Supplemental Materials

Participant-facing dashboard

We created an anonymous URL for each participant to view their study progress for each study intervention and specific study assessments (ACE and their daily mood survey (PHQ-2, see below). They could click on their assigned link to view a) how their averaged mood changed across the course of the study, if they had completed their daily mood survey (Ginger.io) or when they interacted with their assigned intervention app (e.g. PST) across the entire study period. They could also view which of the games in the ACE application they had successfully completed at each assigned time period. A green highlighted cell indicated that data for said task had been received, whereas a grey highlighted cell indicated that particular data point was absent.

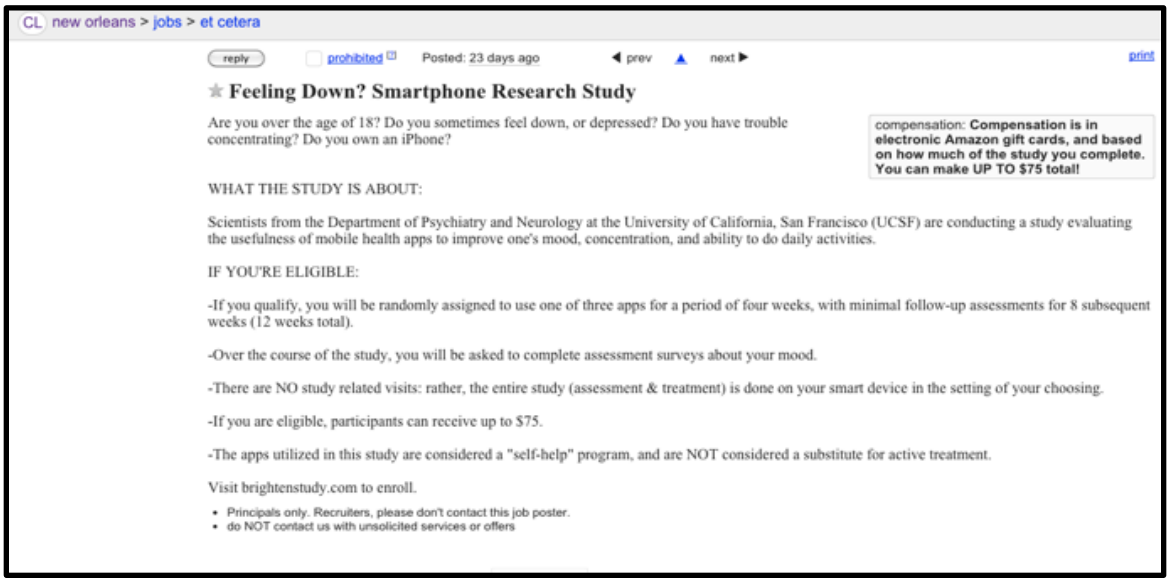
eFigure 1. Example of participant dashboard

Recruitment

Of the different recruitment strategies used, Craigslist provided the greatest response rate, with these posting costing a total of $775 for the study period.

1) Traditional recruitment consisted of outreach to provider networks, print and radio advertisements and fliers placed in strategic locations, such as coffee shops, libraries and bus stops across the city of San Francisco, as well as in online classified pages for volunteers and part-time paid positions (see eFigure 2). Ads specified that UCSF was conducting a study to better understand the effects of mobile apps for one's wellbeing, and was seeking volunteers. A web-link to the study portal was provided in the ads. Craigslists ads were placed in the largest cities in each state under volunteer opportunity as well as under 'Jobs etc./part-time jobs'.

eFigure 2. Screen shot of craigslist advertisement posted under 'Jobs etc./part-time jobs'



CL new orleans > jobs > et cetera

reply prohibited Posted: 23 days ago ◀ prev ▲ next ▶ print

Feeling Down? Smartphone Research Study

Are you over the age of 18? Do you sometimes feel down, or depressed? Do you have trouble concentrating? Do you own an iPhone?

compensation: **Compensation is in electronic Amazon gift cards, and based on how much of the study you complete. You can make UP TO $75 total!**

WHAT THE STUDY IS ABOUT:

Scientists from the Department of Psychiatry and Neurology at the University of California, San Francisco (UCSF) are conducting a study evaluating the usefulness of mobile health apps to improve one's mood, concentration, and ability to do daily activities.

IF YOU'RE ELIGIBLE:

-If you qualify, you will be randomly assigned to use one of three apps for a period of four weeks, with minimal follow-up assessments for 8 subsequent weeks (12 weeks total).

-Over the course of the study, you will be asked to complete assessment surveys about your mood.

-There are NO study related visits: rather, the entire study (assessment & treatment) is done on your smart device in the setting of your choosing.

-If you are eligible, participants can receive up to $75.

-The apps utilized in this study are considered a "self-help" program, and are NOT considered a substitute for active treatment.

Visit brightenstudy.com to enroll.

- Principals only. Recruiters, please don't contact this job poster.
- do NOT contact us with unsolicited services or offers

2) Social network-based recruitment consisted of social media lead advertising (thanks to our partner ehko.me) to promote our study to users on Twitter who used key words that indicated they may be suffering from symptoms of depression (see eFigure 2b). This approach involves identifying potential participants based on publically available conversations being held across social media networks to produce a real-time sample of individuals who may be interested in participating in this type of study. These potential participants were forwarded one of several similar brief advertisements making them aware of the BRIGHTEN study, with a link to the study website.

Brighten Center
@BrightenCenter

Got 5 min? Have a health #app on your #mobile device? Take our online survey and be part of UCSF health research

Reply Delete Favourite More

Be Part of Cutting Edge Digital Health Research.

BRIGHTEN UCSF

Take the Survey!

Share your name and email address with Brighten Center

Brighten Center
@BrightenCenter
br****@gm****.com

View advertiser privacy policy

3:04 pm - 16 Jul 2014 Flag media

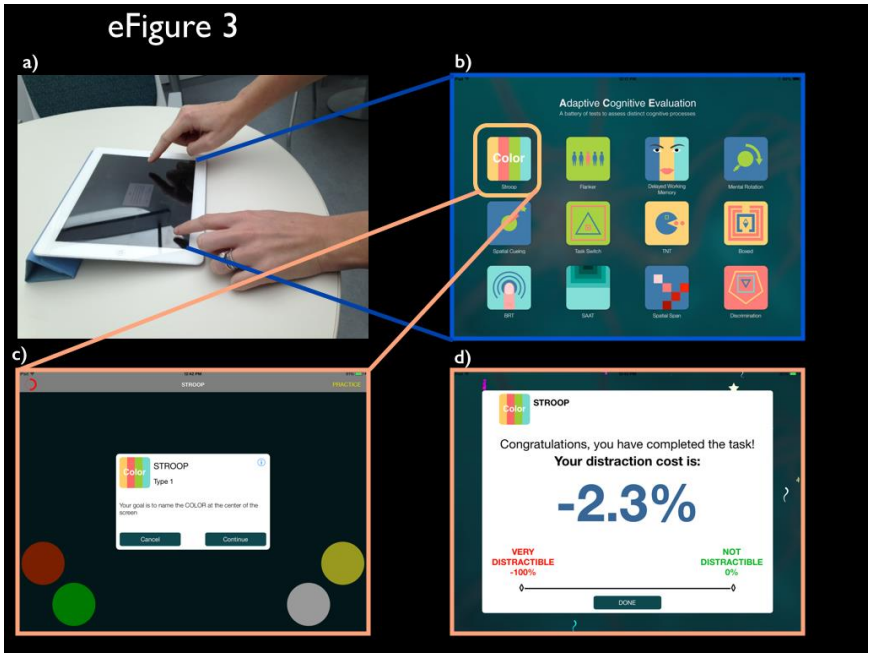
3) Search engine-based recruitment consisted of strategically placed ads, similar to ads that appear in usual media recruitment, on search engines and social networking communities (e.g., Google Adwords). The ads that will appear via this method are similar to the traditional ads, with a direct link to the study portal provided on the ads.

eFigure 2b) Social network-based recruitment: example of social media lead advertising on Twitter.

Adaptive Cognitive Evaluation (ACE)

ACE (see **eFigure 3**) utilizes adaptive psychometric staircase algorithms to ensure that comparisons between individuals reflect actual differences in that cognitive ability and not disparities in the testing parameters. Critically, this approach removes any biases of age-related slowing, instrumentation, or ceiling/floor effects, finding an individualized level of performance that is specific to said user. This approach also facilitates the battery being completed in a time-efficient fashion (the entire battery can be completed in ~30-40 minutes). Each task is designed to change its level of difficulty in a dynamic, trial-by-trial basis until the participant is performing at ~80% rate of accuracy [1-3]. Calculating these baseline levels lead to the creation of *within-task indices* (a single number) for each cognitive construct that are presented at the end of each task. ACE was meant to be used before participants used their study-specific app, and then completed again at the week 4, week 8, and week 12 time points in the study to monitor potential changes in cognitive function

eFigure 3. ACE platform. 3a,Visualization of a participant performing a task on the ACE battery. 3b, Screen image of the home screen. 3c, Image of one of the ACE games, Stroop, during the instruction screen. 3d, Image of feedback following the completion of one of the games (e.g. Stroop).



eTable 2. ACE tasks

Task name	What it measures
BRT[4]	Basic Response Time
Stroop[5]	Attention (with distraction)
Flanker[6]	Attention (with distraction)
Delayed Working Memory[7]	Working memory (fidelity)
Mental Rotation[8]	Working memory (mental imagery)
Task Switch[9]	Goal Management (e.g. task switching)
TNT[10]	Goal Management (e.g. multitasking)
Visual Search[11]	Attention (searching)
SAAT[12]	Attention (sustained)
Spatial Span[13]	Working memory (capacity)
Discrimination[14]	Attention (perception)

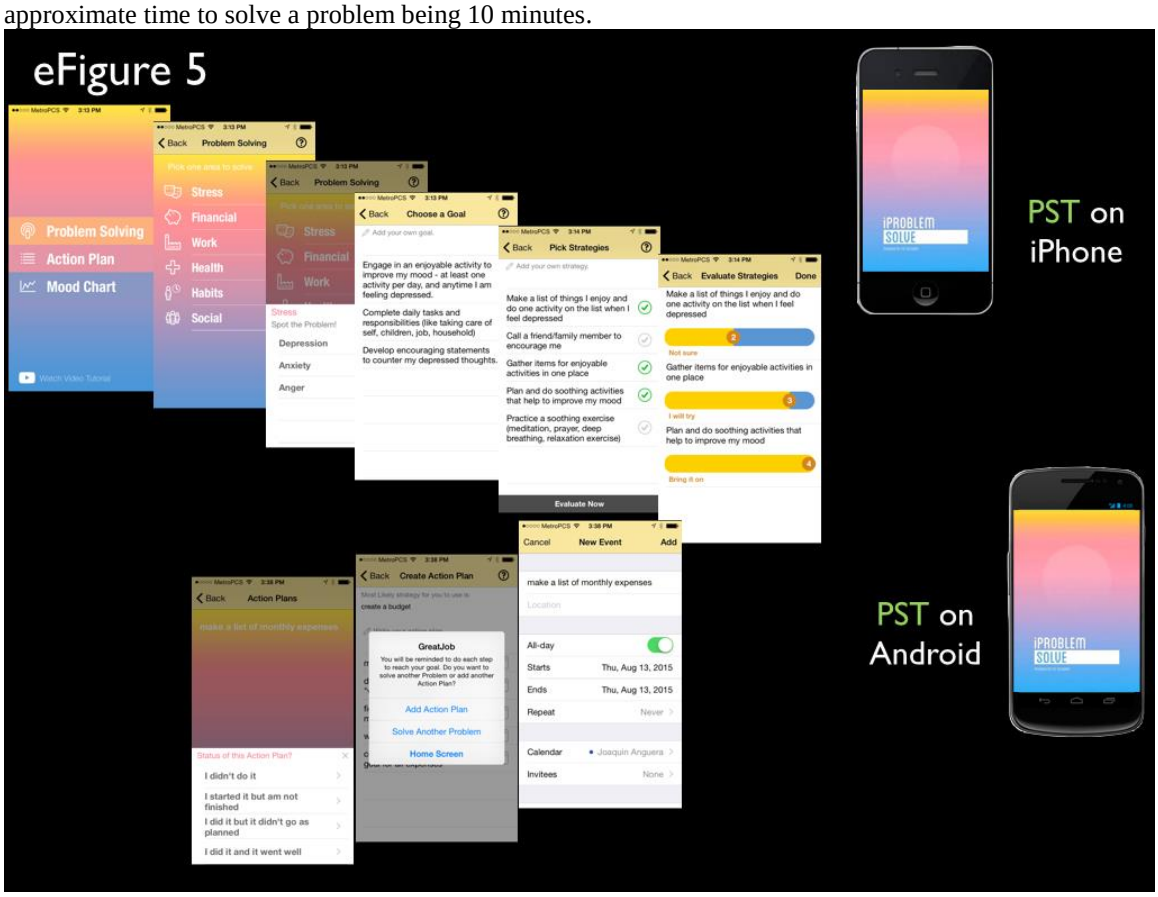
Cognitive Training

The cognitive therapy application was Project: EVO (**eFigure 4**), which is a mobile immersive video game designed to measure and modulate cognitive functioning based upon our work with a related cognitive training intervention, NeuroRacer [10]. Project: EVO is built from the ground up as a consumer-quality action video game on the leading mobile game engine, Unity (www.unity3d.com). Additionally, Project: EVO utilizes a proprietary set of adaptive game algorithms that make the game function at a level of difficulty that is continually personalized to the user to ensure user engagement and that the training is properly titrated for each individual. Participants randomized to this arm of the study were asked to play Project: EVO 6 days a week for 1 month, approximately 30 minutes/day.

eFigure 4. Project: EVO cognitive training platform. Images from during game play are presented on the left panel, with examples of how the game looks on the iPhone and iPad.

Problem Solving Therapy

The PST application, ("iProblem Solve"; **eFigure 5**) developed by our group is based on the social problem solving protocol developed by Nezu and D'Zurilla [15]. Participants are asked to identify an area where they are experiencing problems (e.g. stress, finances, work, etc). Upon selecting an area, more specific problems are provided (for example, depression, anxiety, or anger are listed under the stress domain) and participants are asked to choose a goal to help overcome their problem, or are given the option to write in their own goal. From there, participants are asked to identify three strategies to help them achieve their goal (or to write in their own strategy). They are then asked to evaluate their strategies and rate them on their likelihood of completing, with the app then choosing the most likely strategy for them to use as well as generating a potential list of action plans to reach their goal. Participants can select multiple action plans (or create their own), and are asked to set a date & time to complete the action plan(s). Finally, participants are asked to rate their success in meeting their goal, their mood, and if they want to solve another problem once they have completed (or not completed) the action plan. PST is meant to be played daily[1], with the approximate time to solve a problem being 10 minutes.



eFigure 5. iProblemSolve application. Images from the PST application showing the steps a participant would encounter in the process of selecting and solving a problem.

[1] To try this app, please visit brightenstudy.com/DEMO using your mobile device (iPhone or ANDROID).

Health Tips

Using the Ginger.io platform, we also delivered Health Tips that provided daily suggestions for overcoming depressed mood in the form of pop-up messages at the beginning of each day. In the first session, participants are given general information about depression, and that they must engage in one mood improvement strategy daily to overcome their mood problems. Suggestions include self-care (e.g., sleep behavior, taking a bath), physical activity (e.g., taking a walk), and social activities (e.g., going to the movies, calling a friend). Health Tips are pushed to participants every day for the first month of the study, with participants able to rate how useful these suggestions were to them.

Tool Download Description

For each of the primary arms of the study, 65% of the enrolled individuals actually downloaded their survey app, 43% downloaded the cognitive assessment platform, and 49% downloaded their intervention. For the phone only arms of the study, 44.3% downloaded the EVO game and 65.4% downloaded their survey app, while 70.9% in the Health Tips group downloaded their app. There was a group difference between the primary study arms with respect to the number of participants who actually downloaded their survey application (x_2^2 = 7.48, p = .02), such that individuals in the PST condition were 1.76 times more likely to download their survey application than in the EVO condition (x_2^2 = 7.48, p = .01). There were no group differences in downloading their cognitive assessment application (x_2^2 = .53, p = .77), or their cognitive intervention (x_1^2 = .05, p = .83)[2]. There was no difference in depression severity between participants who downloaded their survey application and those who did not (t(707.40) = .57, p = .57), or the cognitive assessment application (t(592.87) = 1.51, p = .13.). The same was true for age, t(712.47) = .57, p = .57, ethnic minority status (x_1^2 = 2.32, p = .13), and gender (x_1^2 = .00, p = .96).

Approaches taken to ensure quality of data

The possibility of individuals looking to take advantage of this study to acquire the research payment was a concern we looked to mitigate in a number of ways. The idea of 'gaming the system' here is not a foregone conclusion, even if the length of time in the study required to receive full payment (12 weeks for $75) would inherently prevent individuals from trying to do this. First, the enrollment web portal would refresh the entire survey if one were to hit the 'back' button on their web browser to change a given answer. Second, our requirement for both a valid email and phone number (and our ability to monitor if any duplicates of each emerged) restricted the ability to create multiple accounts. If there was anything seemingly amiss with respect to the enrollment questions (e.g. multiple attempted enrollments by an individual using the same email address), we would not enroll the individual, thus preventing them from receiving access to any of the study tools. Finally, the link to download subject specific study tools was only valid for a single user, with a password required to even view the download page. This was to prevent individuals not enrolled in the study or even those interested in the study from seeing what the apps were like (and try to 'game' their way into specific study arms).

Engagement in other treatments & perceived improvement

Participants were asked if they were using any other apps for mood, functioning or cognitive reasons. If they indicate 'yes', we would ask them what type of app they are using, brain games or apps based on psychological principles. Participants were asked to provide their perception of their level of improvement since beginning treatment. Specifically, participants are asked, "since using this app, I feel that I am: (1) much worse (2) worse (3) no different (4) improved (5) much improved."

[2] Note that only the PST and EVO apps were present in this analysis, as the HealthTips app was downloaded automatically with the survey app.

Passive data overview

These data were collected in collaboration with our partner Ginger.io. Ginger.io is a HIPAA-compliant mobile sensing platform that collects both self-reported and passive data through a free smartphone application. Passive data collection is gathered unobtrusively through a background process on the mobile device. The background processes are launched automatically by the application once the user logs in. After the initial logon, the process continues to be automatically launched whenever it is not already running (on phone restart or other events that terminate the process). The data collected through the device includes communication data such as call and sms logs (including call/sms time, call duration, sms length, and screen usage), as well as mobility data such as activity type and distance traveled. Private information such as actual content of voice calls or sms messages or emails is never read, recorded or transmitted.

Data Acquisition Parameters

Participant data from each application was automatically sent to a secure server via custom API calls in JSON format. This data was used to populate a customized researcher dashboard to provide a quick overview of participant compliance and progress. We used a MongoDB database to capture all data; however, specific summary data extracted from the JSON was also written in parallel to a MySql database for additional summary statistics used to populate participant-specific dashboards to provide an ongoing view of their progress in the study.

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