weekly screenshots of battery use for 9 weeks with a 94% retention rate over 5 weeks and 60% retention rate over 9 weeks [28]. A further advantage of the BUS approach is the ability to collect comprehensive data related to mobile smartphone screen time without the need for an additional app or programming. Thus, this methodology is accessible for researchers without the means for software or app development.
Limitations:

There are limitations within this feasibility study. The sample size of screenshots analyzed is limited and is not representative of the larger adolescent population. In addition, the battery use page only displays use of phone while an iPhone is not charging and may not account for full time spent using a smartphone device. Finally, in this feasibility study only iPhone screenshots were evaluated. Results may not generalize to all smartphones or mobile devices with battery use tracking. We did not test the BUS tracking method against other methods of tracking app use to assess its accuracy.

Conclusion:

Though feasibility with the BUS methodology showed challenges in phone ownership rates and upload capacity of young teens, availability of data was generally strong across this large dataset. The data available from screenshots has the potential to provide key insights into precise mobile smartphone screen use and amount of time spent per mobile application. The BUS approach may provide an innovative and complementary approach to understanding smartphone screen use without the need for complex programming or mobile application development. Future studies could improve upon the BUS methodology to correlate mobile smartphone screen time with health outcomes.

Conflicts of Interest:

There are no conflicts of interest to report.
References


