An Internet-Based Ecological Momentary Assessment Study Relying on Participants’ Own Mobile Phones: Insights from a Study with Young Adult Smokers

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Key Words
Ecological momentary assessment · Internet-based assessment technique · Cell phones · Survey development · Participant compliance · Smoking

Abstract
Background: In this paper we describe a novel Internet-based cell phone-optimized assessment technique (ICAT) to conduct an ecological momentary assessment (EMA) study. Participants could access the assessment instrument via the web browsers of their mobile phones. Methods: We report results from 92 young adult smokers (18–25 years old) who completed the baseline assessment and the first of 4 waves (3 days/wave) of EMA. Random prompts were issued via text messages sent to the participants. The participants were also instructed to self-initiate reports of smoking situations. Results: Compliance with the study protocols was low. In total, the participants completed 885 assessments during the 3 days of monitoring. Only 50.2\% of random prompts were responded to, and 52.4\% of those were completed within the first 10 min after issuing. Furthermore, reports of smoking situations were rarely self-initiated. In a multivariate regression analysis, age (positively) and female gender (negatively) predicted the number of completed assessments. Conclusions: This study adds to the limited experiences made with ICAT in substance use research. Similar to the few prior ICAT studies, compliance was low compared to traditional EMA studies. While using ICAT is technically feasible, specific improvements should be implemented to tap ICAT’s full potential in future studies.

Introduction

Electronic diaries (EDs) programmed with study-specific software have become the default tools for conducting ecological momentary assessment (EMA) studies [1, 2]. Such devices have many advantages (e.g. they are highly flexible and allow for complicated sampling schemes) [1]. However, in addition to the substantial up-front costs associated with purchasing and preprogramming, an important practical limitation of using a stand-
alone EMA device is that it makes long-term and/or large-scale monitoring of behavior change prohibitively difficult.

One solution to this limitation may be to utilize participants’ own Internet-enabled devices for EMA monitoring. Use of the Internet, and mobile devices to access it, is becoming ever more widespread in developed countries [3]. In Germany for example, 45% of adolescents and young adults (14–29 years old) use mobile phones to access the Internet [4]. Given the increased uptake, online questionnaires may be a viable method of conducting EMA studies. Advantages of utilizing Internet surveys include that they are inherently scalable (experimenters do not have to purchase costly equipment for participants) and highly flexible (since the program is centralized, it is easier to implement changes in the study procedures). Indeed, some researchers have already tested an Internet-based cell phone-optimized assessment technique (ICAT) to examine the drinking behavior of young people [5] or the relapse process among adult smokers [6] using time-based assessment with random prompts. In this paper we describe our initial experiences with an ICAT system to assess the smoking behavior of young adults in everyday situations.

Methods
Overview
To explore our experience with ICAT, we draw on data from a smoking study designed to monitor the trajectory of smoking patterns among young adult light or intermittent smokers (LITS) and heavy smokers (HS). EMA monitoring took place in 4 waves: 3 consecutive days every 4–6 weeks for 4.5 months.

Participants
Participants were recruited mostly through online measures. Specifically, advertisements were placed on the social media site, Facebook [7], and postings were made in Facebook groups and online message boards frequented by students. To be eligible, applicants needed to be between 18 and 25 years old, have the intention to quit within the following 6 months, have already smoked ≥5 cigarettes per day or (2) HS: ≥10 cigarettes per day. Until mid-December 2012, 1,572 participants had completed an online screening. Of those, 149 fulfilled the inclusion criteria and were invited to fill in time-based assessment with random prompts. In this paper we describe our initial experiences with an ICAT system to assess the smoking behavior of young adults in everyday situations.

Procedures
All study procedures were approved by the ethics commission of the German Psychological Society. After screening, the eligible applicants were immediately informed of their selection and were invited to provide their cell phone number, hours of the day they wanted to receive the random prompts (flexible start 7–9 a.m. and finish 10–12 p.m.) and approval of the general terms and conditions. The average selected wake time was 8.30 a.m. and the average bedtime was 10.45 p.m. After the baseline, the participants were instructed that their first wave of EMA would occur on the following Thursday through Saturday.

During the 3 EMA days, the time interval participants had selected was divided into 5 sampling windows of an even duration. At 1 randomly selected time during each of these sections a text message was sent to participants asking them to complete an assessment (random prompt). Each text message contained a hyperlink leading to the questionnaire itself (described below). The website automatically logged the time the text message was sent as well as the time the assessment was completed. Based on this information, we were able to calculate the response time intervals. If participants reported a nonsmoking situation in response to this random prompt, they were instructed to complete another assessment for the next cigarette they smoked (event-based sampling).

Each EMA wave consisted of 3 days of monitoring (Thursday, Friday, Saturday) with up to 10 expected assessments per day (5 random prompts and 5 self-initiated assessments). A maximum of 5 random prompts per day was implemented to limit the response burden for participants. Participants received an incentive of EUR 5 for each day on which they completed at least 4 prompted assessments and could obtain a live status of their earned incentives by logging into the study website.

After the participants had finished the study, qualitative interviews with a sample of 20 participants were conducted over the phone in order to assess the reasons for compliance and to collect recommendations for improvement.

Measures
The participants could access the questionnaires through the browsers of their mobile phones. Each assessment consisted of 20 questions and took approximately 2 min to complete. The participants were asked whether they reported a smoking or nonsmoking situation and how many cigarettes they had already smoked on that day. Furthermore, they were asked to report internal characteristics (e.g. affect, craving, use of strategies to control smoking [8]) and external characteristics (e.g. place, smoking restrictions, activity, presence of and smoking by others, consumption of food or alcoholic and nonalcoholic drinks [9]) of the current situation.

Results
Sample Characteristics
The sample consisted of 92 young adults (mean age = 21.17; SD = 2.23) and 42.4% were female. Most of the participants were current university students (77.2%). Furthermore, the sample was split almost evenly between

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LITS and HS. The 45 LITS currently smoked an average of 3.52 cigarettes per day (SD = 1.21) and the 47 HS smoked 16.10 cigarettes per day (SD = 4.14).

**EMA Assessments**

The quantity and quality of EMA assessments are described in Table 1. Overall, 885 observations were reported, of which 708 (80.0%) were from random prompt assessments. The mean number of overall situational assessments per person was 9.62 (SD = 7.07), and 55.4% of participants completed assessments on all 3 days of the sampling periods. In our study, 65.3% of participants repeatedly participated and completed 5 or more EMA assessments, which has been defined as retention in a previous ICAT study [5]. The mean number of assessments per day on days when there was at least 1 assessment was 4.17 (SD = 2.77).

In order to examine which participant characteristics may be related to EMA compliance, we used age, gender and baseline smoking status (LITS vs. HS) to predict the overall number of completed assessments in a multivariate regression analysis. Higher age was significantly related to more completed assessments (β = 1.11; t = 3.4; p < 0.01) and female gender to fewer completed assessments (β = –3.01; t = –2.1; p < 0.05). Smoking status did not significantly predict the number of EMA observations.

**Compliance with Random Prompt Assessments**

Participants responded to 50.2% of random prompts (table 1), and 52.4% of those were completed within the 10-min window typically allowed with EMA studies that utilize EDs; the time taken to respond to a random prompt ranged from 1 to 1,070 min (mean = 43.65; SD = 107.08; median = 10).

**Total Assessments of Smoking Situations**

In total, 420 smoking situations were reported by the participants (47.5% of all recorded assessments). HS recorded 5 or more smoking situations on 12.1% of days of the assessment period, in spite of stating a daily use of far more than 5 cigarettes at baseline. LITS reported their personal average number of cigarettes (as indicated by baseline data) or more on 21.5% of assessment days.

**Self-Initiated Assessments of Smoking Situations**

Of all 420 reported smoking situations, participants self-initiated 177 (42.1%) of these reports and 243 (57.9%) were reported as a response to a random prompt. The proportion of days when participants reported any self-initiated assessments was 33.7%.

**Interviews with Participants after Study Completion**

After study completion, 20 participants were contacted by study staff over the phone and interviews were conducted. Problems with timely responding to random prompts included specific situations (school, work, driving a car, traveling), problems with phone reception, failure to notice a prompt (e.g., because the phone was mute, switched off, out of battery), and prompts sent too early in the morning (especially on Saturdays). Similarly, we asked participants about issues encountered that prevented them from reporting self-initiated smoking situations. Frequent responses included forgetting, smoking fewer than 5 cigarettes that day and problems with the availability of questionnaires (questionnaires were blocked for 15 min after each assessment in order to ensure that it was a new observation).
Discussion

While we showed that an ICAT relying on the mobile phones of participants to assess smoking behavior is technically feasible, there appear to be shortcomings with regard to participant compliance. Overall, participants only recorded about half of all expected random assessments and a very limited number of self-initiated reports were completed. Furthermore, only every second completed random prompt was responded to within the first 10 min after issuing.

Studies using traditional EMA devices such as EDs to assess smoking behavior have reported varying figures of participant compliance with random prompt assessments [10]. Two studies comprising adult smokers with a mean age over 40 years reported rates of random prompt compliance of 91% [11] and 76% [12], while other studies examining the smoking behavior of college students reported compliance with random prompts ranging from 81% [13] to as low as 52% [14]. This could indicate that it may be more difficult to engage younger participants such as the sample in our study in a highly compliant response behavior, and hence some of our compliance may have been driven by the study sample rather than our study methodology per se – the fact that younger age was related to less overall EMA compliance in our study may underline this issue.

While a limitation of a centralized survey design such as ours is that we cannot be entirely sure whether a participant actually received a prompt, or may not be able to access the online questionnaire due to lack of Internet connection, it is unlikely that such situations would fully account for the observed poor compliance. A more plausible reason for our low rate of compliance may be the fact that our study was completely conducted online without any personal contact with participants or participant training. Indeed, the two available substance use studies using similar ICAT procedures reported similar overall response figures. For example, one recent study using the ICAT to assess drinking behavior in young adults reported responses to 52% of all prompts and the median response time was 25 min [5] (compared to 10 min in our study). Another recent study examining the smoking relapse process among adult smokers aged 20–40 years with 3 random prompts per day over a 4-week interval reported a response rate of 54.7% to all random prompts [6]. No data on response times were reported in this study.

Based on our initial experience, several aspects of the design may be improved in future studies. Firstly, it may be necessary to conduct face-to-face or telephonic training with participants, as is typical with standard EMA studies. Furthermore, personal contact with the experimenters may increase the motivation of participants to adhere to study protocol, and tailoring of feedback after each EMA assessment (e.g. mean response time, percent of assessments completed, etc.) may improve their response behavior. Thirdly, the incentive for regular participation we provided (approx. USD 80) may not have been high enough for our target group, or bonus incentives that are tied more directly to compliance may need to be offered. Fourthly, participants should be able to customize the time window for EMA assessments on a daily basis to account for different wake times between weekdays and weekends. Finally, one particular problem of this approach seems to be the event-based sampling of smoking situations and the subsequent reliance on self-initiated reporting by participants, which resulted in particularly low response rates. A possible reason for this may be a strong reactivity as a result of self-monitoring in our sample of young smokers with the intention to quit. An alternate way of tracking events may be through instructing participants to report every event and then selecting a subsample of these events for assessment – an approach that has been used successfully in ED studies [11]. Such a sampling protocol would also allow for more detailed time series analyses [1].

Conclusion

Our study showed that it is possible to collect EMA data on smoking behavior using an ICAT that utilizes the mobile phones of the participants. As in other ICAT studies, compliance levels are far from the levels reached in studies that used EDs for EMA with older adult participants. Future studies have to test whether low compliance is due to less personal contact between participants and study staff and less training and support of participants in ICAT protocols or because of age-related factors. Future ICAT studies should implement additional measures to improve the compliance of participants. Finally, it should be noted that low compliance of participants does not automatically result in low quality of the resulting data – future analyses will have to test for eventual systematic bias relevant to the topic studied.

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Disclosure Statement

Dr. Ferguson’s research group supplies EMA data collection software for research studies; however, he receives no personal remuneration for this service. The other authors declare that they have no conflicts of interest.

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