Improving the Design and Implementation of Behavioral Intervention Technologies for Depression

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www.cbits.northwestern.edu
Northwestern University

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Northwestern University Center for Behavioral Intervention Technologies (CBITs)

- Founded in September 2011
  - Includes faculty representing behavioral sciences, engineering, computer science.
  - Contains a technology intervention development core that now serves more than 25 investigators nationally and internationally.

- Integrated into Center for Engineering and Health in September 2012
  - CE&H integrates CBITs with the School of Engineering, Communications, and the Segal Design Center.

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• 12 month prevalence rates for mood disorders are 9.5% and 6.7% for Major Depressive Disorder. (Kessler Arch Gen Psychiatry, 2005. 62: 617-27)

• In 2 surveys in primary care at UCSF & Northwestern (≈950)
  o More than 50% of patients reported at least one substantive access barrier.
  o More than 75% of depressed patients (PHQ>10) reported access barriers

• Most barriers are structural
  o Cost
  o Lack of available services
  o Time constraints
  o Participation restriction (e.g. disability/symptom interfering)
  o Caregiving responsibilities
  o Other non-structural issues include
    o Stigma
    o Negative impressions of therapy/therapists
    o Lack of motivation

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## Table 2. Effect sizes change in depressive symptoms

<table>
<thead>
<tr>
<th>Study</th>
<th>N randomized to telephone-administered psychotherapy</th>
<th>N randomized to control treatment</th>
<th>Standard mean difference</th>
<th>95% CI</th>
<th>Standard mean gain</th>
<th>95% CI</th>
<th>Attrition</th>
<th>Proportions (%)</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bailey 2004</td>
<td>21</td>
<td>20</td>
<td>0.01</td>
<td>(-0.61, 0.63)</td>
<td>0.15</td>
<td>(-0.16, 0.46)</td>
<td>5.0</td>
<td>(-4.68, 14.7)</td>
<td></td>
</tr>
<tr>
<td>Heckman 2006</td>
<td>44</td>
<td>46</td>
<td>-0.04</td>
<td>(-0.45, 0.37)</td>
<td>0.30</td>
<td>(0.13, 0.47)</td>
<td>18.0</td>
<td>(6.4, 29.6)</td>
<td></td>
</tr>
<tr>
<td>Heckman 2007</td>
<td>108</td>
<td>107</td>
<td>0.08</td>
<td>(-0.19, 0.35)</td>
<td>0.26</td>
<td>(0.11, 0.41)</td>
<td>10.0</td>
<td>(4.2, 15.8)</td>
<td></td>
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<tr>
<td>Lynch 1997</td>
<td>15</td>
<td>14</td>
<td>1.08</td>
<td>(0.03, 2.13)</td>
<td>0.37</td>
<td>(0.16, 0.58)</td>
<td>17.0</td>
<td>(5.7, 48.3)</td>
<td></td>
</tr>
<tr>
<td>Miller 2002</td>
<td>18</td>
<td>15</td>
<td>0.45</td>
<td>(-0.27, 1.17)</td>
<td>1.60</td>
<td>(0.83, 2.37)</td>
<td>31.0</td>
<td>(7.8, 54.2)</td>
<td></td>
</tr>
<tr>
<td>Mohr 2000</td>
<td>16</td>
<td>16</td>
<td>0.86</td>
<td>(0.01, 1.71)</td>
<td>1.27</td>
<td>(1.02, 1.52)</td>
<td>5.0</td>
<td>(-0.8, 10.8)</td>
<td></td>
</tr>
<tr>
<td>Mohr 2005 (T-CBT)**</td>
<td>62</td>
<td>N/A</td>
<td></td>
<td></td>
<td>1.07</td>
<td>(0.86, 1.28)</td>
<td>6.0</td>
<td>(0.2, 11.8)</td>
<td></td>
</tr>
<tr>
<td>Mohr 2005 (T-SEFT)**</td>
<td>65</td>
<td>N/A</td>
<td></td>
<td></td>
<td>0.97</td>
<td>(0.43, 1.51)</td>
<td>5.0</td>
<td>(7.8, 54.2)</td>
<td></td>
</tr>
<tr>
<td>Mohr 2006</td>
<td>8</td>
<td>N/A</td>
<td></td>
<td></td>
<td>1.50</td>
<td>(1.33, 1.67)</td>
<td>7.0</td>
<td>(3.1, 10.9)</td>
<td></td>
</tr>
<tr>
<td>Napolitano 2002</td>
<td>38</td>
<td>39</td>
<td>0.36</td>
<td>(-0.10, 0.82)</td>
<td>0.58</td>
<td>(0.37, 0.79)</td>
<td>5.0</td>
<td>(-2.7, 12.7)</td>
<td></td>
</tr>
<tr>
<td>Sandgren 2003</td>
<td>90</td>
<td>55</td>
<td>0.17</td>
<td>(-0.16, 0.50)</td>
<td>0.18</td>
<td>(0.03, 0.33)</td>
<td>1.0</td>
<td>(-0.9, 2.9)</td>
<td></td>
</tr>
<tr>
<td>Simon 2004</td>
<td>198</td>
<td>195</td>
<td>0.38</td>
<td>(-0.17, 0.59)</td>
<td>1.50</td>
<td>(1.33, 1.67)</td>
<td>7.0</td>
<td>(3.1, 10.9)</td>
<td></td>
</tr>
<tr>
<td>Tutty 2000</td>
<td>28</td>
<td>94</td>
<td>0.35</td>
<td>(-0.08, 0.78)</td>
<td>2.10</td>
<td>(1.50, 2.70)</td>
<td>7.0</td>
<td>(-2.7, 16.7)</td>
<td></td>
</tr>
<tr>
<td>Overall effect size</td>
<td></td>
<td></td>
<td>0.26</td>
<td>(0.14, 0.39)</td>
<td>0.81***</td>
<td>(0.50, 1.13)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chi-squared value</td>
<td></td>
<td></td>
<td>Q = 10.6 (df = 9, p = .31)</td>
<td></td>
<td>Q = 241.5 (df = 11, p &lt; .0001)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Z-value for overall effect</td>
<td></td>
<td></td>
<td>4.18 (p &lt; .0001)</td>
<td></td>
<td>5.07 (p &lt; .0001)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note:** The table compares the effect sizes of telephone-administered psychotherapy versus treatment-as-usual for the change in depressive symptoms. The study by Mohr 2005 (T-CBT)** and Mohr 2005 (T-SEFT)** include two different conditions. The overall effect size is calculated using a chi-squared test with a significant Z-value, indicating a statistically significant difference.
T-CBT vs. F2F-CBT
Non-inferiority trial

- Trial Characteristics
  - 325 Patients recruited from Primary Care
  - MDD + Ham-D ≥16
  - 18 session of CBT
  - PhD therapists supervised by Beck Institute
  - Non-inferiority Margin: \( d = 0.41 \)

<table>
<thead>
<tr>
<th></th>
<th>F2F Mean</th>
<th>T-CBT Mean</th>
<th>( p )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>47±13.5</td>
<td>47±12.6</td>
<td>0.87</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td>0.71</td>
</tr>
<tr>
<td>Female</td>
<td>78.4%</td>
<td>76.7%</td>
<td></td>
</tr>
<tr>
<td>Race</td>
<td></td>
<td></td>
<td>0.63</td>
</tr>
<tr>
<td>African American</td>
<td>24.0%</td>
<td>24.3%</td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>65.3%</td>
<td>60.1%</td>
<td></td>
</tr>
<tr>
<td>More than one race</td>
<td>8.0%</td>
<td>12.2%</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>2.7%</td>
<td>3.4%</td>
<td></td>
</tr>
<tr>
<td>Ethnicity</td>
<td></td>
<td></td>
<td>0.76</td>
</tr>
<tr>
<td>Not Hispanic or Latino</td>
<td>13.0%</td>
<td>14.2%</td>
<td></td>
</tr>
<tr>
<td>Education</td>
<td></td>
<td></td>
<td>0.57</td>
</tr>
<tr>
<td>High School</td>
<td>8.6%</td>
<td>12.3%</td>
<td></td>
</tr>
<tr>
<td>Some college</td>
<td>25.3%</td>
<td>24.5%</td>
<td></td>
</tr>
<tr>
<td>Bachelor’s Degree</td>
<td>39.5%</td>
<td>33.7%</td>
<td></td>
</tr>
<tr>
<td>Advanced Degree</td>
<td>26.5%</td>
<td>29.5%</td>
<td></td>
</tr>
</tbody>
</table>
PHQ-9 Outcomes


\[ p = 0.89 \]
\[ \text{ES} = -0.02; \quad 90\% \text{ CI} (-0.20, 0.17) \]
Attrition

- Total Attrition ($p = 0.02$)
  - F2F-CBT 32.7%
  - T-CBT 20.8%

- Failure to Engage (> 4 sessions; $p = 0.005$)
  - F2F-CBT 13.0%
  - T-CBT 4.3%

- Failure to Complete ($p = 0.46$)
  - F2F-CBT 20.0%
  - T-CBT 16.6%

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Among 495 Primary Care Patients from Northwestern’s GIM who want psychological/behavioral intervention
Challenges in BITs for depression

• Coach-supported web-based interventions have been moderately effective at reducing depressive symptoms ($d=.61$). (Andersson & Cuijpers (2009). *Cogn Behav Ther*, 2009;38:196-205)
  • Mean logins range 2-9 over 5-8 weeks (Christensen, *JMIR*, 2009;11;e13).
• Standalone web-based treatments are minimally effective ($d=.18$) and patients are less adherent (<2 logins)
• Randomized controlled trials of mobile apps for depression are lacking.
• Depression is characterized by decreased motivation.
• We’ve focused on two strategies for improving adherence.
  • Design
  • Human support

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Design features associated with increased adherence

Kelders, *JMIR* 2012;14:e152

- Frequently updated new material ($p=0.002$)
- Expected usage ($p=0.01$)
- Dialogue support, such as automated reminders, suggestions, praise ($p=0.006$)
- Interaction with coach ($p=0.04$)
moodManager

- Based on CBT principals, teaching behavioral activation and cognitive restructuring.

- **Learning modules** (10-15 min).
  - 7 core lessons + 12 optional lessons addressing comorbidities (anxiety, anger, interpersonal difficulties, etc.) updated after 3 tool uses or 1 week

- **Interactive tools** (1-2 min) that help patients implement learning.

- **Coach interface** that can track patient utilization on the site, observe work performed, and receive alerts (e.g. for suicidality).
Dashboard

Today's To-Do List
Below are the activities on your agenda today:

1. Mood Rating  
2. Please select another Life Lesson  
3. Schedule your next appointment on MoodManager  

Did you know...

that many world leaders have struggled with depression, including Dwight D. Eisenhower, Abraham Lincoln, Thomas Jefferson, Winston Churchill and Queen Elizabeth II of England.

Welcome back NIH. You are in week 8 of your program.

Selected Life Lesson Plan: Core [completed]

- Getting Started
- Monitoring Activities
- Scheduling Activities
- Unhelpful Thoughts
- Thought Distortions
- Alternative Thoughts
- Action Experiments

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Life Lessons

Core [completed]
Learn how to manage your mood by learning to track and change what you do (Activities) and what you think (Thoughts). These lessons demonstrate fundamental concepts that will be used throughout the rest of moodManager.

Guilt/Shame [completed]
This lesson plan provides an in-depth look at how Guilt and Shame affect your life and demonstrates strategies used to manage these feelings.

Anger [completed]
These lessons help you manage your anger in response to situations, apply strategies on being more assertive, and learn how to relax and be mindful.

Anxiety [completed]
Learn to evaluate situations that cause anxiety and harness your existing strengths and resources to combat anxiety. Learn to control your physical anxiety response with relaxation and mindfulness.

Personal Relationships [completed]
Your depression may affect the way you behave around your peers. These life lessons help you to learn how to interact more positively and manage conflicts with others.

Additional Life Lessons [completed]
A la carte lessons that provide other ways to manage your feelings and thoughts.

Core Lesson Plan [completed]
- Getting Started [completed]
- Monitoring Activities [completed]
- Scheduling Activities [completed]
- Unhelpful Thoughts [completed]
- Thought Distortions [completed]
- Alternative Thoughts [completed]
- Action Experiments [completed]

Other Life Lessons
- Guilt/Shame [completed]
- Anger [completed]
- Assertiveness [completed]
- Relaxation [completed]
- Mindfulness [completed]
- Anxiety and Worry [completed]
- Improving Personal Relationships [completed]
- Communication Skills [completed]
- Living Your Strengths and Values [completed]
- Coping [completed]
- Maintaining Gains [completed]
How thoughts, feelings, and behaviors are related

These video clips include stories describing how thoughts, feelings and behaviors affect each other and how these people were able to make some changes in their lives to improve their mood.

Before watching the clips, please make sure your computer's audio is turned on.

Peter    Megan    Sherri    George
Situation
"I was late for work"

Thought
"I'm going to get in trouble"

Emotion
Anxious
Thought Diary

The Unhelpful Thought Diary

This tool is the first step in learning how to recognize automatic thoughts, finding out what triggers them, and then seeing how they relate to your feelings.

It is a good idea to complete an Unhelpful Thought Diary when you notice a significant change in emotion, like going from feeling OK to feeling very angry.

How to complete a Thought Record

- SITUATION
- FEELING
- THOUGHT
Go ahead and select activities for your scheduler. Don't forget to choose the "Reason" for your activity!

We would like to schedule your positive activities for the next 3 days. Ideally, you will check in with MoodManager every day or two to update this schedule and keep track of your activities.

<table>
<thead>
<tr>
<th></th>
<th>03/07/2011</th>
<th>03/08/2011</th>
<th>03/09/2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morning</td>
<td>Morning</td>
<td>Morning</td>
<td></td>
</tr>
<tr>
<td>Afternoon</td>
<td>Afternoon</td>
<td>Afternoon</td>
<td></td>
</tr>
<tr>
<td>Evening</td>
<td></td>
<td>Evening</td>
<td>Evening</td>
</tr>
<tr>
<td>Sometime This Day</td>
<td>Sometime This Day</td>
<td>Sometime This Day</td>
<td></td>
</tr>
</tbody>
</table>

Drag and drop activities from the Activity List to the calendar.

<table>
<thead>
<tr>
<th>Categories</th>
<th>Activity List</th>
</tr>
</thead>
<tbody>
<tr>
<td>My Own Activities</td>
<td>Attend an aerobics class, Go boating (canoeing, kayaking)</td>
</tr>
<tr>
<td>My Positive Activities</td>
<td>Go bowling, Go for a bike ride</td>
</tr>
<tr>
<td>Artistic</td>
<td>Go horseback riding, Go rock climbing</td>
</tr>
<tr>
<td>Helping</td>
<td>Go running or jogging</td>
</tr>
<tr>
<td>Home/Family</td>
<td>Go skiing</td>
</tr>
<tr>
<td>Internet</td>
<td></td>
</tr>
<tr>
<td>Learning/Reading/Writing</td>
<td></td>
</tr>
<tr>
<td>Nature</td>
<td></td>
</tr>
<tr>
<td>Physical</td>
<td>Go sledding, snowmobiling</td>
</tr>
<tr>
<td>Relaxation</td>
<td>Go swimming; take a swim, Join a local sports team</td>
</tr>
<tr>
<td>Self-Care</td>
<td></td>
</tr>
<tr>
<td>Add your own activity:</td>
<td>Learn a new sport, Play baseball or softball</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Reasons</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
</tr>
<tr>
<td>Assertiveness</td>
</tr>
<tr>
<td>Communication</td>
</tr>
<tr>
<td>Relaxation</td>
</tr>
<tr>
<td>Signature Strengths</td>
</tr>
</tbody>
</table>
Relaxation Tool

- **Breathing Exercises**  
  Reduce stress, headaches, and anxiety...

- **Progressive Muscle Relaxation**  
  Good exercises to try after Deep Breathing.

- **Autogenic Exercises**  
  Mental repetition of words and phrases to suggest heaviness, warmth, and relaxed breathing.

- **Visualization**  
  Use your imagination to visualize a relaxing scene...

- **Mindfulness**  
  Focus your attention more fully on the present moment.

### Top 5 Exercises

<table>
<thead>
<tr>
<th>Exercise</th>
<th>Stress: Before</th>
<th>Stress: After</th>
</tr>
</thead>
<tbody>
<tr>
<td>(10-13) Harp, Nature Sound</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>(4-12) Elevator and Garden</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>(12-23) Introduction to Dee...</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>(11-19) Guided PMR</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>(11-23) Introduction to Dee...</td>
<td>5</td>
<td>2</td>
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</tbody>
</table>

### Relaxation Log

<table>
<thead>
<tr>
<th>Exercise</th>
<th>Stress: Before</th>
<th>Stress: After</th>
</tr>
</thead>
<tbody>
<tr>
<td>(4-12) Elevator and Garden</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>(12-23) Introduction to Dee...</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>(11-19) Guided PMR</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>(10-13) Harp, Nature Sound...</td>
<td>4</td>
<td>8</td>
</tr>
</tbody>
</table>

### Breathing Exercises

- **Introduction to Deep Breathing**  
  - **[Review]**  
  - **[Rate]**  
  - **[Schedule]**

- **Deep Breathing (male voice)**  
  - **[Review]**  
  - **[Rate]**  
  - **[Schedule]**

- **Breath Awareness (harp/na...**  
  - **[Review]**  
  - **[Rate]**  
  - **[Schedule]**

- **Deeo Breathing (female voice)**  
  - **[Review]**  
  - **[Rate]**  
  - **[Schedule]**

- **Diaphragmatic Breathing (...**  
  - **[Review]**  
  - **[Rate]**  
  - **[Schedule]**
Mood Ratings

Over Time

Mood Rating

Rate the degree to which you've had the following emotions/experiences since you last logged in, with 1 = the least you've ever felt that way, and 10 = the most you've ever felt that way.

Feeling interest or pleasure in doing things?

1 2 3 4 5 6 7 8 9 10
least ever

Feeling down, depressed, or hopeless?

1 2 3 4 5 6 7 8 9
least ever

Feeling guilty or shameful?

1 2 3 4 5 6 7 8 9
least ever

Feeling angry or irritated?

1 2 3 4 5 6 7 8 9
least ever

My Progress

Activities:

Thoughts:

Date:

March 6, 2011

logged into the website:

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March 3, 2011
TeleCoaching Model: Supportive Accountability


[Diagram showing the TeleCoaching Model with nodes for Human Support, Motivation, Communication, and Adherence.]

- **Human Support**
  - Bond
  - Accountability
  - Legitimacy: benevolence, expertise

- **Motivation**
  - In-Extrinsic

- **Communication**
  - "Bandwidth"

- **Adherence**
TeleCoach

- Based on Supportive Accountability
- First call was a 25 min “engagement session”.
- Weekly calls of 5-10 minutes
- Calls were designed to engage patient when logins were low, create accountability, and reinforce adherence.
- Does not require mental health specialization to administer.
moodManager Pilot

• Patients with current MDD were recruited from primary care
• Randomized to
  • moodManager + S/A TeleCoaching (12 weeks)
  • moodManager alone (12 weeks)
  • Wait list control (6 weeks)
### Descriptive Statistics

101 patients enrolled

<table>
<thead>
<tr>
<th>Category</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age</strong></td>
<td>M = 48.2</td>
</tr>
<tr>
<td><strong>Female</strong></td>
<td>71%</td>
</tr>
<tr>
<td><strong>Marital Status</strong></td>
<td></td>
</tr>
<tr>
<td>Single</td>
<td>34%</td>
</tr>
<tr>
<td>Married/Partnered</td>
<td>50%</td>
</tr>
<tr>
<td>Divorced</td>
<td>16%</td>
</tr>
<tr>
<td><strong>Race</strong></td>
<td></td>
</tr>
<tr>
<td>African American</td>
<td>34%</td>
</tr>
<tr>
<td>Caucasian</td>
<td>59%</td>
</tr>
<tr>
<td>Other</td>
<td>7%</td>
</tr>
<tr>
<td><strong>Education</strong></td>
<td></td>
</tr>
<tr>
<td>High School</td>
<td>3%</td>
</tr>
<tr>
<td>Some college</td>
<td>24%</td>
</tr>
<tr>
<td>Bachelor’s Degree</td>
<td>34%</td>
</tr>
<tr>
<td>Advanced Degree</td>
<td>38%</td>
</tr>
<tr>
<td><strong>Employment</strong></td>
<td></td>
</tr>
<tr>
<td>Unemployed</td>
<td>27%</td>
</tr>
<tr>
<td>Disabled</td>
<td>16%</td>
</tr>
<tr>
<td>Employed</td>
<td>57%</td>
</tr>
</tbody>
</table>
moodManager

Baseline Week 6 Week 12

PHQ-9

Coached mM
mM only
WLC

p = .06
p = .01
p = .97

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## Adherence

<table>
<thead>
<tr>
<th>Use Variable</th>
<th>Coached mM Median</th>
<th>Range</th>
<th>mM Only Median</th>
<th>Range</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weeks to last use</td>
<td>9</td>
<td>0-12</td>
<td>5</td>
<td>0-11</td>
<td>0.007</td>
</tr>
<tr>
<td>Login days</td>
<td>13</td>
<td>0-100</td>
<td>6</td>
<td>1-24</td>
<td>0.01</td>
</tr>
<tr>
<td>Lessons used</td>
<td>8.5</td>
<td>0-18</td>
<td>5</td>
<td>0-18</td>
<td>0.03</td>
</tr>
<tr>
<td>Types of tools used</td>
<td>3</td>
<td>0-5</td>
<td>2</td>
<td>0-5</td>
<td>0.02</td>
</tr>
<tr>
<td># Tools Used</td>
<td>159</td>
<td>0-721</td>
<td>39</td>
<td>0-332</td>
<td>0.08</td>
</tr>
</tbody>
</table>

### Logins from previous trials
- Mean number of logins for coached interventions: 2 - 9.1
- Mean number of logins from standalone interventions: <2
## Relationship between Site Use and Change in Depression

<table>
<thead>
<tr>
<th>Use Variable</th>
<th>Use/Outcome</th>
<th>( \beta )</th>
<th>( p )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weeks to last use</td>
<td></td>
<td>0.03</td>
<td>0.35</td>
</tr>
<tr>
<td>Login days</td>
<td></td>
<td>0.1</td>
<td>0.02</td>
</tr>
<tr>
<td>Lessons used</td>
<td></td>
<td>0.37</td>
<td>0.01</td>
</tr>
<tr>
<td>Types of tools used</td>
<td></td>
<td>1.04</td>
<td>0.03</td>
</tr>
<tr>
<td># Tools Used</td>
<td></td>
<td>0.37</td>
<td>0.01</td>
</tr>
</tbody>
</table>
Next Steps

• Currently conducting a trial of a stepped care protocol for the treatment of depression.
• Treatment is initiated with coached, web-based treatment, stepping up to telephone CBT for non-responders.
• Primary goal is to examine if the initiation of treatment with a web-based treatment improves cost-effectiveness.
Onward – Peer Networking for Cancer Survivors

• Once we begin to understand the principles of why and how coach involvement improves outcomes and adherence, we can apply the principles in new contexts, such as online peer networks.
• Approximately 1/3rd of cancer survivors experience clinically significant levels of depression after completion of chemo or radiation treatment.
• Online support groups, are very popular among cancer survivors.
• Could peer interactions in an online intervention, designed to promote supportive accountability, improve adherence?
Week 8: Valued Living, Part 2

today's to-do list
1. Mood Rating
2. Continuing the Journey
3. My Life Map
4. Discussion Board
5. Follow-Up Mood Rating

discuss

What have you learned from your experience with Project Onward? For example:
What did you learn from the lessons or tools?
What did you learn from people in your group? What was valuable to you about your group?
What would you like to remember about this experience as you move onward?
What is the home message of your experience with Project Onward?

Mark says:
I learned that Dr. Duffey is very helpful.

Jenna says:
I learned that Mark likes hipster music.

Mark says:
I am a new post! Yay!

Mark says:
I am another new post.

respond to the discussion

Post

You are the in the last week of Project Onward. Congratulations!
Promoting Accountability In Peer Groups

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Onward Pilot Trial

17 cancer survivors with depressive symptoms randomized ($p = 0.12$)

Onward Adherence

- Mean Logins
  - Onward: 14.5
  - moodManager-C: 8.0

HADS - Depression

Baseline | Week 4 | Week 8
---|---|---
Onward (d=1.27) | moodManager-C (d=0.89)

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Next Steps

- Currently developing a peer networking site based on supportive accountability for
  - Treatment of depression in adults
  - Prevention of depression in youth
Mobile Interventions

Two basic components of behavioral interventions have been tested in mobile phones

- Components similar to Internet interventions, including didactic content and interactive tools.

- Ecological Momentary Intervention (EMI). Users can log information about their situation or current state. Personalized messages are sent to assist the user with problems. (Patrick K, et al. *J Med Internet Res. 2009;11e1*)

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General Model of e-Health Activity & Information Flow

- Initiate Use
- Data Input (Logging activities)
- Feedback (Graphs → Insight)
- Behavioral Prescriptions (Instructions → Behavior Change)
Context Awareness

- Context awareness refers to the idea that computers can both **sense**, and **react** based on their environment.

- Example: Body area networks (BANs) can transmit data from sensors which can be used to monitor health conditions.
  - Sensors can include ECG, oxygen saturation, accelerometers, etc.
  - BANs have been used with a variety of health states (contexts) such as diabetes, asthma, and health-related behaviors such as physical activity.

- Mobile phones today include numerous sensors that can potentially be harnessed to understand patient states.
Context Inference System

The Machine Learner is “trained” using EMA (queries)

Mobile Device: Sensed Data
- Accelerometers
- Bluetooth Devices
- WiFi Networks
- Cell Phone OS Processes
- (Build Your Own)
- ... 

SENSORS

Mobile Device: User Interface
- User Labels
- Active Data Collection

Machine Learner
- Location
- Social Context
- Activity
- Mood

CENTRALIZED SERVER

Action Components
- Web Services
- Broadcasts
- Scriptable Actions

Outreach & Management
- TABI Website
- SMS Patient Notifications
- (Other Applications)
- ...

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How **mobilyze** context sensing works

1) An mobile phone PASSIVELY collects 10000s of **RAW** data points of in-phone “probes”

- 41.8322 N, 87.6513° W
- 250 m, 70% accurate, Wifi, Currently Near 4 Wifi Networks [Linksys, VultureWeb, Bob’s HouseNet], more...
- Called for 3 minutes @ 2:30PM
- Text @ 1 PM
- Email @ Noon
- More...

- 2012-09-12 04:38:36Z
2) Participants are prompted to engage in ACTIVE (self-reported) DATA COLLECTION during a wide range of instances:

1. Randomly
2. Whenever they want
3. Retrospective ratings (to capture contexts that when current ratings are not feasible, such as driving, or to protect privacy)
4. User-Scheduled Intervention Moments
5. Anomaly Detection
6. Classification Model Validation...
3) Building a Model Starts with “Pairing”

PASSIVE Sensor Data (2:59PM)
PASSIVE Sensor Data (3PM)
PASSIVE Sensor Data (3:01PM)
PASSIVE Sensor Data (3:02PM)
PASSIVE Sensor Data (3:03PM)
PASSIVE Sensor Data (3:04PM)

A “pair”
ACTIVE Assessment Data (eg Happy) (~3:03 PM)

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Now we build a set of pairs

Training Set

- LOTS OF SENSOR DATA
- LOTS OF SENSOR DATA
- LOTS OF SENSOR DATA
- LOTS OF SENSOR DATA

- MOOD = 3 out of 10
- MOOD = 7 out of 10
- MOOD = 1 out of 10
- MOOD = 10 out of 10
And build it...

Lots of sensor data is sent to which crunches them together and makes a MOOD model.

Can use a variety of analytics:
- Decision Tree
- Naïve Bayes
- Logistic Regression

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4) We make educated guesses by continuously monitoring probes with our models.

<table>
<thead>
<tr>
<th>Time</th>
<th>Model</th>
<th>Accuracy</th>
<th>Mood Prediction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wed</td>
<td>Model</td>
<td>37%</td>
<td>6 out of 10</td>
</tr>
<tr>
<td>Thirs</td>
<td>Model</td>
<td>58%</td>
<td>2 out of 10</td>
</tr>
<tr>
<td>Fri</td>
<td>Model</td>
<td>84%</td>
<td>1 out of 10</td>
</tr>
</tbody>
</table>

They must be: **Accurate Enough**  
**Intervention Worthy**
5) When the model is accurate enough and pertinent, we intervene OR assess...

- Model Accuracy: 0.84
- Passive Sensor Data (930AM)
- Mood Prediction: 1 out of 10

Image: Screen with options: Are you unhappy? Options: This is true and I'd like help, This is true but I don't want help, Not true, I'm just fine.
Field Trial

- **Aim:**
  - Conduct initial feasibility study
  - Beta-test the context awareness system
- **Mobilyze Intervention (8 weeks):**
  - Weekly didactic information provided to support behavioral activation
  - Interactive tools (activity monitoring and scheduling, managing avoidance)
  - Weekly 5-10 minute calls to support adherence and obtain usability info
- **8 patients with MDD enrolled**
  - 7 women
  - Mean age: 37 (range 19-51)
  - 6 had comorbid anxiety disorders

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Mobilyze!

- 1 participant dropped out due to problems with the phone.
- Satisfaction was reasonable (M=5.7 on a 1-7 likert scale)

<table>
<thead>
<tr>
<th>Depression Outcomes</th>
<th>Week 1</th>
<th>Week 8</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHQ-9</td>
<td>17.1 ± 3.8</td>
<td>3.6 ± 4.1</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>QIDS</td>
<td>13.8 ± 2.1</td>
<td>3.4 ± 3.1</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>MDE</td>
<td>8 (100%)</td>
<td>1 of 7 (14.3%)</td>
<td>&lt;.01</td>
</tr>
</tbody>
</table>

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Patients were asked to train the phone by answering 11-15 questions, 5 times/day for the first few weeks. (They could also answer the questions without prompting)
### Accuracy of Prediction Models

<table>
<thead>
<tr>
<th>Context</th>
<th>% Accuracy</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>60.3</td>
<td>43.2 – 77.2</td>
</tr>
<tr>
<td>Alone in the Immediate Vicinity</td>
<td>80.1</td>
<td>76.2 – 84.5</td>
</tr>
<tr>
<td>Friends in the Immediate Vicinity</td>
<td>90.8</td>
<td>84.3 – 95.7</td>
</tr>
<tr>
<td>Alone in the Larger Environment</td>
<td>72.6</td>
<td>61.0 – 82.8</td>
</tr>
<tr>
<td>Miscellaneous People in the Larger Environment</td>
<td>90.9</td>
<td>83.8 – 97.3</td>
</tr>
<tr>
<td>Having a Casual Conversation</td>
<td>66.1</td>
<td>54.0 – 77.6</td>
</tr>
<tr>
<td>Not Conversing</td>
<td>64.5</td>
<td>58.4 – 70.3</td>
</tr>
</tbody>
</table>

Accuracy for many models (e.g. mood) was not better than chance [www.cbits.northwestern.edu](http://www.cbits.northwestern.edu)
Sample Learning Algorithm

Location Model
(Decision Tree Diagram)

Current Cell Tower = 7838

Time of Day <= 8:41 AM
In Transit: Bus/Train

Time of Day > 8:41 AM
In Transit: Biking/Walking

Current Cell Tower = 7828

Longitude <= 87° 39' 35"

Acceleration: Y Axis <= 34
My Spaces: My Home

Acceleration: Y Axis > 34
In Transit: Biking/Walking

Longitude > 87° 39' 35"

Latitude <= 41° 55' 33"
In Transit: Bus/Train

Latitude > 41° 55' 33"
My Spaces: My Home

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Problems

- Multiple technological problems, for example
  - Battery drainage and connectivity issues
  - Poor sensor data quality
  - Assessment problems (e.g. low variability)
  - Usability problems
  - And...
Data does not equal information

LOTS OF SENSOR DATA = 41.8322 N, 87.6513° W
250 m, 70% accurate, fWifi, Currently Near 4 Wifi Networks [Linksys, VultureWeb, Bob’s HouseNet], more...

MOST RAW DATA DOESN’T HAVE MUCH MEANING

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Most raw data doesn’t have much meaning.

So we build features to help us understand the raw data better.

- Use domain specific expertise to develop features.
- Location sensors might be coded as distance from key locations (home, work).
- Days of week might be coded as work days/non-work days.
- Complex features might combine these (distance from home X workday/weekend).

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Lots of sensor data is sent to which crunches them together and makes "SMART" features. Each are now validated independently and the most accurate is used:

- Decision Tree
- Naïve Bayes
- Logistic Regression
- Support Vectors
- Neural Network

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Extending Mobilyze

• Currently building and evaluating features.
• Field trial expected to begin in summer.
• Mobilyze is now being extended to identify risk states for bipolar disorder (Evan Goulding, MD).
• Context sensing framework is being used to identify states in youth with asthma (Ruchi Gupta, MD).
Medication Adherence

Figure 1: MedLink System

Primary Care Team Activation

- Actionable information on
  - Current Depression Level
  - Response to Treatment
  - Side Effects
  - Information on Adherence
  - Recommendations for Guideline Congruent Care

MedLink Servers

Patient Activation

- Electronic Medication Monitoring
- In-the-Moment Adherence Reminders
- Assessment of:
  - Treatment Response
  - Side Effects
  - Positive Reinforcement
  - Education
Summary

• Work with the plain old telephone suggests we can extend care into people’s environments, increasing the reach of behavioral care.

• Web-based and mobile interventions for depression continue to be plagued by low use.

• Human support models are needed that are defined and scalable.

• Design is important.
  • Providing interactions in a manner and frequency that is useful, increases motivation, and is appealing.
  • Reducing burden on the user may improve adherence.

• “The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it.” Weiser M. Sci. Am. 1991;265(3):94-104

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Darren Gergle, Ph.D.
Bernice Ruo, MD

Funding:
P20 MH090318
R01 MH090318
R01-MH059708
R34 MH095907
One-off websites and mHealth interventions have a number of disadvantages.

- Making changes can be difficult
- Development of new interventions requires starting over
- Interoperability can be problematic
- Costs are high

We have developed a platform that is modular and extensible.
We (over time) dissect and define the major constituent parts of an intervention:

- **Lifestyle Intervention**
- **Stress / Depression Intervention**
- **Medication Adherence Intervention**

**Assessment**

**Didactic Content** (lessons, movies)

**Interactive Content** (tools)

**Data Definitions** (user data)
We treat these individual parts like collections of documents that can be checked out of a library:

- **Assessments**
- **General Didactic Content (lessons, movies)**
- **General Interactive Tools**
- **Data Definitions (user data)**

**Diagram:**
- Assessments
  - Assesments
  - General Didactic Content (lessons, movies)
  - Interactive Content (Tools)
  - Data Definitions (user data)
We build these collections into an intervention:

- Assessments
- Didactic Content (lessons, movies)
- Interactive Content (tools)
We treat the intervention like a document that can be checked out onto any device or platform:
All intervention data is stored the same way in a standardized, virtual, deployable server instance.
Your Experiences in Survivorship

If, when looking at that list of responses to stress, you found yourself identifying several physical, behavioral, thinking-related and emotional responses that you have experienced, you're not alone. Many people adjusting to life after cancer find that several of these problems appear in response to stressors they face after cancer. In fact, it's quite rare to go through the transition from cancer treatment to life as a cancer survivor without experiencing some kind of unhelpful response to stress.

There are three messages to take away from this:

1. Experiencing the effects of stress during cancer survivorship is common. It reflects nothing negative about you, and others can appreciate the challenges you have to face daily.

2. Although the effects of stress take many different forms, they all happen because of the stress. If you can change your relationship with stress, any one (or more) of these symptoms may improve.

3. Each person has their own path to healthy survivorship, which has similarities to other survivors as well as aspects unique to each person's journey. Through using this site, you will start the journey of creating a care plan to fit your needs to gain maximum benefit to your emotional well-being.
Step 1: Identify a Situation

There are two ways you can use this Thought Journal. It can be helpful in examining difficult situations that you experienced, but it can also come in handy to highlight when you handled a tough situation well.

Think about a situation that was challenging for you or you would typically find stressful. Sometimes, it’s useful to examine a time when you experienced a strong negative emotion, like feeling sad or worried.

Another useful way to examine thoughts is to look at a situation that typically would have been stressful but went better than anticipated. This is an opportunity to review what strategies worked well for you. Consider the following questions about the situation:

- What happened?
- Who were you with?
- Where were you?
- What were you doing?

A good situation description is not a feeling or a thought and shouldn’t include those words. This is just the factual description! For example:

- My co-worker and I had a disagreement.
- I procrastinate in doing chores at home.
- Lunch with my mother went well, when we normally would

Examining a situation (a video example)

The process of using the Thought Journal is often included an example to help you figure out how to play a video that demonstrates an actual event.

Now, learn how to apply the concepts from this situation:

An expert opinion on how to choose a situation:

Play the expert opinion

An expert one on one:

The expert helps to sort it out.
Discussion Question:

Please read and comment on the profiles of your group members. This is an opportunity to get to know each other a little bit more. Is there anything in a group member's profile that is similar to your experience? Or surprisingly different?

Discussion Question:

Please read and comment on the profiles of your group members. This is an opportunity to get to know each other a little bit more. Is there anything in another group member's profile that is similar to your experience? Or surprisingly different?

Discussion Question:

What is one activity that you would like to plan this week? What is it about this activity that is valuable or makes it important to you?
<table>
<thead>
<tr>
<th>Feedback Response</th>
<th>Condition One</th>
<th>Condition Two</th>
<th>Condition Three</th>
<th>Priority</th>
<th>Days into Treatment</th>
<th>Active?</th>
</tr>
</thead>
<tbody>
<tr>
<td>It looks like you're feeling more upset than usual. Try logging into the website and using a</td>
<td>Phone Just Trained (Phone) ≤ True (Logical) AND Current Mood Prediction (Phone) &lt; Avg Mood -2 Std Dev (Site)</td>
<td>None</td>
<td>None</td>
<td>1</td>
<td>8</td>
<td>Active (Update Feedback)</td>
</tr>
<tr>
<td>Excellent! It looks like your mood is better than usual. Try taking a moment to think about</td>
<td>Phone Just Trained (Phone) ≤ True (Logical) AND Current Mood Prediction (Phone) &gt; Avg Mood +1 Std Dev (Site)</td>
<td>None</td>
<td>None</td>
<td>1</td>
<td>3</td>
<td>Active (Update Feedback)</td>
</tr>
<tr>
<td>It looks like you're feeling more upset and may need some help. Try to take action by</td>
<td>Phone Just Trained (Phone) ≤ True (Logical) AND Current Mood Prediction (Phone) &lt; Avg Mood -2 Std Dev (Site)</td>
<td>None</td>
<td>None</td>
<td>1</td>
<td>8</td>
<td>Active (Update Feedback)</td>
</tr>
<tr>
<td>It seems like your mood has been lower the past couple times you've rated it. If things</td>
<td>Phone Just Trained (Phone) ≤ True (Logical) AND Current Mood Prediction (Phone) &lt; Avg Mood -2 Std Dev (Site) AND Phone Mood Entry (1 old) ≤ Current Mood Prediction (Phone) &gt; Avg Mood +1 Std Dev (Site)</td>
<td>Phone Mood Entry (1 old) (Phone)</td>
<td>Phone Mood Entry (2 old) (Phone)</td>
<td>2</td>
<td>3</td>
<td>Active (Update Feedback)</td>
</tr>
<tr>
<td>It looks like this has been a difficult week for your mood. Please take a moment and</td>
<td>Avg Mood Past Week (Site) &lt; None</td>
<td>None</td>
<td>None</td>
<td>0</td>
<td>8</td>
<td>Active (Update Feedback)</td>
</tr>
</tbody>
</table>
### Assessment Manager

- **Tools now linked to PROMIS allowing computer adaptive testing on the mobile device**

Visually, there's a table showing various assessment tools and their details:

<table>
<thead>
<tr>
<th>Measure Details for Patient Health Questionnaire</th>
<th>Mark Regale</th>
<th>PHQ description</th>
<th>PHQ source</th>
<th>PHQ score</th>
<th>PHQ score description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHQ 9</td>
<td>Patient Health Questionnaire</td>
<td>9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HADS</td>
<td>Hospital Anxiety and Depression Scale</td>
<td>14</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>QIDS</td>
<td>Quick Inventory of Depressive Symptomatology</td>
<td>16</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Demographics</td>
<td>Demographics</td>
<td>23</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PANAS</td>
<td>Positive and Negative Affect Schedule</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FACT-F</td>
<td>Functional Assessment of Cancer Therapy (Fatigue)</td>
<td>13</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FACT-G</td>
<td>Functional Assessment of Cancer Therapy (General)</td>
<td>27</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BPI</td>
<td>Brief Pain Inventory (Full)</td>
<td>?</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Survey Questions

<table>
<thead>
<tr>
<th>Question</th>
<th>Values</th>
<th>Responses</th>
<th>status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Little interest or pleasure in doing things</td>
<td>0</td>
<td>Not at all</td>
<td>locked</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Several days</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>More than half the days</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Nearly everyday</td>
<td></td>
</tr>
<tr>
<td>Feeling down, depressed, or hopeless</td>
<td>0</td>
<td>Not at all</td>
<td>locked</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Several days</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>More than half the days</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Nearly everyday</td>
<td></td>
</tr>
<tr>
<td>Trouble falling asleep, or sleeping too much</td>
<td>0</td>
<td>Not at all</td>
<td>locked</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Several days</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>More than half the days</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Nearly everyday</td>
<td></td>
</tr>
<tr>
<td>Feeling tired or having little energy</td>
<td>0</td>
<td>Not at all</td>
<td>locked</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Several days</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>More than half the days</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Nearly everyday</td>
<td></td>
</tr>
<tr>
<td>Poor appetite or overeating</td>
<td>0</td>
<td>Not at all</td>
<td>locked</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Several days</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>More than half the days</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Nearly everyday</td>
<td></td>
</tr>
<tr>
<td>Feeling bad about yourself, or that you are a failure, or have let yourself or your family down</td>
<td>0</td>
<td>Not at all</td>
<td>locked</td>
</tr>
<tr>
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<td>Trouble concentrating on things, such as reading the newspaper or watching television</td>
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[www.cbites.northwestern.edu](http://www.cbites.northwestern.edu)
Research Description (appears on David's home page)

Nearly 80% of those with cancer diagnoses will survive for at least 5 years, with approximately 19.5 million cancer survivors in the United States. The time of transition for cancer patients, from active treatment to survivorship, has been identified as a time of high risk for depression and anxiety. The internet promises to provide inexpensive access to mental health treatment at any time of the day or night. Unfortunately, the potential for internet delivered services has not been realized. Studies examining treatments that simply provide access to an internet site commonly result in very high dropout after the first site visit, and typically little or no improvement in target symptoms. To mitigate these problems, investigators have examined whether providing support via email or brief calls from research assistants can increase adherence; in general email support improves adherence and telephone support can improve adherence even more. Another type of support that has only begun to be investigated is the use of social networks to help maintain adherence.

Participant Information (appears on participant home page)

The study gives patients access to our website. Patients may also be given access to other resources such as a trained coach or a social network made up of other cancer survivors; during this period to help them maximize their use of the website and its tools.

We will also conduct several telephone interviews and questionnaires with you. You will receive a total of $100 for completing four 45-minute evaluations over the 12 week course of the study.

To participate in Project Onward, you must:

- Have had a Stage 1-3 cancer
- Have completed cancer treatment in the past 9 months and currently be in remission
- Currently experiencing depression, anxiety, or other emotional distress
- Have an active email address
- Have access to high speed internet and telephone in a private place

For more information, contact ehealth@northwestern.edu or call 312-503-3111

Consent Form

For more information, contact ehealth@northwestern.edu or call 312-503-3111
# Use Data

**Group Share Overview for** Group 4

**Intervention start date:** 01/17/2011  
**Time into intervention:** 102 days (14.57 weeks)

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**Total usage so far:** 322

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**Tool specific usage for:**  
- Thought Journal  
- Activity Calendar  
- Thought Journal  
- Relaxation Tool  
- Resource Quiz  
- Daily Review  
- Mood Rating  
- Follow-Up Mood Rating  
- Mad Lib  
- Coping Card  
- Free Journal  
- Worry Practice Tool  
- Care Plan Tool  
- Resource Lessons  
- Anxiety Tool

**Authoring Content**  

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**Total usage so far:** 19

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www.cbons.northwestern.edu
DorisD’s mood based on location
updated on October/5/2011
The Northwestern University Center for Behavioral Intervention Technologies (CBITs) was inaugurated in September 2011.

• With the Purple Development Platform we have developed more than 15 funded NIH grants, and 15 non-federal grants with investigators from around the US and abroad.

• As our number of collaborators grows, CBITs is becoming a repository for knowledge about the design and implementation of BITs
  • Conceptually (understanding of what works)
  • Data (which are tagged consistently across projects)
  • Emerging methods