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1. CBT Assistant: Mobile apps for Cognitive Behavioral Therapy (CBT)

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Video-demo of CBT Assistant


This is an on-going project in collaboration with Psychological Medicine at NUS, academic researchers and therapists using CBT among other therapeutic methods in their clinical practice.

We started by conducting a survey of CBT apps. We found out that existing CBT apps play mostly self-help, educational role. Limitations: lack of customization features; lack of support for the end-to-end treatment process; lack of support for specific interventions; not using smartphone capabilities (mainly text-based mode).
We formulated requirements for CBT Assistant apps to overcome the above limitations. We extracted CBT scenarios from typical CBT sessions run by our collaborators.

Our CBT Assistant apps target patients suffering from a mental disorder who are currently undergoing CBT sessions with trained professionals. CBT Assistant apps help a patient absorb the CBT instructions learned during the face-to-face session with a therapist, and adhere to doctor-recommended CBT homework exercises.

At the end of the therapy session (Figure 1), the therapist configures and customizes mobile CBT interventions for the patient using an intelligent tool on the therapist’s PC. A custom CBT Assistant app – tailored to the patient’s profile, the stage of the therapy and recommendations for coming weeks - is uploaded to patient’s mobile phone and assist the patient in-between sessions.

As a pilot, we implemented two CBT Assistant apps, one for patients suffering from Social Anxiety Disorder, called CBT-SAD for short, and another one for panic attack, called CBT-PA.

CBT Assistant app for Social Anxiety Disorder, CBT-SAD supports the following:

The patient performs graded exposure exercises with the guidance of the app.

App provides the detailed instructions for each exercise for a patient to refer to on the move.

On the first attempt of each exercise, the patient is asked to fill in a Fear Plan. The app helps the patient think through the different problems that she may face in the upcoming situation and the possible steps or skills she can use to overcome these challenges.

A self-assessment tool based on the Watson and Friends’ Social Avoidance and Distress (SAD) Scale is available to allow the patient to evaluate her level of social anxiety before and after the exercise.

After performing the exposure exercise, the patient is asked to fill in an exposure diary. This allows the patient to log in her thoughts and experiences when it is most fresh in her minds.

Aside from the exposure exercises, CBT-SAD also supports other forms of monitoring with templates such as Personal Diary and Thought Diary. Checklists for symptoms and triggers of Social Anxiety Disorder are available to allow the patient to constantly record and monitor the respective items.

A Help page is present for patients to review past concepts that they have gone through during their therapy sessions.

Other features include weekly alarms and reminders - for the user to set their reminders for the different exercises - and a summary page for the app where the user can view their progress.

**On-going Project**

We plan evaluations of CBT Assistant first with healthy students and then with patients. Second iteration of CBT Assistant apps will start in August 2014.
2. Mobile versions of validated paper-based mood self-assessment scales

*Students:* Ouh Eng Lieh, Henry Chua, Jiang Yaoxuan, Lim Jia Rong, Eugene Sim Shengming, Le Minh Khue

*Video demos* of two apps implementing mobile mood scales: MMS Video Demo and PAD-SAM Video Demo

Le, M.K. and Jarzabek, S. “Mood Self-Assessment on Smartphones,” submitted to for publication

With fast evolution of mobile technology, smartphones are becoming a potential tool for collecting user data that can be useful in medical treatment and self-monitoring for personal improvement, among many other possible applications. Among user data, mood is most elusive, difficult to capture, but at the same time important in devising intelligent human-computer interactions, affective computing, and user-aware mobile apps. In mobile apps for healthcare (mHealth), knowing the fluctuations of patient’s mood patterns may be useful in patient monitoring, as an indicator whether a given medicine or medical intervention works for a patient or not.

As mood is a subjective feeling, we must first accurately capture user’s rating of own experienced mood before we can design methods for automated mood recognition from user’s behavior or from physiological data captured via sensors. In last decades, psychologists developed a number of paper-based self-assessment mood scales that have been empirically validated. A typical mood scale includes from two (Russell’s core) to 60 (extended PANAS) mood items that are rated separately, typically on five-point scales (seven- and nine-point scales are also used in mood studies). An overall mood (or its positive and negative component) is then computed from separately rated mood components. Mood scales are used in clinical practice, surveys, basic studies on mood in psychological research, and in attempts to build mood engines to infer mood from user behavior captured by smartphones.

There are good reasons to equip smartphones with mood self-assessment capability. Paper-based life satisfaction and mood surveys are expensive to conduct and are usually limited to small sample of participants. Similar surveys with smartphones could include large population, at low cost. If mood self-assessment via smartphones can be as accurate as paper-based mood questionnaires, then smartphone-based surveys could lead to observations and findings beyond what was possible to achieve before with paper-based surveys. Unlike paper-based surveys, smartphones can collect in-situ mood self-reports, many times during the day, over extended period of time. This also opens the possibilities of new types of mood studies, yielding new results compared to what was possible with paper-based methods. Many participants in mood studies may find entering mood frequently and for longer time tedious and boring. Smartphones can add an element of social connectivity, feedback, collaboration or competition (using gamification strategies) to counter such risks. Finally, paper-based scales use linguistic terms and numeric scales. Mobile technology creates interesting options to make mood self-assessment more intuitive. We may use color, brightness, animation, visual effects, pictures, sound or haptics (pressure or vibrations) to engage human senses that are more closely linked to mood than linguistic terms or numbers.

With the above motivations and goals in mind, we developed Mobile Mood Scales (MMS) app running on Android 4.1 or higher described in this paper. MMS implements validated mood scales called PANAS, short PANAS, SPANE, PAM and AffectButton.

**Applications of mobile mood scales:** While MMS can be used as a standalone app for mood tracking, our prime goal was to provide psychology researchers conducting studies on mood and designers of mHealth apps where it is important to know fluctuations of patient’s mood, with a package of mood scales that can be flexibly adapted to their specific needs. Other applications of MMS include large-population low-cost mood and well-being surveys, research on mood inferring, and in Affective Computing. MMS can be adapted in flexible way to multiple application contexts. In particular, mHealth researchers and app developers can select a mood scale required in their mHealth app or experiment, as well as specific optional features such as the use of visual effects for that scale.

**On-going projects on mobile scales**

We build a Mood Self-Assessment app suite (mobile + web-based), customizable package with major validated mood self-assessment scales which we plan to release to general public (as a mood tracking app enhancing emotional awareness), to the doctors who need evaluate their patients’ mood in real-time, and to researchers studying mood and emotions.

For that we enhance current mood scale apps by adding/enhancing the following features:

1) Flexible customization capability to allow the user (a researcher planning an experiment or an end user) to customize the scales (e.g., to enable/disable various features).
2) Scheduling, reminding and monitoring capabilities. This will allow the user to set mood report collection protocol – when, how frequently and for how long the mood data is to be reported. The monitoring component will check mood reporting adherence to the pre-defined protocol, providing feedback and encouragement to the user.
3) Analysis and visualization of mood data.
4) Web-based apps for mobile mood scales.

3. A framework for rapid development of mobile/web self-reporting scales and questionnaires

There are many self-reporting scales used by doctors in clinical settings for assessment of pain, the severity of disorders such as anxiety or depression. There are scales/questionnaires for self-assessment of life satisfaction, subjective well-being etc. In this project, we build a framework for rapid development of any mobile/web scales from high-level specifications indicating the number scales/questions, their phrasing, types of scales (5-point, 7-point) and details of the required UI. Entering these specifications of scales or questionnaires on the PC does not require any programming skills.

We envision application of the mobile/web scale framework in clinical practice, research projects that require self-reporting capability on mobile phones and/or PC, and in large-population surveys.

4. Medication Adherence app

Students: Riandy

50% of patients suffering from chronic diseases do not take prescribed medication. 30% of patients drop therapies after initial sessions with a doctor. In this project, we research and implement into the app a range of strategies for patient engagement and behavioral change to assist patient outside clinics and keep them on the course of the therapies. Exercise adherence and diet adherence can be built on the core functionality of medication adherence app.

5. Monitoring the effects of an immunosuppressive drug on subjects’ mood

Collaborator: Prof. Johnson Fam, Psychological Medicine, Yong Loo Lin School of Medicine, NUS

Participants in this study will carry smartphones equipped with self-reporting scales, alerts/reminders and data collection capabilities. Self-reporting scales include physical/mental discomfort scales and a Hospital Anxiety and Depression Scale commonly used in clinical practice.

6. A framework for rapid development of mHealth apps

mHealth apps for many different medical applications have similar functional components: Most mHealth apps need scales and other self-reporting capability, journaling, alert/reminder setting, active support for various interventions prescribed for the patient, data storing, analysis and visualization, secure data transfer from patient’s mobile phone to the cloud and doctor’s PC. More advanced medical apps may also need user- and context-sensing or data collection from mobile phone logs, sensors and wearable sensors. Figure 1 outlines component architecture of CBT Assistant that is also shared by other apps that we build. Instead of developing each mHealth app from scratch, we can reuse these components after proper adaptation. Using APIs and flexible customization technique called ART (art.comp.nus.edu.sg) developed in our lab, we build a framework that will facilitate rapid development of mHealth apps from components engineered for reuse.

7. Special challenges in mHealth apps

7.1 Usability, attractiveness of apps and user engagement

mHealth apps must be frequently used, for extended period of time, before patients can observe benefits. To adhere to mobile interventions, patients may need to modify their habits. Therefore, attractiveness, user engagement, and encouraging behavioral change are key properties of successful mHealth apps.
Each time a patient opens an app, she should find something new there, surprising, funny, inspiring. We must give patients good reasons to look forward to opening an app again and again. Apps must be appealing, providing freshly updated and relevant contents adapted to the patient situation. Ideally, apps would evolve in sync with the progress of the therapy, and as the patient evolves from novice to expert user of the intervention supported by the app.

Challenge: how to make intervention apps sticky?

The following strategies can help us achieve attractiveness of mHealth apps: Gamification - scoring star badges, achievement levels, elements of competition; Social networks: sharing experiences, success and failures with others, getting help from others, connecting to friends and doctors for feedback and encouragement; Exploring technological options on smartphones to build engaging apps – sound, videos/graphics, and touch; Use of analogies - mountain climbing, adventure trip, and expedition; participating in the story via avatar; use of virtual environments.

7.2 Encouraging behavioral change

A common critic of existing mHealth apps is that they provide healthcare information and recommendations/interventions, but do not help user effectively conduct interventions, measure the progress and sustain the practice in long run. In addition to alerts and providing healthcare information in attractive form, mHealth apps need address the follow up behavioral change relevant to app’s goal. Existing evidence-based behavioral change strategies must be adapted for mobile context of application. Technological options available on mobile phones can allow us to define and experiment with novel forms of behavioral change strategies.

Users need use mHealth apps regularly for extended time. To progress with the therapy, users may need question some of the habitual behaviors, modify them or replace with new behaviors. There is a body of evidence-based strategies for behavioral change and it is a great challenge to explore how they can be adapted for mHealth apps.

8. Mobile Sensing Framework (MSF)

Students: Gabor Novak, Daniel Dan

Project funded by Microsoft Research Asia.

Mobile Sensing Framework (MSF) automatically collects user and environmental data from phone usage logs (calls, texting, use of apps, Facebook activity, etc.), and smartphone sensors (location, movement, weather and others).

The purpose of MSF is to equip future mHealth apps with intelligent behavior based on the knowledge of patient condition and environmental context. Apps such as CBT Assistant, remote patient monitoring, medication adherence improvement can benefit from such knowledge.

MSF will facilitate studies on mood inferring from phone usage patterns and sensor data (described below). MSF has been released to the research community to facilitate studies http://sourceforge.net/p/dynamixdcf/wiki/Home/.

MSF described in papers:


9. Inferring mood from data collected by smartphones

Project supported by Microsoft Research Asia grant.

This project is planned but has not started yet. The goal is to develop capability on smartphones to infer users’ mental (e.g., mood) or physical condition from automatically collected phone usage logs and smartphone sensor

1 Gamification: the use of game elements (mechanics) and game design techniques to enhance engagement in non-game context
data. The project is facilitated by the Data Collection Kit comprising the Mood Self-Reporting Kit and Mobile Sensing Framework.

The study will be conducted with participants spanning different group ages and cultures, with motivated people mainly recruited from Quantify Self communities in Singapore, Poland, Canada, Hungary.

Project overview:

![Figure 2. Overview of mood inferring project](image)

**Recruitment of participants.** Participants will be students and individuals motivated to participate in the experiment for 6-8 weeks. We will ask the candidates to fill in the pre-study questionnaire based on which we will select the participants.

**Data collection.** Participants will carry smartphones with Data Collection Kit (DCK) installed. DCK will run in the background and collect sensor data. At the beginning of the study, each participant will fill in the personality trait and Quality of Life questionnaire, using one of the validated scales. Participants will be self-reporting their mood over 6-8 weeks using validated mood scales, three times daily. At the end of the day, participants will report their daily activities. Sensor data annotated with self-reported data will be stored.

**Data analysis.** We will analyze collected data to find statistically significant correlations between person’s mood and user data collected via mobile phone sensors. We’ll build mood models based on these correlations. A mood model will infer user’s mood from data collected by sensors.

**Validation of mood models.** Participants will carry smartphones with DCK and mood models installed. Mood models will infer user’s mood from sensor data collected in real life. Inferred mood will be compared with self-reported mood to assess the validity of mood predictions.

## 10. mHealth in Asia-Pacific

I think mHealth has great potential to address vital needs of people in Asia. In December 2013, I visited Kathmandu University and we set up plans for mHealth project and research lab there. May-June 2014 I spent in Bhutan as a volunteer on invitation of the Bhutan Innovation & Technology Centre (BITC) in Thimphu TechPark to explore mHealth and e-Government projects. In Bhutan and Nepal, many people live in hard-to-reach mountainous regions, with poor access to healthcare centers by road. Like many other developing countries, Bhutan and Nepal are rapidly setting up a robust telecommunication infrastructure, including mobile services and wireless connectivity at the remote locations using TV white spaces technology. Large populations have mobile phones. Mobile technology can disseminate healthcare education to hard-to-reach populations living in mountainous areas, and connect them to health givers. In countries with low ratio of the number of doctors per a population group, mHealth solution can ease the healthcare giver burden, allowing doctors to attend and effectively monitor more patients.

To identify and better exploit mHealth potentials in Asia, I have initiated mHealth Asia Initiative with the following objective and action plan:

The purpose of mHealth Initiative is to identify and then implement mHealth strategies that can benefit Asian countries.
The first step towards this goal is to build an international network of mHealth stakeholders in Asian countries including academic researchers, healthcare practitioners and policy makers, and telecommunication representatives.

The following plan outlines the scope of this mHealth Initiative and what will happen next:

1) Set up an international network of mHealth stakeholders in Asia Pacific countries including academic researchers, healthcare practitioners and policy makers, and telecommunication representatives.
2) Set up mHealth Research Labs at academic institutions in participating countries (if none exists)
3) Start research and training at Labs in mHealth methods and technologies
4) Identify healthcare problems on government priority list in your country, and shortlist problems that can benefit from mobile support
5) Discuss shortlisted problems with other labs participating in mHealth Project Force; Team up with mHealth Research Labs in other countries who wish to work on a similar problem
6) Define the goal, scope and mHealth methods for a Pilot Project to be conducted in one of the participating countries
7) Invite international collaborators in areas where you need expertise
8) Apply for research funds to one of the international agencies supporting mHealth projects in developing countries (examples below); Should local funds be available, a more extensive preliminary study could be done first. Research grants are competitive, and already demonstrated initial results will strengthen our chances in competing for project funding.
9) Conduct a Pilot Project and evaluate results
10) Define and run similar projects in other countries
11) Evaluate and generalize experiences from pilot projects
12) Scale mHealth methods developed in the Pilot Project to large populations

11. Planned projects

I am looking for partners to work out a system for child growth and development monitoring. At the Global Humanitarian Technology Conference in Trivandrum, one doctor described the following project: they found that in some remote parts of Kerala mortality of children is very high. They figured out that malnutrition had to do with that and implemented a system for tracking young mothers and newborns to identify underfed children early. While the above might not be relevant to Singapore where is more than enough food (though eating the right food is as important as having plenty to eat), an interesting extension of this project could be a system for tracking the growth and development of children during the initial years after birth (e.g., checking periodically if a child reaches expected stages of development – mental capabilities, movement such as being able to lift head or walk down the stairs http://www.nlm.nih.gov/medlineplus/ency/article/002456.htm).

There would be much room for the technology to make child growth & development monitoring easy and effective, helping doctors in early detection of any deviations from norms – mobile apps with schedules, instructions, reporting using multimedia capabilities, data collection/analysis, etc.

It would be interesting to know how tracking child development is done in Singapore now, and if there is a room for improvement with smartphone apps.

--- The End ---