Published in final edited form as:

Asian J Psychiatr. 2014 August ; 10: 90–95. doi:10.1016/j.ajp.2014.04.004.

Use of Mobile Assessment Technologies in Inpatient Psychiatric Settings

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Abstract

Mobile electronic devices (i.e., PDAs, cellphones) have been used successfully as part of research studies of individuals with severe mental illness living in the community. More recently, efforts have been made to incorporate such technologies into outpatient treatments. However, few attempts have been made to date to employ such mobile devices among hospitalized psychiatric patients. In this article, we evaluate the potential use of such devices in inpatient psychiatric settings using thirty-three hospitalized patients with schizophrenia. Employing an Experience Sampling Method approach, we provide support for the feasibility of using such devices, along with examples of potentially clinically-relevant information that can be obtained using such technologies, including assessment of fluctuations in the severity of psychotic symptoms and negative mood in relation to social context, unit location, and time of day. Following these examples, we discuss issues related to the potential use of mobile electronic devices by patients hospitalized at inpatient psychiatric settings including issues related to patients' compliance, assessment schedules, questionnaire development, confidentiality issues, as well as selection of appropriate software/hardware. Finally, we delineate some issues and areas of inquiry requiring additional research and development.

1. Introduction

Technological advances over the past decade have made it feasible to incorporate electronic mobile devices (i.e., PDAs, cellphones) into psychiatric research and treatment. Specifically, mobile devices have been used to study “real world” daily functioning of individuals with severe mental illness including people with schizophrenia and acute psychosis (Kimhy et al., 2006, 2010, 2012; Granholm et al., 2008, 2012; Spaniel et al., 2008; Johnson et al., 2009;

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Depp et al., 2010; Swendsen et al., 2011; Ben-Zeev et al., 2011, 2012; So et al., 2013), bipolar disorder (Husky et al., 2010; Depp et al., 2010; Bopp et al., 2010; Kwapil et al., 2011), schizotypy (Kwapil et al., 2012; Barrantes-Vidal et al., 2013), as well as individuals at clinical high-risk for psychosis (Kimhy & Corcoran, 2008). While these technologies were utilized primarily to collect research data, in recent years a number of attempts have also been made to incorporate such technologies into treatments (Kimhy & Corcoran, 2008; Spaniel et al., 2008; Depp et al., 2010; Granholm et al., 2013).

Recent reports reviewing the use of mobile technologies in research and treatment of individual with severe mental illness have highlighted the feasibility and potential benefits of such practice (Kimhy et al., 2012; Ben-Zeev et al., 2013). However, these reports have concentrated, for most part, on the application of such technologies to outpatient individuals living in the community. In contrast, few reports have focused on the feasibility and utility of incorporating mobile technologies into assessment and/or treatment of hospitalized individuals. In fact, to date only few studies using mobile devices were conducted in inpatient psychiatric settings (Kimhy et al., 2006, 2010; So et al., 2013). To address this gap in the literature, we assessed the feasibility of using mobile technologies among hospitalized individuals with schizophrenia. Next, we provide examples of potential clinical information that may be obtained using mobile technologies to inform clinical decisions and treatment at inpatient psychiatric settings. Finally, we discuss issues related to the potential use of mobile electronic devices by patients at inpatient psychiatric settings including selection of software/hardware, confidentiality issues, assessment schedule, questionnaire content, and patients' compliance.

2. Experimental/Materials and Methods

2.1 Participants

Participants with schizophrenia and related disorders were recruited from patients hospitalized at the New York State Psychiatric Institute (NYSPI). Forty-one individuals were approached to participate in the study of which 33 (80.5%) enrolled in the study. Decline to participate did not appear to relate to clinical status. All participants provided written informed consent, and the study was approved by the NYSPI's Institutional Review Board. Table 1 presents data on the participants' demographic and clinical information.

2.2 Procedure

On the morning of the study, participants were provided with a mobile device (Palm Tungsten T3) to carry with them throughout the day. Next, participants received a brief introduction to basic operations of the mobile device and completed two full practice sets of questions. The introduction sessions typically lasted 20 min. The mobile device was programmed to beep at random times 10 times a day between 10:00 am and 10:00 pm to elicit information about current symptoms, mood, location, and social context. Upon hearing the beep, subjects were instructed to respond to a questionnaire presented on the screen of the mobile device (i.e., "I feel depressed"; "I hear voices that other people can't hear"). For each symptom and mood question, subjects were asked to indicate on the mobile device's screen the quality of their current experience on a graphical slider similar to a visual analog

scale (from “not at all” to “very much”; see Figure 1). Responses were represented in the output as a value between 1 (“not at all”; leftmost extreme) and 100 (“very much”; rightmost extreme). Additionally, subjects were asked about their current location on the unit and their social context. This procedure was used successfully in two previous reports documenting use of mobile assessment technologies among hospitalized patients with schizophrenia (Kimhy et al., 2006, 2010).

2.3 Data Analyses

Data were first analyzed descriptively to check range and distribution of all variables. Next, patient self-reported rating of mood and symptom were analyzed by multilevel linear mixed effects model analyses controlling for correlation among repeated measurements at the day level and the subject level by including subject-specific random intercepts, and day-specific random intercepts. Association between mood and symptom outcomes and social context (being alone), unit location (different rooms in the unit) and time was examined by testing significance of these predictors included as fixed effects in the model. The mean of mood and symptom outcomes estimated from the linear mixed effects models and their standard errors were reported. All tests were two-sided and statistical significance was defined as $p < 0.05$.

3. Results

On average, the participants responded to 81% of the 20 questionnaires presented over the 2-day assessment period. Only one patient discontinued his participation due to a clinical exacerbation associated with use of the mobile device and no mobile devices were broken or damaged during the assessments. Similarly, patients' reports of comfort and ease of use of the mobile devices were similar to previous reports among hospitalized individuals with schizophrenia and comparable to rating among healthy controls (Kimhy et al., 2006; See Table 1).

3.1 Association between Mood and Social Context

Social context, as indexed by the question “Am I alone?” (response options: Yes or No) was reported by participants as part of each questionnaire completed on the mobile device, allowing determination of potential differences in severity of mood related to social context. Patients reported being by themselves during 35% of their experience samples vs. 65% in the company of others. Depressed mood was significantly higher when alone than when in the company of others ($F=4.33$, $p=.038$; mean=41.83, SE= 4.61 vs. mean=36.77, SE= 4.44, respectively; See Table 2).

3.2 Association between Severity of Psychotic Symptoms and Unit Location

As part of each questionnaire completed on the mobile device, patients also reported about their location on the unit, allowing determination of potential differences in severity of symptoms associated with specific unit locations. Figure 2 displays a schematic map of the unit in which our data collection took place. Table 3 presents a distribution of the time spent by patients in various unit locations. There were no significant differences in auditory hallucinations (as indexed by the item “I hear voices that other people don't hear”) based on

unit location ($F=1.43$, $p=.21$). However, inspection of the data indicates that the lowest ratings were made by patients while in the art room (mean=12.45, SE= 6.30) and activity room (mean=18.59, SE= 5.60), areas where patients typically engaged in goal-directed staff-guided activities. In contrast, the highest severity of auditory hallucinations was recorded in the Community/TV rooms area (mean=22.07, SE= 5.32).

3.3 Severity of Psychotic Symptoms as a Function of Time of Day

Figure 3 displays the course of average ratings of paranoid ideation over time among all patients. While the differences over time were not significant ($F=.95$, $p=.49$), inspection of the figure suggests that severity of paranoid ideation varied considerably over the course of a day, with high paranoia ratings during morning hours, reductions in severity from 12 to 2 pm and again from 5 to 6 pm, and elevations during evening hours.

4. Discussion

Our results provide support for the feasibility and clinical utility of using mobile devices in inpatient psychiatric settings. Our findings are consistent with previous studies reporting use of mobile devices by hospitalized schizophrenia patients (Kimhy et al., 2006, 2010; So et al., 2013), as well as individuals with schizophrenia living in the community (Kimhy et al., 2012). The findings suggest that variables such as social context, unit location, and time of day may have important impact on severity of symptoms and mood among hospitalized individuals with schizophrenia. In contrast to outpatient individuals who typically have highly heterogeneous living environments for which clinicians have little ability to control, inpatient psychiatric settings offer clinicians the possibility to use data to enhance treatment more directly. For example, our results indicate that increased depressed mood, a common symptom among hospitalized individuals, is associated with social context – being alone on the unit. Such information may be used to inform the design of unit activities and schedules that enhance patients' exposure to others. Our sample size and relatively brief assessment time precluded the possibility of conducting more refined analyses about the potential impact of specific social contexts on patients' mood and symptoms. However, the use of mobile devices may allow inquiry about the impact of various social context variables and their impact on mood and symptoms (e.g., being in the company of other patients vs. staff; having male vs. female vs. mixed company; crowdedness – being in the company of one vs. more people, etc.). Future studies should aim to explore these social context variables and their potential impact on patients' mood and symptoms.

Similarly, the use of mobile devices may allow evaluating potential locations on inpatients settings that are associated with elevations in negative mood and/or symptoms. While the differences in our data did not reach significance, potentially due to a relatively small sample size and brief assessment period, the results suggest that various unit locations are associated with distinct levels of symptoms. Specifically, being in the Community/TV rooms was associated with the highest ratings of auditory hallucinations. In contrast, the lowest reports of auditory hallucinations were reported in the art and activity rooms. While the physical settings of these rooms may have had an influence on symptoms, it is likely the ratings were also related to the specific activities conducted in each room. In particular,

engaging in passive activities, such as watching TV, may increase severity of auditory hallucinations. These findings are consistent with results reported among individuals with schizophrenia living in the community (Delespaul et al., 2002). Likewise, engaging in goal-directed activities, similar to ones often completed in art and activity rooms by patients and unit staff, may potentially be associated with lower ratings of auditory hallucinations. In our final example, we characterized paranoid ideation over the course of a day. The data suggests that severity of paranoid ideation varied considerably over the course of a day, with reductions in severity from 12 to 2 pm and again from 5 to 6 pm. Coincidentally, these dips in severity of paranoia parallel lunch and dinner times (12pm and 5pm, respectively) at the inpatient unit, suggesting a potential link between the act of eating and reduction in paranoid ideation. A similar pattern of results, indicating symptomatic elevations during moments of hunger, was reported among individuals with schizophrenia and related disorders living in the community (Delesapul, p. 209, 1995).

The use of mobile devices in inpatient psychiatric settings may necessitate specific considerations. While not all patients would be agreeable to using the devices, in our current and previous inpatient studies refusal rate were relatively minimal, despite substantial symptom severity. Similarly, studies among paranoid individuals living in the community reported broad acceptability among such individuals (Kimhy et al., 2012). It is also worth nothing that, unlike participants in the studies conducted in the community, participants in this investigation did not receive compensation for their participation. While the use of mobile devices may carry a risk of patients incorporating the use of their device into their delusional thinking, in our experience such risk is relatively low, and can be minimized substantially by providing the patients with a clear explanation of the purpose of using the devices and emphasizing the voluntary nature of using the devices.

Another issue for consideration is the design of the assessment schedules and questionnaires. Studies using mobile devices among individuals with schizophrenia and related disorders typically collected data 10 times/day over a 6-day period (Kimhy et al., 2012). However, the selection of length of assessments is dependent on the expected period of assessment, with longer durations of assessment generally calling for fewer daily questionnaires. Another consideration is the time course of the variables of interest. For example, delusions are common among individuals with schizophrenia (Kimhy et al., 2005). However, studies using experience sampling reported that participants with schizophrenia reported experiencing delusional thinking in less than one-third of the experience samples over a weeklong period (Myin-Germeys et al., 2001; requiring completion of 60 experience samples to obtain reports of ~20 delusional moments). In contrast, mood ratings of 25 or higher (on range 1–100) were recorded on 98% of our experience samples (Kimhy et al., in press). Thus, a shorter and/or less frequent collection period may be adequate to obtain sufficient number of data points on emotions (i.e., one would require to complete 20 experience samples to obtain ~20 “emotional” moments).

An important step in implementing use of mobile devices is the development of the questionnaire. In contrast to retrospective questionnaires that tend to focus on trait-like experiences, momentary questionnaires should involve short cues that reflect the experience of momentary states as they occur in commonplace situations. Likewise, it is important to

use language and vocabulary that is simple and commonly used by lay people. For example, asking about “hearing voices” is preferable to asking about “auditory hallucinations”. Likewise, negatively formulated items are less frequently endorsed, leading to skewed distributions, whereas positively formulated items usually have a normal distribution (Myin-Germeys, 2011; Kimhy et al., 2012).

Because participants have to answer questions on a frequent basis in their normal daily lives, the duration of the assessment should generally be brief (less than 5 minutes). However, in developing questionnaires, clinicians may need to be aware that asking a person to repeatedly reflect on their mood or symptoms may actually negatively impact their experience, leading to exacerbation of negative mood or symptoms. One strategy to minimize this influence is to incorporate questions that are content or valence-balanced. For example, questions about negatively-valenced mood (anxiety and depression) may be balanced by items about positive ones (happy). A frequent concern when using repeated momentary assessments is the possibility that participants may lose motivation, resulting in lower compliance over time (fatigue effects) or that repeatedly asking an individual how they think, feel, or behave may change the intensity or frequency of those variables (reactivity). Evidence from previous studies has found no indication of fatigue or significant reactivity to mobile assessments in patients with schizophrenia (Granholm et al., 2008; Johnson et al., 2009). However, clinicians developing questionnaires for use with mobile devices need to be aware of this potential risk.

Use of mobile technologies in inpatient settings may also require paying attention to a number of technological issues – for example, use of Wi-Fi-enabled devices over local wireless networks may require utilizing secure, password-protected communications in order to ensure confidentiality of patient-related data. Likewise, the choice of mobile devices may need to be informed by unit privacy regulations – e.g., use of devices with no camera/video capabilities. Additionally, depending on the type and capabilities of the mobile devices used, clinicians may want to consider allowing devices that offer possibilities to access online services and email or whether such services should be blocked. Finally, arrangements need to be made to allow patients to charge the batteries of their mobile devices.

While our study provides preliminary support for the feasibility and clinical utility of using mobile devices in inpatient psychiatric settings, a number of issues remain unaddressed. First, previous reports were based almost exclusively on use of mobile devices as part of research studies, typically over a 6-days period. While, the average length of hospitalization of patients with serious mental illness is only slightly longer (10 days; Lee et al., 2012), the feasibility and clinical utility of such devices as part of regular clinical inpatient treatment needs to be evaluated and confirmed. Second, in order to implement the use of mobile devices as part of regular clinical care and make the most out the rich data collected, a centralized data analyses system needs to be developed. Such system should provide unit's clinical staff with timely information that will allow identification of useful clinical indicators and inform clinical decisions at both the individual patient level, as well as the inpatient setting in general. Finally, future advances in technologies may allow integration of mobile devices with other ambulatory assessments such evaluations of heart rate, blood

pressure, and other physiological indicators to provide clinical staff with even more comprehensive clinical picture. Preliminary work in this area has already begun (Kimhy et al., 2010), integrating clinical information from mobile devices with concurrent ambulatory cardiopulmonary data obtained from Holter monitors.

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Figure 1.
Screen Shot of Question Presented on the Mobile Device

Figure 2.
Schematic Map of the Psychiatric Inpatient Unit

n = 33 patients with schizophrenia; Severity of paranoia: range from 1 ("not at all") to 100 ("very much"). Time of day: 10 = experience samples between 10am-11am, 11 = experience samples between 11am-12pm, etc.

Figure 3.
Mean Severity of Paranoia Across Time of Day

Table 1

Demographics and Clinical Information

	N / Average	% / SD
Age (years)	27.8	6.3
Sex (Female)	15	45%
Racial Background		
Caucasian	17	52%
Black / African-American	6	18%
Asian	4	12%
More than one race	6	18%
Ethnic Background (Hispanic / Latino)	10	43%
Diagnosis		
Schizophrenia	23	70%
Schizoaffective Disorder	7	21%
Depression with Psychotic Symptoms	2	6%
Delusional Disorder	1	3%
Primary Language (English)	25	76%
Education (years)	13.8	2.7
Positive Symptoms (SAPS Global Ratings)		
Hallucinations	3.12	1.97
Delusions	3.51	1.57
Bizarre Behavior	.67	1.10
Positive Formal Thought Disorder	1.29	1.40
Negative Symptoms (SANS Global Ratings)		
Affective Flattening	2.43	1.45
Alogia	1.20	1.46
Avolition-Apathy	2.41	1.65
Anhedonia-Asociality	2.61	1.62
Attention	1.89	1.31
Ease and Convenience of Using the Mobile Devices		
I had difficulties understanding the questions	1.24	.41
I had difficulties typing my responses	1.39	.92
I had difficulties operating the device	1.03	.35
The device was comfortable to carry	4.30	1.01
The beeps interfered with my activities	2.21	.90
Overall, this experience was pleasant	3.88	1.15
Overall, this experience was challenging	1.97	1.09

	N / Average	% / SD
Overall, this experience was stressful	1.63	.55

n=33; SAPS - Scale for the Assessment of Positive Symptoms ; SANS - Scale for the Assessment of Negative Symptoms; Ease and Convenience - ratings on a 5-point Likert-scales (from 1 "not at all" to 5 "very much").

Table 2

Mean Severity of Symptoms by Social Context

Alone?	ES (%)	Paranoid Ideation (S.E.)	Auditory Hallucinations (S.E.)	Depressed Mood (S.E.)
Yes	182 (36%)	26.93 (3.99)	21.09 (5.27)	41.83 (4.61)
No	330 (64%)	23.27 (3.80)	21.04 (5.21)	36.77 (4.43)

n=33; ES – Experience Samples.

Table 3

Mean Severity of Symptoms by Unit Location

Location	ES (%)	Paranoid Ideation (S.E.)	Auditory Hallucinations (S.E.)	Depressed Mood (S.E.)
My Bedroom	80 (16%)	↓ 19.56 (4.49)	19.87 (5.38)	↓ 35.59 (5.13)
Community / TV Rooms	111 (21%)	27.49 (4.29)	↑ 22.07 (5.32)	39.61 (4.97)
Dining Room	182 (35%)	23.94 (4.06)	21.50 (5.25)	37.25 (4.74)
Art Room	18 (4%)	24.05 (6.93)	↓ 12.45 (6.30)	↑ 44.85 (7.46)
Activities Room	45 (9%)	24.93 (5.13)	18.59 (5.60)	44.12 (5.74)
Other Areas	77(15%)	↑ 27.98 (4.53)	21.28 (5.40)	38.48 (5.19)

n=33; ES – Experience Samples; The up and down arrows indicate the highest and lowest ratings (respectively) for each symptom and mood.