以行動式平台互動介面探討憂鬱者與照顧者之人際互動特性

A Mobile Mediation Tool for Enhancing Interaction between Depressed Individuals and Caregivers

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Abstract

Depression, a common mental health disorder, significantly affects an individual’s ability to live a regular life. Excessive reassurance-seeking behavior, i.e. a common interpersonal characteristic of depression, often leads to negative interaction between caregivers and depressed individuals, who seek excessive assurance from the caregivers at inappropriate times e.g. when caregivers are busy. Such negative interaction results in elevated feeling of burden in care-giving and care-receiving. However, maintaining a good relationship between depressed individuals and caregivers is crucial in overcoming difficulties time during depression. Therefore, this work proposes a mobile care mediation tool that helps improve communication in care-giving and care-receiving between depressed individuals and caregivers. By sharing the mood and availability status of givers and receivers of care, the proposed mobile care mediation tool enhances satisfaction of their relationship, and reduces burdens in care-giving.
摘要

憂鬱症為一種心理疾病，它對個人正常生活的能力及生活品質有顯著的影響。「尋求再保證」為憂鬱者之人際行為特徵之一。這種人際行為往往會導致憂鬱者與其照顧者之間的負向人際互動。例如，當照顧者正忙於其他事時，憂鬱者若在這個不適當的時間點重複尋求他人的保證，將可能會影響雙方的互動。此負向人際互動若持續，將同時對照顧者與憂鬱者都會形成情緒的壓力與負擔。然而，如何維持雙方的良好關係，對協助憂鬱者之憂鬱情緒調節與康復有關鍵的重要性。

在這篇論文裡，提出以行動式平台互動介面探討並試圖增進憂鬱者與照顧者之間的人際互動。互動介面提供了憂鬱者與照顧者的心情與忙碌狀態的即時訊息，期望能藉由增進雙方對互相狀態的了解而改善雙方的溝通與互動模式，提高關係滿意度及減少照顧者因照顧憂鬱者所造成的主觀負擔。
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Chapter 1

Introduction

Depression has become a common mental disorder, affecting an increasing number of individuals in recent decades. As a mental disorder, Major Depressive Disorder is a leading cause of disability in the United States [1]. According to the Global Burden of Disease Estimate (GBD) of WHO [2], unipolar depressive disorders place an enormous burden on society and rank as the fourth leading cause of burden among all diseases. If the current trend for demographic and epidemiological transitions continues, then the burden of depression becomes the second leading cause of DALYs lost after ischaemic heart disease for both sexes worldwide by the year 2020 [3]. The Department of Health, Executive Yuan (Taiwan) estimates that approximately 1 million individuals currently suffer depression in Taiwan. Moreover, suicide is one of the top 10 causes of death in Taiwan [4], and also most suicide victims suffer from major depression around the time of death [5] [6].

Information technology can be used to help treatment of depression. Computer-based software tools have been designed to help depressed individuals follow a specific cognitive behavioral therapy [37] [38]. Online treatments for depression (web-based applications or web sites) have been developed to enable self-help treatment
for depression and anxiety [40]. Palmtop or PDA based cognitive behavioral therapy treatments [36] [41] have also recently appeared to let the patients access treatment more easily (e.g. at work or at school). Therefore, mobile computing technology can also assist depressed individuals.

Excessive reassurance-seeking behavior from Interpersonal Model of Depression and ruminative responses from Responses Style Theory of Depression are two significant contributing factors that exacerbate and prolong depressive mood and symptoms. Excessive reassurance-seeking is a common characteristic in interpersonal behavior among depressives [8]. Depressed individuals tend to seek reassurance from others to alleviate their doubts about their own worth and to realize the love and care from their caregivers (e.g. significant others). Therefore, depressed individuals always face a dilemma, in that they both need and doubt the assurance of others. However, this reassurance-seeking behavior is so repetitive that the caregivers may finally become frustrated and irritated. The caregivers perceive an increased burden in caring for depressed individuals, causing them to reject the requests for help from depressed individuals. Consequently, depressed individuals become ever more depressed, since they cannot obtain reassurance from caregivers to help them overcome difficult periods. Therefore, excessive reassurance seeking leads to a vicious cycle of negative interaction between depressed individuals and caregivers. Ruminative response is defined as follows: “An individual puts too much attention on self depressive symptoms or self negative attribution, and the repetitive thinking of causes and consequences of these depressive symptoms or negative attribution. [33]” Rumination is the intrapersonal behavior. The results of experimental studies have shown that ruminative responses exacerbate or maintain self-depression. Hence, enhancing the quality of interaction and
distracting the ruminative responses to pleasant or neutral activities [34] can slow down or shorten depressed mood and symptoms.

Figure 1. Two vicious cycles of maintaining depression

Ubiquitous computing technology can serve as a mediator between depressed individuals and caregivers. First, ubicomp technology can provide valuable awareness information, such as the status of the depressed individuals and caregivers. For example, the depressed individual knows the caregiver is available for advice or assurance. Meanwhile, the caregiver knows whether the depressed individual is in a negative mood and can thus give love and care when needed by the depressed individual. Second, ubicomp technology can serve as agents giving behavioral suggestions to depressed individuals to distract them from rumination, and also to give suggestions to the caregivers for caring to the depressed individuals.

This work describes how ubicomp systems can mediate the interactions between caregivers and depressed individuals. This mediation can reduce depressive moods in depressed individuals, thus reducing the burden of caregivers, and enhancing interactions between them in the following ways.
Figure 2. Proposed solution for mediating interaction between a depressed individual and a caregiver

1. By providing awareness of a user’s own mood state, and giving behavioral suggestion when the user is in a negative mood, the system can help the depressed individual to regulate his/her rumination.

2. The system can help increase understanding of both parties, thus reducing reassurance-seeking behavior, by providing awareness of the other party status.

3. Lowering stress from caring for depressed individuals can help reduce the caregivers’ perceived burden.

4. Enhancing the quality of interaction between depressed individuals and caregivers can improve the quality of relationship between them.

This work presents a mobile tool that provides distraction functionality for depressed individuals, and mediation functionality between depressed individuals and caregivers. This mobile care mediation tool displays and communicates information between two users. The idea of designing a mediation tool on mobile device is inspired by a scenario involving campus lovers. “Miss A is a campus student and has depressive symptoms. She also has boyfriend who also is a campus student with a different major. They take different courses during the day and sometimes take part in different activities
after class. They each go back to their own homes in the evening. Therefore they cannot be together most of the time. They communicate using mobile phones and desktop computers when they are apart. They do not usually have access to their own computers during the day and therefore usually call each other. She always calls her boyfriend whenever she feels depressed, and asks him about her worth whether he truly loves to her. However, she does not know whether her boyfriend is free to talk to her. If her boyfriend is busy and unable to accept the call, then she calls him repeatedly often losing her temper. She would blame him for not accepting the call as soon as possible once he had answered. She doubts that her boyfriend is care enough for her. On the other side, her boyfriend also feels guilty and frustrated, because his comfort to her does not fulfill her needs. This behavior makes him afraid to talk to her. These negative interactions occur because of Miss A’s reassurance-seeking behavior, and the lack understanding between them.”

Most individuals use mobile phones in their daily life to make calls and send SMS/MMS messages. However, the information provided by mobile phones is still limited, as indicated by the above scenario. Therefore, providing additional awareness information on mobile phones would be valuable for both depressed individuals and caregivers to enhance their interaction. Mobile care mediation tools are designed for mild and moderate depressed individuals. Four goals for designing and implementing a mobile care mediation tool are described below. Hypothesis 1: Mediation tools provide depressed individuals with awareness information of mood and suggestion of distractive behaviors, and thus reduce ruminative responses when they are in negative moods. Hypothesis 2: Mediation tools provide caregivers with awareness of the mood of their
depressed individuals and recommendations of caring behaviors, and thus help to reduce their burden in caring for depressed individuals.

Hypothesis 3: Mediation tools provide depressed individuals with the information about mood and availability status of caregivers, thus reducing reassurance-seeking behavior by depressed individuals to caregivers.

Hypothesis 4: Mediation tools enhance the quality of interaction (relationship satisfaction) between depressed individuals and caregivers.

The remainder of this thesis is organized as follows. Chapter 2 discusses related work. Chapter 3 introduces design considerations for the ESM tool and the mobile care mediation tool. Chapter 4 presents the implementation and evaluation of the ESM tool. Chapter 5 describes the implementation of the mobile care mediation tool. Chapter 6 shows the evaluation results of the mobile care mediation tool. Chapter 7 discusses the lessons learned and observations from the user study for designing the mobile care mediation tool. Conclusions are finally drawn in Chapter 8, along with the future research directions of the mobile care mediation tool.
Chapter 2

Related Work

Obtaining in-situ data and remote health care (including physical and mental) are receiving much attention in ubicomp and mobile device research. Much ubiquitous technology work in experience sampling focuses on sensing, and uses sensors to trigger experience sampling studies on mobile devices. The context-aware experience sampling (CAES) tool [16] utilizes environmental sensors and biosensors to trigger sample collections from specific circumstances (e.g. the person is near the store). MyExperience [17] adapts sensors into their experience sampling tools to help evaluate user interaction with mobile devices and applications, and supports automatic logging of device states and sensor data. SocioXensor [30] applies logging sensors (such as conversation, location and Bluetooth proximity) and user subjective data to evaluate social phenomena. The next chapter also describes a context-aware experience sampling tool for depressed individuals and evaluates it by eight-day study involving 17 users. The influencing factors of context-aware sensing for depressed individuals are discussed in the following chapter.

Some studies focus not only on collecting in-situ data, but also support interaction
with professionals and researchers. Momento [18] is a client-server architecture that uses SMS/MMS as its communication medium. A mobile client gathers data and uploads them to a server, enabling the server-side researcher to send the information required by the mobile user. MAHI [19] is an experience sampling tool with a blood glucose meter, and also captures voice notes and photographs. Users also share their records via a website, and can discuss with diabetes educators. The proposed mobile care mediation tool focuses both on enhancing understanding and quality of interaction between depressed individuals and caregivers, but not between users and professionals.

Caring for a loved one or for oneself is essential for a good quality of life. Many studies have designed systems that display a user’s status to family members or the user. The Digital Family Portrait system [28] displays information in a digital photo frame about the day-to-day activities of a distant family member who is not living with the family in order to provide a sense of family connectedness. The CareNet Display [27] adopts an augmented digital picture frame to provide care to an elder within a care network. This work helps care network members to coordinate care activities, ensuring that the elder person receives the required care. The above two studies focus on providing awareness information about others. The UbiFit Garden [31] encourages a user to increase his/her own activity by providing feedback in a virtual garden of a mobile home screen. The Playful toothbrush [35] embeds a behavioral intervention when brushing teeth among children in kindergarten. A virtual-teeth game is presented to suggest brushing technique and to encourage children to brush their teeth properly. These two projects provide users aware of their own behaviors. The mobile care mediation tool makes a user aware of the other user’s status and suggests actions for a user to perform. Therefore, the proposed tool incorporates an awareness display
interface that is designed to show the status of both users on a mobile phone home screen.

Ubiquitous psychotherapy [21] is a general tool developing for mobile devices, and the tool tries to assist therapists and patients in cognitive behavior therapy (CBT). It provides a personalized homework tool for patients so that therapists can assign and adjust artifacts for each patient during CBT treatment. Blues Begone [38] is a computer-based software tool to help depressed individuals to recover from depression. The software provides a structured daily program of cognitive behavioral knowledge and techniques to discover and rectify the faulty thoughts, beliefs and assumptions. The above two studies focused on CBT treatment and are lack of support from social environments. The mobile care mediation tool is also designed to help caregivers give support to the depressed individuals.
Chapter 3

Design Considerations

Users carry their mobile devices throughout every day. Designing a care mediation tool for mobile devices needs to minimize interruption or inconvenience to the users. The prototypes of the proposed ESM tool and mobile care mediation tool were based on the following six main design considerations.

3.1 Collecting situated mood/availability data

A depressed individual’s inner cognitions affect his/her interpretation of the encountering events. These maladaptive cognitions may result in negative mood and depressive symptoms. Therefore, collecting daily mood fluctuations in natural living/working environments provides valuable information to caregivers for caring to depressed individuals at the right moment. Not only do depressed individuals have mood fluctuations, but caregivers may also sometimes have negative moods. Furthermore, caregivers become involved in many daily activities. For instance, when caregiver is very busy, the depressed individual seeks too much assurance from him, causing negative interaction to occur between them. The caregiver’s mood and
availability provides a cue for the appropriate time to interact and seek assurance. Mobile computing technologies have the potential to provide mood and availability information without requiring users to fix in a place to check it.

3.2 Engaging

Since mood and availability are very subjective experiences, the tool requires user input to display their statuses. However, the tool should avoid forcing the users (depressed individuals and caregivers) to record the information, and should persuade them to engage in providing valuable information to each other. The system can let users decide whether to update the information. The system can also offer reward or sharing information to encourage users to provide data. This study designs two ways to attract users’ willingness: (1) games with rewards for providing just-in-time information, and (2) sharing recently recorded information with the other party.

3.3 Easy to operate

The tool should provide easy-to-use user interfaces. The tool should not modify the functions of the mobile phone systems such as calling, SMS messaging and picture taking. Word typing is not as easy on a mobile phone as on a desktop computer, so the mobile care mediation tool should reduce asking users to type words to change their statuses. For instance, the tool should provide radio/combo box choices or buttons to change status.
3.4 Information glanceability

Awareness display information should provide clear messages that the users want to convey, so that the other party can understand the information on display just at a glance. Two important factors influencing the glanceability are the complexity and layout of the content information. Providing the latest updated information of both parties status can reduce information overloading and complexity. A mobile PDA phone has a small screen size, limiting the space in which both parties can place information. To provide glanceable layout information, the tool separates the information into two parts; one part is for the device’s user and the other for the other party. Users can thus look at the other party’s information without becoming confused with their own information.

3.5 Timestamp update

Although the latest updated information is provided to minimize complexity, the users cannot know the precise time that the information is updated by other party, and how long has passed after the information is updated. Therefore, the users might doubt whether they should trust this information. For instance, the caregiver might see the negative mood state of a depressed individual in the morning, but cannot be sure whether the depressed individual updated the information that morning or the previous night. This can cause caregiver to worry about whether to give care. In this case, providing the timestamp for the latest updated information enables the user to make a decision without doubt.
3.6 Sensing

A mobile phone itself can act as a sensor for capturing some context information. First, a mobile phone has a built-in camera, enabling depressed individuals and caregivers to capture environmental context information to represent their statuses. Sharing photos sometimes can convey much information about where the user is or what the user is doing. Second, if a depressed individual needs assurance and caregiver is not in face-to-face nearby, then the depressed individual might call the caregiver repeatedly. However, these repeated calls might make the caregiver wish to stay away from the depressed individual. Therefore, the tool can help to sense the calling behavior, and give just-in-time suggestions to encourage depressed individual to do some other activities rather than calling.

A mobile phone has Bluetooth communication, allowing it to communicate with other sensors for context-aware sensing. Activity sensing can provide the activity level of depressed individuals, and can also describe some types of activities carried out by the depressed individuals. A depressed individual in a negative mood may fall down into ruminative responses from which he cannot easily escape. The tool can recommend depressed individuals to perform some distraction activities, and sensors can detect their level of achievement. These log data can help examine the correlation between activity level and duration of ruminative responses in the field study.

3.7 Suggestion

The mobile care mediation tool can act as an agent between a depressed individual and a caregiver on behalf of the therapists. Therefore, the tool can provide suggestion
lists to depressed individuals and caregivers. The tool is designed to remind depressed individuals to be aware of their negative moods, and encourage them to perform distraction activities. The tool is also designed to give behavior suggestions to caregivers for caring for depressed individuals in negative moods.
Chapter 4

Implementation and Evaluation

(ESM tool)

The hypotheses make two assumptions, as described in Chapter1: (1) negative mood and ruminative responses are correlated, and (2) negative mood and reassurance-seeking behavior are correlated. Recent studies in psychology have indicated that negative mood and ruminative responses are relevant. However, no field studies have shown that they have significant correlations in daily life in Chinese culture. Therefore, the prototype ESM tool for examining the correlation of these two assumptions can provide some observations for designing the care mediation tool. M. Csikszentmihalyhi and R. Larson stated that paper-based experience sampling can provide validity and reliability data in daily life [7]. Comparison studies of paper-based and PDA-based ESM need to be performed to verify that PDA-based ESM can also provide validity and reliability data collected from depressed individuals. The PDA-based ESM tool also includes functions such as activity sensing and a simple game to encourage users to enter valuable data.
4.1 Implementation

![Image](a) ![Image](b) ![Image](c)

Figure 3. Mobile components of ESM tool

4.1.1 Questionnaires design on ESM tool

The mobile experience sampling tool was developed on a Dopod p800w PDA phone as illustrated in Fig. 3(a). The ESM questionnaire was designed in each form page for every question, as shown in Fig. 4. The ESM questions were presented with different formats: (1) radio buttons for single choice questions; (2) combo box for multiple choice questions, and (3) written text input or recording voice for open questions. Therefore, the ESM tool supports multi-modality. The mobile device collects experience samples by delivering and prompting questionnaires to users. The ESM tool is designed to remind users to reply the questionnaires based on the current phone profile setting. The phone has three states to inform the user: (1) sound, (2) vibration and (3) no alarm. The ESM tool triggers questionnaires by time-based sampling to collect data. The device automatically logs a timestamp when a user completes the questionnaire. The questionnaire and replies are saved in an XML format. Figure 4 shows screenshots of the questionnaire on the PDA phone.
4.1.2 Logging activity sensing data

Many mobile phones have the Bluetooth connections. A SparkFun accelerometer worn on the waist, as illustrated in Fig. 3(b), is used to sense activity. The sensor box includes one WiTilt v2.5 accelerometer (Fig. 3(c)) and one battery, and is designed to be as small as possible. The sensor box volume is 6cm[L]x4cm[W]x2cm[H]. However this accelerometer does not have storage capability in itself. Therefore the sensing data are sent to the PDA phone using the Bluetooth connection. The accelerometer is set to transmitted data at 75Hz. The tool logs the sensing data after the depressed individual performs the suggested activities. These activities are: (1) taking a walk, (2) running or bicycling, (3) shopping, (4) listening to music, (5) listening to relaxation exercise, and (6) chatting to someone. All these activities are asked to do at least 15 minutes. The first three activities are physical activities that can be sensed by the accelerometer sensor. The purpose of the design is to measure a depressed individual’s activity level after the individual is advised to perform activities and the type of activity carrying out. Activity sensing technologies are not still mature enough to provide to a good level of accuracy. Focusing on a small range of activity types can improve accuracy in activity sensing.
Therefore, the tool recommends activities that can be easily achieved in our daily life without extra cost. Activity sensing has two objectives: (1) collecting training data from the natural environment, and (2) testing the feasibility of the sensors to wear and operate in daily life for depressed individuals.

4.1.3 Simple version of world visiting game

Although the experience sampling method can provide validity data by avoiding error and memory bias, it potentially causes interruption in daily life. Depressed individuals should be encouraged and engage to record samples in situ because these samples are helpful for psychologists to more understand depressed individuals and can also reflect to depressed individuals about their mood. Hence, this study develops a simple version of a mobile flash game that rewards depressed individuals after they fill questionnaires and perform distraction activities. Figure 5 shows a flash version of a world visiting game, in which the user has to visit three places. The user selects a character (boy or girl) before starting to play the game. Every place involves walking 50 steps, after which the user visits somewhere else.

The game rules are as follows:

1. A user receives 1 step and 1 milk bottle after filling a questionnaire.
2. A user receives 2 steps and 2 milk bottles after doing distraction activities.
3. A user rolls dice after gathering 3 milk bottles. The user’s character walks extra steps according to the dice results.

The game is designed to attract users to explore different scenes in each place of the game, and is intended to encourage users to complete questionnaires and perform distraction activities.
4.1.4 Paper-based ESM

To make a comparison study with PDA-based ESM, paper-based experience sampling method is designed. A desktop automatic calling tool was implemented to call users in random time. The tool was designed to save the users’ cell phone numbers, and trigger Skype to call users from the desktop computer. The users carried the booklet questionnaires throughout the day. Recorded voice messages were played through Skype calling to remind users to fill questionnaires and perform activities.

4.2 Evaluation

This evaluation comprises three parts: (1) user study design, (2) results and (3) discussion of conclusions and lessons learned from this user study.

4.2.1 User study design

The user study was conducted in collaboration with the Department of Psychology in National Taiwan University (NTU).

Participants: The participants were NTU students and recruited from an Internet
advertisement. Students with dysphoric symptoms were screened by Beck Depression Inventory-II (BDI-II)*.

**Procedure:** All signed-up students participated in the pre-ESM assessment (BDI-II, BAI (Beck Anxiety Inventory), Negative Mood) and were paid NT$150 for participating. The participants with BDI-II>15 were invited to join an eight-day ESM experiment and post-ESM assessment, and paid a further NT$500. Each Participant was randomly assigned to one of three experimental groups: (1) Group 1: PDA-based ESM group, (2) Group 2: PDA-based ESM and game feedback group and (3) Group 3: Paper-based ESM group. Because of the time and resource limitations, the numbers of participants in each group were not equally. Group 1 had 8 participants, Group 2 had 9 participants and Group 3 had 11 participants.

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<table>
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<th>SD</th>
<th>Mean</th>
<th>SD</th>
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<td>3.24</td>
<td>13.95</td>
<td>3.54</td>
<td>4.12</td>
</tr>
</tbody>
</table>

**Table 1. Descriptive statistics and group difference of the participants**

The total number of participants who joined the experiment was 28 students out of the 49. Table 1 lists the descriptive statistics (mean and standard deviation) of selected

* BDI-II: The BDI-II (Beck, Steer, & Brown, 1996) is a 21-item, self-reported measure of the severity of depression symptoms. Items of various severities of depression symptoms are rated on a 4-point Likert scale, with total scores ranging from 0 to 63.
samples and excluded samples in the pre-ESM assessment. The participants with high BDI-II scores also had high BAI scores and negative moods.

**Measurement:** During the ESM experiment period, questionnaires were designed to measure mood fluctuation, ruminative responses, the context information of place and activities carrying out and interpersonal behaviors (e.g. reassurance seeking from other). Questionnaires were triggered 5 times in a day to collect in-situ data. Questionnaires were popped up randomly with average two and half hours interval. Activities were assigned following questionnaires two times in a day, with one during the day and another after 5 pm.

The following items were evaluated in this study.

1. The compliance rate of users replying to ESM questionnaires for providing psychometric data.
2. The correlation between rumination and mood based on a daily experience.
3. The correlation between interpersonal behaviors (reassurance-seeking behavior) and mood based on a daily experience.
4. The user choices of assigned activities to accomplish.
5. The comparative compliance rates of three different groups.
6. User experience of using the ESM tool for popping questionnaires five times a day

**4.2.2 Results**

1. **Average compliance rate**

   Totally 667 ESM samples were collected from 28 participants during the eight-day ESM study. Table 2 lists the mean and standard deviation of compliance rates. On average, the participants answered questionnaires three times a day and performed one
assigned activity in a day.

<table>
<thead>
<tr>
<th></th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>8</td>
<td>9</td>
<td>11</td>
</tr>
<tr>
<td>Mean</td>
<td>0.55</td>
<td>0.67</td>
<td>0.59</td>
</tr>
<tr>
<td>SD</td>
<td>0.13</td>
<td>0.12</td>
<td>0.15</td>
</tr>
<tr>
<td>Questionnaires</td>
<td>0.47</td>
<td>0.48</td>
<td>0.40</td>
</tr>
<tr>
<td>Activity</td>
<td>0.17</td>
<td>0.17</td>
<td>0.22</td>
</tr>
</tbody>
</table>

Table 2. Compliance rates of three groups

2. The relationship between negative mood and rumination

The Pearson Correlation between negative mood and ruminative responses were significant in the two-tailed test ($r=0.513$, $p<0.01$). Table 3 shows the regression analysis between negative mood and ruminative responses. This result indicates that negative mood is a good predictor of ruminative responses, leading depressed individuals to increase rumination. Adoption of rumination in response to negative mood was also analyzed, revealing that 73.62% (SD=0.23) adopted rumination.

<table>
<thead>
<tr>
<th>Ruminative responses</th>
<th>$\Delta R^2$</th>
<th>$\beta$</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Negative Mood</td>
<td>.28***</td>
<td>3.36***</td>
<td></td>
</tr>
</tbody>
</table>

| $R^2$                | .28          |
| Adjusted $R^2$       | .28          |
| $F$ value            | 85.57***     |
| df1, df2             | 3            |

Table 3. Regression analysis between negative mood and ruminative responses ($***p<0.001$)

3. Interpersonal reassurance-seeking behavior

To understand interpersonal behaviors in daily life, the depressed individuals were asked some questions within one hour of ESM survey time, to identify their interactions
with others, their desire for reassurance seeking (RS) from others, and their degree of
distress for having this need. Four items were measured for RS behavior, and each item
was rated on a 6-point Likert scale. If no RS behavior choice was indicated for an item,
then the score for that item was 0. Thus, the degree of RS desire ranged from 0 to 20
scores for all 4 items. The result shows that the average RS score for every collected
sample was 4.8. The participants thus had the desire for reassurance seeking in each
sampling time. Table 4 also shows correlations between negative mood and desire for
RS behavior, and between negative mood and degree of distress for having such RS
desire.

<table>
<thead>
<tr>
<th>Desire for RS behavior</th>
<th>Degree of distress</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Negative Mood</td>
<td>0.19</td>
<td>0.23</td>
</tr>
</tbody>
</table>

Table 4. Correlation between reassurance seeking and negative mood

4. Assigned activities choices

![Activity choices by PDA-based users](https://via.placeholder.com/150)

**Figure 6. Activity choices by PDA-based users**

Table 2 shows that the average activity completion rate was nearly 50%; users
performed one activity in a day on average. The results in Fig. 6 reveal that almost all of
the activities completed were motionless. Physical exercises, such as walking, shopping
and running, were completed 7 out of 129 times by 17 users in the eight-day study. User
feedback on performing activities is discussed in the following section.

5. User experience

Although the compliance rates were not significant in PDA-based ESM, the overall user experience was better in PDA-based ESM than in Paper-based ESM, as shown in Table 5. No subject dropped out in PDA-based ESM, while 2 participants in the Paper-based ESM failed to return the ESM questionnaires without telling any reason. Paper-based participants responded that questionnaire design was more complex than the PDA-based participants. Interference in daily life was more significant in Paper-based group. PDA-based participants had more positive attitude to ESM study than Paper-based participants. Even though none of the users had any experience in using touch screen PDA phone, they replied that replying to the ESM questionnaires was very straightforward.

<table>
<thead>
<tr>
<th></th>
<th>Paper-based ESM</th>
<th>PDA-based ESM</th>
<th>Group Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N=11</td>
<td>N=17 (8+9)</td>
<td></td>
</tr>
<tr>
<td>Questionnaire design</td>
<td>0.92 0.30</td>
<td>0.47 0.51</td>
<td>-2.54 *0.02</td>
</tr>
<tr>
<td>Interference in daily life</td>
<td>1.72 0.64</td>
<td>1.11 0.48</td>
<td>-2.85 **0.01</td>
</tr>
<tr>
<td>Positive attitude to ESM</td>
<td>1.67 0.50</td>
<td>2.18 0.73</td>
<td>2.14 *0.04</td>
</tr>
</tbody>
</table>

Table 5. User experience feedback on ESM study
4.2.3 Discussion

This section describes three observations from the user study. These observations are discussed from the initial purposes of the study to the results from the evaluation process.

4.2.3.1 Activity choices

The user study requesting participants to perform activity had the following initial purposes: (1) testing the feasibility of adopting activity sensors and PDA phones when performing physical exercises; (2) collecting sensing data for analyzing accuracy when the users chose to perform physical activities; (3) encouraging users to perform activities, and (4) to understand the user choices. Analytical results indicate that most of the users chose to perform motionless activities. The users’ feedback was categorized into three classes.

1. Inconvenience

Since the sensor did not have storage and computation capabilities, all the raw data were transmitted back to the PDA-phone for storage and computation. Therefore, users were requested to carry these devices when they were performing physical activities. Users made the following responses: (a) the sensor was too big to wear on the waist; (b) it might get lost, and (c) wearing the sensor and carrying the phone when doing physical activities were very inconvenient.

The weight and visibility of the sensor thus made it inconvenient to use in daily life. The sensor in the Nike+iPod toolkit is a better choice than that adopted herein, since it is placed in the shoes; however, it is proprietary, limiting access by researchers to use it with other embedded devices.
2. Different in difficulty levels

The requested activities were (1) taking a walk, (2) running or bicycling, (3) shopping, (4) listening to music, (5) listening to relaxation exercise and (6) chatting to someone. These activities require different levels of motion. The first three are physical activities performed outside. The other three activities are motionless activities that can be carried out more easily than physical exercises. Users would reasonably be expected to choose the easier challenges to accomplish. The purpose of designing the choices of activities was to advise depressed individuals to perform distraction activities rather than forcing them to do physical exercise. Therefore, if a user can accomplish one of the choices, then the suggestion to perform distraction activities is attained.

3. Lack of flexibility

Activities were assigned at random times of a day. The lack of flexibility in designing activities caused two problems: (1) users were not always able to carry out activities at the requested times; (2) users could not trigger the system when they were available to carry out activities. Flexibility can be improved by providing a link on a home screen that users can easily trigger it when they have a desire to perform activities.

4.2.3.2 Game

The simple world visiting game was designed to encourage users to reply the ESM questionnaires to record daily fluctuation and completing assigned activities. The result in Table 2 shows that group 2 (PDA-based ESM+game) had only a marginally higher questionnaire compliance rate than the other groups. Group 2 did not have a significantly higher activity compliance rate than the other groups. Feedback from users is described below.
1. Lack of controllability

The game was designed to pop up for playing after questionnaires and activities were completed. Users could not play the game at times convenient for them to reach the goal. User could not trigger the game to play. Users were passively involved in the game, rather than actively participating. Therefore, users were not attracted by the game, and were not encouraged to complete more questionnaires and activities. The game did not support user controllability.

2. Lack of diversity

Even though the game has different scenes for a character to pass, it is still insufficiently diverse to attract users to play very often. The users can only walk steps by steps or roll dice. The lack of surprises in the game, or another character to compete with, made the game too boring to play.

Designing a game for adult is more difficult than designing a game for young children. Adults have played many more games than young children, and so have higher expectations of games. If a phone can operate like a Wii remote control to play a game on a desktop computer, then the depressed individual may be encouraged to perform physical exercises without going outside, and may also be distracted from negative mood through having fun from playing the game.

4.2.3.3 ESM data collection

The ESM collected data indicate that negative mood and ruminative responses have significant correlation. Additionally, the negative mood and desire for reassurance seeking are correlated. The PDA-based ESM also provided similar validity and reliability data to the Paper-based ESM. Negative mood is a good predictor that participants may be in ruminative responses, or may desire to seek reassurance.
Chapter 5

Architecture and Implementation

(Mobile care mediation tool)

The previous study results indicate that students with dysphoric symptoms exhibited ruminative responses and reassurance-seeking behavior to cope with their negative moods. Therefore, mobile care mediation tools can be based on the negative mood level to give suggestions to depressed individuals. A mobile care mediation tool was implemented based on the design considerations mentioned in Chapter 3. Mobile care mediation tool not only supports collecting data, but also provides clear information, senses calls, suggests activity and caring, and communicates data between a depressed individual and a caregiver.

5.1 Architecture

This mobile care mediation tool enables two-way communication, sharing information between depressed individuals and caregivers using text messaging (SMS) and media messaging services (MMS). The mobile care mediation tool has a
three-tiered architecture of Input (e.g. record mood), Decision Agent and Output (e.g. display).

### 5.1.1 Mobile database

An SQL Server 2005 Mobile Edition (SQL Mobile) database is used for local storage on PDA phones. The database stores input data such as mood, availability and calling time log to each party. Additionally, the decision agent also queries the database to determine which information to show on the display screen, or to remind the user of a behavior suggestion if the logic condition set in the decision tree is true.

![Figure 7. Architecture of mobile care mediation tool: input, decision agent, output](image-url)
5.1.2 Input

Input refers to user interaction on the device, or user input to answer ESM questionnaires (such as mood). The CareMe display in Fig. 8 acts not only as an output display, but also as input interface for the users (depressed individuals and caregivers) to modify their availability status and to capture images. The mobile care mediation tool is designed around the user input to communicate between depressed individuals and caregivers. Both the depressed individuals and caregivers need to input their mood and availability. Additionally, since most mobile phones have built-in cameras, the contextual information of environment is easy to capture. This contextual information can convey much information about the location and the activity of the other party. The tool senses the calling to the caregiver as an input, enabling the tool to analyze the calling behavior of a depressed individual.

5.1.3 Decision agent

The decision agent handles input data, and acts as an agent for making decision. The input mood from questionnaires is split into three types: (1) positive mood, (2) negative mood and (3) depression indicator. The agent sets threshold levels for determining the level of the mood state. If the input data matches the condition logic, then the agent queries the output of that condition from the database. The agent then determine to update the CareMe display, to give suggestion to the depressed individual, such as encouraging the depressed individual to perform distraction activities rather than staying in a negative mood, or sending a suggestion to help the caregiver to care for the depressed individual.
5.1.4 Output

The agent outputs its decision in three formats. In the first format, output data is presented in the CareMe display, as in Fig. 8. The display contains mood emoticons, availability status background, avatar images and a few shortcut links. Second, the behavioral suggestion guides depressed individuals and caregivers to interact in the correct way. One behavioral suggestion is as follows: “You are now feeling bad. When we feel this way, we usually look to caregivers for supports, but they cannot always be there for you. We suggest that you do distraction activity, and help improve your mood.” Third, output messages are sent to the other party by SMS, MMS communication on the mobile phone, while mood, availability status and avatar images are updated.

5.2 UI design and implementation details

Figure 8. CareMe display on HTC Touch

Figure 9. Five levels of mood
Figure 10. (a) Red button to modify to busy status; (b) Sharing availability between a depressed individual and a caregiver

Figure 11. (a) Mood questionnaire to modify mood status; (b) Sharing mood status between a depressed individual and a caregiver

The mobile care mediation tool is implemented using C#, C++ and Windows CE API. The tool can be deployed on Windows Mobile 5.0 (e.g. Dopod P800W) and Windows Mobile 6.0 (e.g. HTC Touch). The UI components of mobile care mediation
tool are described in detail below.

### 5.2.1 CareMe display

The CareMe display is implemented as a plugin to the PDA phone home screen, as illustrated in Fig. 8. To fulfill the design consideration of glanceability, the display screen layout is separated into two parts, the upper part for the other party, and the lower part for the user. The upper part contains mood, availability status and photos updated by the other party. It also has two shortcut links, respectively for calling and for sending messages to the other party. It also displays the timestamp of the latest information updated by the other party. The lower part displays the user’s own information, and contains mood, availability status and photos. It has four shortcut links, namely (1) link to SMS inbox, (2) self-report mood questionnaires, (3) distraction activities and (4) changing availability status.

The display is updated by receiving broadcasting window messages, and CareMe display then repaints its windows by querying updated information from the local database. The emoticons on display represent any of five levels: very happy, happy, normal, sad and very sad as illustrated in Fig. 9. The availability status is identified by the background color, where green signifies free and red signifies busy.

### 5.2.2 Sharing mood and availability

The mobile care mediation tool is used to share mood and availability status among participants by sending SMS messages. Users click the desired availability status from the display screen as shown in Fig. 10(a). The display screen updates the user’s own availability status first, and then sends the modified status to the other party as depicted
Users reply to 10 questionnaire items to update the current mood status. These 10 items are designed according to PANAS (Positive and Negative Affect Scale) to identify positive mood, negative mood and depressive indicator. The mood level is determined after replying the questionnaires. The emoticon is updated to the display screen, and sent to the other party to update the mood status as illustrated in Fig. 11(b).

To receive these SMS updated messages, the proposed system implements a message rule client (MAPI Rules), which is a COM object that processes the incoming MAPI messages. The MAPI rules client intercepts all incoming SMS messages, and compares the messages with the rules implemented within it. Hence, messages tagged with “OInfo:” are processed by our custom program, and other messages are passed to the default Inbox of the device. The handled messages about mood and availability are stored in the local database, and are also updated to the display including the timestamp.

![Figure 12. Flow chart of intercepting and parsing SMS messages](image)

5.2.3 Suggestion notifications

The agent of the mobile care mediation detects the depressed individual’s current mood state, and presents suggestions to the depressed individuals or caregivers. The decision agent decides whether to display the corresponding suggestion to the depressed individual once he has completed the questionnaire. The behavior suggestion sent to the
caregiver is notified using pocket pc notifications as illustrated in Fig. 13. A suggestion is accompanied by a light bulb notification icon on the navigation bar at the top of the screen as depicted in Fig. 13(a), an information bubble in HTML text anchored at the bottom of the screen as illustrated in Fig. 13(b), and a beep sound. The notification icon remains on the screen until the user clicks to view the suggestion. The suggestion includes some detailed descriptions about the depressed individual’s current state, and supports choices that caregiver can perform to care for the depressed individual.

Figure 13. Suggestion to caregiver: (a) light bulb notification icon, (b) suggestion bubble anchored at the bottom of the screen, (c) suggestion content and choices

5.2.4 Sharing photos

Figure 14. Sharing photos between a depressed individual and a caregiver
To update the image on the display screen, a user can use the phone camera to take a new photo, or select one of the image files from the local storage. An image larger than the limited space is automatically resized to show on the display screen. The updated image is also sent to the other party by using multimedia messaging service (MMS). A custom program was developed to send and receive the images. The photo and timestamp of the other party on the display are updated after the image is received.

The MMS Stack SDK is provided by WinWap technologies [37]. To send an MMS message, the device connects to the GPRS, and uploads the captured image to the MMS server of the telecom company. Since MMS uses the Wireless Application Protocol (WAP), the MMS server pushes the MMS notification message to the device. The custom MMS receiver has to register with the push router registration table to receive WAP push messages. The custom MMS receiver is invoked and connected to the GPRS after receiving notification for a new MMS message. The image can be downloaded from the MMS server as soon as the GPRS connection is established. The following figure 15 illustrates the flowchart of sending and receiving MMS messages.

![Figure 15. Flow chart of MMS sending and receiving](image-url)
Chapter 6

Evaluation

(Mobile care mediation tool)

6.1 User study design

This user study was conducted in collaboration with Department of Psychology in National Taiwan University (NTU) and involved four phases: (1) pre-ESM assessment for screening participants; (2) baseline ESM data collection for one week without adopting the care mediation tool between the depressed individuals and caregivers; (3) two-week experiment periods with the mobile care mediation tool, and (4) post-ESM assessment after using the mobile care mediation tool. The methodology of this user study is described as follows.

Participants: The participants were NTU students and recruited via the Internet
advertisement. The study focused on students with dysphoric symptoms. Participants were screened by Beck Depression Inventory-II (BDI-II >15), and by rumination and reassurance-seeking behavior (score > mean+0.5 SD). All signed up participants took part in the pre-ESM assessment, and the selected participants were requested to find a significant other as a caregiver to participate in this study. The caregiver was required to be in peer relationship (such as intimate friend or boy/girlfriend) and not in senior relationship (such as parents).

Procedures: The researchers arranged a time to meet with the previous selected participants and their caregivers, and then asked their agreement to participate in a three-week study: one week for baseline ESM assessment, and the following two weeks for using the mobile care mediation tool. Therefore, the participants were required to come back twice during the study. The participants were requested to place their own SIM cards into the experiment devices. Following the one-week baseline period, the researchers discussed with participants about using experience of the devices during the one-week study. The participants were then told how the care mediation system worked. Participants were also informed that the mobile care mediation tool sends SMS and MMS messages to both parties to share information. Participants were reimbursed additional cash for sending SMS/MMS messages using their phone numbers as shown in Table 6. Finally, post-ESM assessment was conducted when the participants returned the experiment devices.

<table>
<thead>
<tr>
<th></th>
<th>Dysphoric student</th>
<th>Caregiver</th>
</tr>
</thead>
<tbody>
<tr>
<td>Payment for participating</td>
<td>950</td>
<td>700</td>
</tr>
<tr>
<td>Reimbursement for SMS/MMS</td>
<td>550</td>
<td>550</td>
</tr>
<tr>
<td>Total</td>
<td>NT$ 1500</td>
<td>NT$ 1250</td>
</tr>
</tbody>
</table>

Table 6. Total payment to participants for joining the study
Measurements: During the one week of ESM baseline study, the depressed individuals’ mood and ruminative responses were measured five times daily, while only mood was measured for caregivers. Additionally, the mobile care mediation tool was used to sample the overall feeling of participants at the end of each day.

The following factors relating to the depressed individual were measured at the end of each day:
1. extent of seeking reassurance from the caregiver;
2. feeling of being a burden to the caregiver,
3. level of understanding of the mood and availability of the caregiver during the day.

The following factors relating to the caregiver were measured at the end of each day:
1. reassurance requested from the depressed individual;
2. feeling of burden in caring for the depressed individual,
3. level of understanding of the mood and availability of the depressed individual during the day.

The questionnaires remained the same during the experiment period of the mobile care mediation tool as in baseline period. The CareMe display, sensing, suggestion and communication were included in this phase of the study. Additionally, participants could self-report mood and self-trigger to perform distraction activities during this phase.

Finally, the following measurements were analyzed to verify the hypotheses described in Chapter 1:
1. reduction in ruminative responses;
2. reduction in caregiver’s burden;
3. reduction in reassurance-seeking behavior,
4. degree of relation satisfaction between the depressed individual and caregiver.
6.2 Results

Five pairs of participants participated in the study. All the participants completed the four phases of the study. One pair of participants was excluded from the evaluation results because they involved a person whose depression level was much lower than the pre-ESM screening phase during the remainder of the three-week study. The results in percentage changes before and after using the mobile care mediation tool are presented here. The changes could not be computed based on a global baseline because the participants were not all on the same baseline. Therefore, the percentage changes had to be based on the individual’s pre-scores measured at the beginning of the study. The percentage was calculated as follows: \( \frac{\text{post}\_\text{scores} - \text{pre}\_\text{scores}}{\text{pre}\_\text{scores}} \). The evaluation results are described based on the four major measurements described in the user study design.

1. Ruminative responses

The ruminative responses of the depressed participants were measured with Chinese response style questionnaire (CRSQ). Negative percentage changes indicate reduced ruminative responses in the depressed participants. The results are illustrated in Fig. 17. Among the four depressed participants, participants 2 & 4 had strongly reduced their ruminative responses; participant 1 had no significant changes in ruminative responses after the three-week study while participant 3 exhibited increased ruminative responses at the post-ESM assessment.
2. Caregivers’ burden

An involvement evaluation questionnaire (IEQ) was utilized to measure caregiver’s burden. The burden of participants 2 & 4 was significantly decreased as depicted in Fig. 18. Even though another two caregivers’ burden was not significantly decreased, no caregivers experienced increased burden at the end of the three-week study. The mediation tool can thus help reduce the caregivers’ burden.
3. Reassurance seeking behavior

Reassurance-seeking behavior was measured in both depressed participants and caregivers. Depressive interpersonal relationships inventory - reassurance seeking subscale (DIRI-RS) was utilized to measure reassurance-seeking (RS) behavior felt by depressed participants, and reassurance-seeking behavior that caregivers perceived from depressed participants (Perceived RS). Depressed participants 1 & 2 exhibited a 40% reduction in reassurance seeking. The perceived reassurance seeking of their corresponding caregivers were also decreased. However, depressed participant 3 and his corresponding caregiver experienced the opposite outcomes as shown in Fig. 19. Caregiver 4 exhibited a 33.3% increasing in perceived RS even though depressed participant 4 had only slightly increased in RS behavior.

![Figure 19. % changes of reassurance-seeking behavior experienced by depressed participants and caregivers respectively](image)

4. Relation satisfaction

Relation satisfactions between depressed participants and caregivers were measured by the relation assessment scale (RAS). Both parties replied their relation satisfactions with the other parties. The relation satisfactions of depressed participants 1 & 2 were enhanced. Their corresponding caregivers 1 & 2 also indicated the same positive changes about their relation. However, depressed participants 3 & 4 and their
corresponding caregivers had the opposite outcomes as illustrated in Fig. 20.

![Figure 20. % changes of relation satisfaction experienced by depressed participants and caregivers respectively](image)

**Summary**

Their overall results were very positive for pairs 1 & 2. Not only did the depressed participants reduce their reassurance-seeking behavior, but the caregivers’ burden was also decreased. Their relationship satisfaction to each other was also increased. Their responses were encouraging to our current prototype design of the mobile care mediation tool.

For pair 3, the ruminative responses of the depressed participant increased by 37.04% and reassurance-seeking behavior increased by 19.5%. However, the caregiver’s perceived reassurance-seeking is declined by -25%, and caregiver’s burden was not significantly changed (−4.65%). The relation satisfaction felt by caregiver declined by -13.33%. The mobile care mediation tool cannot control the environmental factors that exacerbate depression. If the ruminative responses and reassurance seeking of the depressed participant increased because of external factors, then the mobile care mediation tool should ideally maintain, and not worsen the interaction between the depressed participant and caregiver. Although the results of pair 3 look promising, a long-term study is still required to discover whether the tool can help prevent the interaction quality from degrading when depression symptoms of the participants
exacerbate.

The overall results of pair 4 were not as good as those of pairs 1 & 2. The results tended to provide positive changes. Even though the perceived reassurance seeking of caregiver was increased by 33.3%, the burden of caregiver was reduced by -30%, and the relation satisfaction of caregiver was still increased by 13.04%.

Four pairs of user study do not provide statistically significant results to claim the hypotheses described in Chapter 1. However, these results indicate that the mobile care mediation tool has the potential to enhance interaction between depressed individuals and caregivers. Additionally, psychologists can explore the interpersonal and emotional factors of the depressed individuals and caregivers with the assistance of technology.
Chapter 7

Discussion

This chapter reviews the current prototype design of the mobile care mediation tool and considers some future research directions. Three main observations are discussed, involving both the original design considerations and the future design of the mobile care mediation tool.

1. Display more subtle and deeper information

The initial goal of awareness display is to enable participants to provide each other with information about their mood and availability status. The display is designed to increase understanding of each other simply at a glance. Mood is divided into five levels, and availability status into two levels. However, the information of awareness display is so rough that participants commented that they could not capture the detailed information of the other party’s status. The intended meaning of a caregiver setting his availability status to busy is not clear: it could mean that the depressed participant cannot contact the caregiver, or that “I do care you and you can contact me even though I am busy.” Two caregivers also mentioned: “I only saw the sad face and the routine
suggestion. These do not provide sufficient clues for me to deliver my care more effectively and efficiently.” Therefore, future designs should provide more subtle and deeper expression of mood and availability for improving understanding.

2. **Ways of conveying emotion between participants**

Participants record their emotions via questionnaires in the current prototype of the mobile care mediation tool. The questionnaires limit the scope for conveying emotion. Participants responded that replying to the same questionnaires frequently was boring, and that the questionnaires could not express their mood or emotion diversely enough. Therefore, the participants need extra ways to convey their emotion to the others. More animated emoticons could be provided to express the mood and emotion status. Furthermore, smart phones might be usable as emotional machines to convey complex emotional changes not obtained through the direct input of the participants. For example, a participant’s emotion could be conveyed by analyzing his choice of music. That is music might help to describe the emotion of depressed participants when they do not know how to express their condition, thus enabling caregivers understand properly how depressed participants feel during the time. This is an interesting research area for communicating emotion between individuals.

3. **Providing intelligent and interactive suggestions**

The mobile care mediation tool also acts as an agent providing distraction suggestions to depressed individuals and providing caring behavioral suggestions to caregivers. The initial aim of the tool is to guide depressed individuals to distract their ruminative responses and reassurance-seeking behavior for regulating their emotion.
Caregivers are also guided to give care to depressed individuals. However, these suggestions are so routine that participants rarely respond to them. To persuade users to follow the suggestions, the agent should be designed to be more intelligent and interactive.
Chapter 8

Conclusion and Future Work

First, this thesis presents a prototype of ESM tool and its evaluation. Second a mobile care mediation tool for depressed individuals and caregivers is prototyped. The conventional usage of mobile phones is harnessed to provide daily fluctuation of information (mood and availability status). However, the mobile care mediation tool collects and shares the information between users. Mobile phones also act as sensors and agents for providing suggestions to both parties. A display interface is designed to present the information in a glanceable manner. Finally, a user study is undertaken to evaluate the tool. The experiment was performed on four pairs of participants, which is insufficient to provide statistical significant results. However, experimental results show a positive feedback for applying the mobile care mediation tool between depressed participants and caregivers.

Technology can help depressed individuals and caregivers to become more easily aware of each other and interact more efficiently. Future work will be to improve the design of the mobile care mediation tool to provide additional ways of conveying information (such as mood, emotion) and increasing understanding between participants.
A user study will also be undertaken for the clinical moderate depressed individuals and their caregivers to evaluate the effectiveness of the mobile care mediation tool.
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