The Pennsylvania State University

The Graduate School

College of the Liberal Arts

EFFICACY OF A SMARTPHONE-BASED SELF-GUIDED TREATMENT FOR DEPRESSION: A MULTI-CASE STUDY

A Thesis in

Psychology

by

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Submitted in Partial Fulfillment
of the Requirements
for the Degree of

Master of Science

August 2011

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ABSTRACT

Smartphones can aid in making psychotherapy available to the many individuals who do not otherwise have access to empirically supported treatments for their psychological disorders. Smartphones combine the capabilities of traditional computer devices with telecommunication technologies including programmability, storage capacity, and wireless communication and networking capabilities. An important benefit provided by smartphones is the ability to conduct ecological momentary interventions (EMIs) with computer applications that more effectively integrate psychotherapy interventions into the daily lives of patients. With smartphone-based EMI applications, smartphones make it easier to collect data from patients as they practice new behaviors and skills within their natural environment and to assess patient progress and application usage on a daily basis (a clinical and research methodology known as ecological momentary assessment, or EMA). The author reports results from a multi-case study of the use of a smartphone application for the treatment of depression. Theoretically relevant rationales for using smartphones in the treatment of depression are enumerated, results of the present study are discussed, and suggestions for future research are presented.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACKNOWLEDGEMENTS

I am honored to have had the opportunity to collaborate with a number of wonderful individuals throughout the course of this project and to have had the valuable support and encouragement of many others.

First, I would like to thank my thesis advisor, Michelle Newman, whose insight and guidance have been invaluable throughout this experience and with whom I hope to collaborate on many future projects. Her dedication to research on the nature and treatment of anxiety and mood disorders and to research on the use of technology in the assessment and treatment of such disorders has been, and continues to be, an inspiration.

I would also like to thank my other committee members, Amy Marshall, Frank Ritter, and Ben Locke, for their methodological suggestions and other constructive comments during the development of the project, as well as for their encouragement.

Finally, I would like to thank my friends and family for their ceaseless support, patience, and encouragement when it was most needed. Their faith in me has meant more than I can express.

Efficacy of a Smartphone-Based Self-Guided Treatment for Depression: A Multi-Case Study

Introduction

Major depressive disorder (MDD) is an important public health concern. In the United States, MDD has a lifetime prevalence of 16.2% and a 12-month prevalence of 6.6% (Kessler, McGonagle, Zhao, Nelson, Hughes, Eshleman, Wittchen, & Kendler, 1994). MDD is typically an episodically chronic-recurrent disorder. Current estimates indicate that 50% to 60% of individuals who experience one depressive episode go on to experience a second one. Of those individuals, 70% to 80% will eventually experience a third episode. Finally, 90% of individuals with three past episodes will go on to experience a fourth episode (American Psychiatric Association, 2000; Burcusa & Iacono, 2007; Lewinsohn, Zeiss & Duncan, 1989; Monroe & Harkness, 2005). In terms of clinical severity within community cases, 38% of individuals with 12-month MDD were classified as being seriously–severely depressed based on Quick Inventory of Depressive Symptomatology (QIDS) assessments, while the remaining 62% of cases were classified as mildly–moderately depressed (Kessler, Berglund, Demler, Jin, Koretz, Merikangas, Rush, Walters, Wang, 2003). These findings suggest that MDD should be classified as a chronic disease, along with such physical diseases as cancer, diabetes, and heart disease. These findings also support growing evidence that major depressive disorder is one of the most seriously impairing of all chronic conditions (Wang, Simon, & Kessler, 2003).

Major depressive disorder is highly comorbid with other mental health issues. Nearly three-fourths of individuals with lifetime MDD met criteria for at least one other DSM-IV mental disorder. Fifty-nine percent experienced at least one lifetime comorbid

anxiety disorder; 31.9% experienced at least one impulse control disorder (ICD); and 24% experienced at least one lifetime comorbid substance use disorder. Similarly, approximately two-thirds (65.2%) of individuals with 12-month MDD met criteria for at least one other 12-month disorder, with 12-month comorbid anxiety disorders (57.5%) more common than either 12-month comorbid substance use disorders (8.5%) or 12-month comorbid ICDs (20.8%; Kessler, Merikangas, &Wang, 2007).

Major depressive disorder has broad societal costs related to health, psychological functioning, and economics (Broadhead, Blazer, George, & Tse, 1990; Klerman, & Weissman, 1992; Luppa, Heinrich, Angermeyer, Konig, & Riedel-Heller, 2007; Wang, Simon, & Kessler, 2008). Depression is predicted to become the second leading cause of mental illness worldwide by 2020 (Murray & Lopez, 1997). The total costs associated with major depressive disorder in 2000 have been estimated to be approximately $83.1 billion. Of those costs, $26.1 billion (31%) were in direct medical costs while $5.4 billion dollars (7%) were in suicide-related mortality costs. The majority of the costs were associated with the impacts of depression on the workplace, including depression-related absenteeism and impaired work performance while on the job (presenteeism; Greenberg, Kessler, Birnbaum, Leong, Lowe, Berglund, & Corey-Lisle, 2003).

Smartphone Technology and Psychotherapy

Rapid technological advances in mobile communications are likely to revolutionize research on psychological disorders and the delivery of treatment for those disorders. Advances in the technical devices themselves, in wireless communication bandwidth, and in the wireless accessibility of the Internet are making it possible to

provide services to more and more people outside the traditional setting of the therapist's office. Many of today's mobile devices combine the portability of a cellular telephone with the processing capabilities of a handheld computer. Patients can access computerized treatment protocols installed on their mobile phone devices to help them learn and practice new life skills to address their mental health issues. Thus, it is likely that one of the most significant impacts that mobile devices will have in clinical psychology is on treatment compliance. By encouraging daily skill use by means of a mobile phone application, psychotherapy interventions are likely to be more effective as clients have more opportunity to incorporate new acquired coping skills into their daily routines.

Clinicians and researchers are also likely to benefit from smartphone use because of the device's ability to collect and store detailed behavioral data. The data collected from a smartphone can be analyzed to assess the efficacy of the computerized treatment application and to make empirically based adjustments to the application as needed. Clinicians and researchers also have the option to receive real-time access to the data through wireless communication for up-to-the-minute observation of patient interaction with the treatment application.

It has long been the goal of clinical psychologists to encourage patients to perform between-session activities as part of their everyday lives. Heron and Smyth (2009) refer to treatments emphasizing close integration of psychotherapy interventions into the daily lives of patients as ecological momentary interventions (EMIs). EMIs can be used to supplement traditional person-to-person psychotherapy or as adjunctive interventions to existing psychotherapy approaches. These interventions take place within patients'

natural environments and can be programmed to engage patients at specific time points throughout the day. EMIs can provide patients with multiple opportunities to apply new skills and behaviors that reinforce learning techniques introduced to them during therapy sessions. An important component of EMI is ecological momentary assessment (EMA). EMA refers to the collection of the data generated as patients' practice new behaviors and coping skills throughout their day. Real-time data of usage behavior can be captured unobtrusively and in the moment. The data can be stored and transferred to the researcher or clinician at a later time or can be transmitted instantaneously via wireless communication.

Palmtop computers and mobile phones have been the primary platforms used in EMI research (Heron & Smyth, 2009). Palmtop computers are small electronic devices that provide a variety of organizational tasks such as calendar or scheduling features as well as the ability to run customized computer applications. Palmtop computers are often referred to as personal digital assistants (PDAs), handheld computers, or pocket computers. Mobile phone devices have the capability of sending and receiving voice and written text messages and, increasingly, pictures and videos.

Until the emergence of the smartphone, palmtop computers were used for more complicated EMI applications while mobile phone devices were primarily used for sending voice messages and text messages or short message service (SMS). Smartphone devices have combined these separate functional areas into a single device. Smartphones have the advantage of programmability and data storage associated with palmtop computers and the telecommunications capabilities of a traditional mobile phone, making them ideal devices for ecological momentary interventions and assessment.

The expanded use of telephony in clinical psychology research has mirrored the development of technology advancements in computers and telecommunications. Several research studies have been conducted to examine the usefulness of telephony in the treatment of depression. In studies examining the effectiveness of Internet-based treatment applications, telephone use has been narrowly prescribed to the role of a tool for reminding participants to access the Internet application (e.g., Christensen, Griffiths, & Jorm, 2004; Griffiths, Christensen, Jorm, Evans, & Groves, 2004; Clarke, Eubanks, Kelleher, O'Connor , DeBar, Lynch, et al., 2005; Robertson, Smith, Castle, & Tannenbaum, 2006). It must be noted that the use of telephones in this way has played an important role in technology-based treatment. Clarke et al. (2005) determined that such reminders, whether in the form of telephone calls or e-mails, led to greater utilization of the Internet program and, subsequently, to better outcomes when compared to studies that provided no type of reminder.

Other studies have shown that telephony can play an even greater role in treatment. The use of telephones in some studies can almost be seen as early prototypes of the eventual fusion of telephony with computer-based applications. Osgood-Hynes, Griest, Marks, Baer, Heneman, Wenzel, et al. (1998) conducted a study using the COPE system, a 12-week self-help system that involved having participants call into an interactive voice response (IVR) system that made self-help recommendations to the participants based on information they provided. The authors found that the COPE system, in conjunction with supplemental booklets, led to reduced depressive symptomology in participants. Eisdorfer, Czaja, Loewenstein, Rubert, Argüelles, Mitrani, & Szapocznik (2003) conducted a study with caregivers of family members with

Alzhiemer's disease who demonstrated caregiver depression. The computer treatment group received family therapy and access to a computer-telephone integrated system (CTIS). CTIS was designed to augment the treatment by providing caregivers the means of accessing support from family members and supportive services outside the home. The SET-CTIS group was compared with a SET-only group. The authors found that the SET-CTIS group showed reduced depressive symptomology at both 6 month and 18 month follow-up. Smartphones provide full fusion of telephony and computer technology in a convenient, portable manner that may help to integrate skill development into the daily lives of patients.

In a recent article, Raento, Oulasvirta, and Eagle (2009) made a case for the use of smartphones in social science research. In their definition of social science they included sociology, social psychology, urban studies, technology assessment, and media studies. The arguments they make for smartphone use, however, are just as applicable to clinical psychology. Raento et al. propose two central arguments for the use of smartphones in research and treatment. The first argument is that of flexible control. Smartphones can be programmed to interact with patients in ways that enhance the user experience of the application, such as with patient-input mediated interactions between the program and the patient; to collect usage data such as which aspects of the application are being utilized most or how often an application is accessed and for how long; and to provide real-time data collection and instantaneous transmission of data to the researcher or clinician. Smartphone devices have advantages over standard mobile phone devices because they include sophisticated sensing capabilities, increased storage capacity, and built-in networking. The second argument that Raento et al. propose is that of cost-effectiveness.

Vast amounts of data can be collected unobtrusively without the researcher or clinician needing to be present. It is often important in assessing treatment effectiveness to know how a patient is engaging in the therapeutic interventions. Such data can be collected on smartphone devices more reliably and cost-effectively than in other ways. Also, device-collected data is less likely to be influenced by subjectivity and bias as can sometimes occur in data gathered through such means as direct observation. Raento et al. predict that data collected through the use of smartphones is likely to lead to improved ecological validity. Another cost-effective benefit of smartphones is the ability for patients to use their own equipment during treatment. It is not necessary for the researcher or clinician to provide another device that the patient has to manage in addition to what they currently carry.

Rationale for studying the use of technology in the treatment of depression

Heron and Smyth (2009) provide a review of studies that have implemented ecological momentary interventions and data assessment. For psychological disorders, most of the studies have involved EMIs for anxiety disorders including panic disorder (e.g., Newman, Kenardy, Herman, & Taylor, 1997; Kenardy, Dow, Johnston, Newman, Thomson, & Taylor, 2003), social phobia (e.g., Gruber, Moran, Roth, & Taylor, 2001; Przeworski, & Newman, 2004), generalized anxiety disorder (e.g. Newman, Consoli, & Taylor, 1999), and obsessive-compulsive disorder (e.g., Baer, Minichiello, Jenike, & Holland, 1988). The author of this paper seeks to extend the research by examining the effectiveness of the smartphone in the treatment of depression.

Major depressive disorder and anxiety disorders share many similar characteristics. Biologically, both types of disorders exhibit abnormalities in the

noradrenergic, serotoninergic, and dopaminergic systems in the brain. Both types of disorders also exhibit increased activation of the hypothalamic-pituitary-adrenocortical (HOA) axis (Thase, Jindal, & Howland, 2002; Barlow, 2004). Cognitive explanations for the disorders are similarly conceptualized as resulting from negative cognitive processes and dysfunctional information processing. However, there are important differences in MDD that make it necessary to study treatment approaches for depression separately from anxiety.

Anxiety involves a hyperactive cognitive schema in which information about oneself, the world, and the future are interpreted as being dangerous. It is characterized by automatic thoughts and images relevant to danger that result in the activation of inappropriate motor, psychological, and affective components of the anxiety response. Anxiety does have an adaptive function that is important in threat-avoidance and self-preservation. However, anxiety becomes problematic when it is caused and maintained by the faulty processing of information as threatening that is not based on a rational perception of current threat.

Depression is characterized by maladaptive cognitive schemata involving themes of loss, inadequacy, failure, and worthlessness. In Beck's theory of depression (1967), depressogenic information processing is "schema-driven" rather than "data driven." Depression is caused and maintained by the activation of negative cognitive schemata resulting in negative automatic thoughts that are pessimistic about oneself, one's world, and one's future. As a result, depressed individuals attend more closely to negative situational information and tend to dismiss positive or neutral situational information. According to the helplessness theory (Abramson, 1989), depression results from the types

of inferences that an individual makes about negative life events. Depressive symptoms result from an individual's causal attributions about an event, inferred consequences of the event, and inferred characteristics about the self. Individuals are susceptible to depression if they have an inferential style that attributes negative events to stable and global causes, that assumes the negative event is likely to lead to other negative consequences, and that infers that the negative event implies that the person is unworthy or deficient. According to either theory, activation of depressogenic information processing leads to the specific symptoms that distinguish depression from anxiety: loss of pleasurable engagement, or anhedonia, and cognitive and motor retardation.

Cognitive-behavioral treatment of anxiety disorders focuses on two broad areas. One aspect of treatment focuses on controlling and reducing the physiological activation of the fear response with such techniques as progressive muscle relaxation, guided imagery, and exposure. The other aspect of treatment focuses on altering the automatic thoughts and underlying cognitive schemata that are responsible for the distorted information processing and the attentional bias towards danger. Cognitive-behavioral treatment for depression focuses on teaching patients to recognize their negative beliefs and information processing styles. Treatment involves three distinct but interrelated components: exploration, examination, and experimentation. Exploration involves examining a patient's dysfunctional beliefs and personal meaning system. Examination involves reviewing the evidence for and against a belief, consideration of alternative explanations and interpretations, and evaluation of the consequences of the belief if it were true and putting it into a realistic perspective. Experimentation involves testing the validity of a maladaptive belief. While there are many similarities between the disorders

and the treatment for the disorders, the differences in their manifestations require differentiated treatment approaches. Therefore, it is necessary to conduct studies specific to depression to ensure that the treatment effectiveness shown for anxiety is replicated for depression. This is equally true for the investigation of technology based treatments.

The Present Study

Goals

The purpose of the current study was to conduct a preliminary exploration of the use of a smartphone application designed for self-guided treatment of depression using an empirically supported treatment approach. For the present study, a smartphone application for treating depression was chosen that was designed to assist a person in learning and mastering the cognitive restructuring technique of Cognitive Therapy, an empirically supported method for treating depression (e.g. DeRubeis, Hollon, Amsterdam, Shelton, Young, & Salomon, et al. 2005; Kovacs, Rush, Beck, & Hollon, 1981). Cognitive explanations of depression emphasize the role that negative cognitions play in the generation and maintenance of depression (Beck, 1976). Beck asserted that pervasive, systematic distortions of both cognitive content and processes are integral to depression. Specific cognitive biases, such as overgeneralization, selective abstraction, arbitrary inference, minimization of positive assets or consequences, and maximization of negative assets or consequences, have been hypothesized to play a role in generating and maintaining depression. The typical cognitions associated with depression and other disorders are called "automatic thoughts." Consequently, the treatment for depression focuses on altering these negative thoughts and beliefs that characterize depression (Beck, Rush, Shaw, & Emery, 1979).

Hypotheses

The first aim of the study was to examine the feasibility of using a predominantly self-guided mobile application to treat mild to moderate depression. The second aim of the study was to address the question of whether cognitive therapy can be effectively delivered by a smartphone application: Is it possible to see reductions in depressive symptomology in people with depression treating themselves with a smartphone application based on an empirically supported treatment technique? It was important not only to see reductions in subjective reports of the symptoms of depression, but also to see reductions in the frequency of negative self-talk and shifts in cognitive bias away from negative biases.

Methods

Patients

Participants were recruited by three methods: (a) through the undergraduate subject pool at the Pennsylvania State University, (b) by recruitment fliers posted around the campus, and (c) by online advertisements posted on University web sites as well as third-party web sites such as Craig's List, the online version of the *Centre Daily Times*, and the *Daily Collegian Online*. Participants were prescreened by completing an online screening questionnaire that included questions gathering demographic information and an online version of the Depression Anxiety Stress Scale (DASS, Lovibond & Lovibond, 1995). Potential participants scoring 10 or greater on the DASS were invited to participate in a diagnostic interview. To be considered for the study, participants were required to meet several inclusion criteria: (a) a primary diagnosis of Major Depressive

Disorder according to the criteria of the *Diagnostic and Statistical Manual of Mental Disorders* (*DSM-IV-TR*; American Psychiatric Association, 2000), (b) mild to moderate depression as determined by a score of 7 or above on the Hamilton Depression Rating Scale (HDRS, Hamilton, 1960; Hamilton, 1967), and an age of 18 years or older. Additionally, participants could not meet the following rule-out criteria: (a) current substance abuse or dependence, (b) a history of psychotic symptoms, (c) current suicidality, (d) refusal to remain off medication or to remain at the current level of medication for the length of the study, and (e) participation in Cognitive Behavioral Therapy within the last 3 years. Three patients were selected to participate in the study.

Patient 1. Patient 1 (P1) was a married, heterosexual, European-American female in her early 40s. She was an undergraduate student at Penn State in her second year of higher education. She had gotten pregnant at an early age and married the father of her child. She had discontinued her education to raise her family. She had not work in a significant capacity outside of the home since she became a mother. Her husband had been the primary wage earner for the family until he suffered a work-related back injury that put him on disability. At the time of enrollment into the study, Patient 1 and her family were living off of her husband's disability payments. Her decision to return to school was partly necessitated by her need to help provide additional financial support for her family.

Patient 1 was the mother of five children. One her sons suffered from a genetic disease that made him susceptible to life-threatening seizures. It was predicted that the child would not live more than three or four years. At the time of enrollment into the study, the child was seven years old. His illness, however, required that he be monitored

24 hours a day. Nurses had been provided by the state to keep watch over the child durig the night so the parents could get some sleep. Patient 1 indicated that even though she had the services of night nurses, she often was not able to get a good night's sleep due to her worry about her son's condition. This concern was reinforced by the fact that some of the night nurses were not as vigilant as they should have been, sometimes falling asleep instead of staying awake throughout the night.

Patient 1 was under a great deal of stress at the time of her enrollment into the study. She was experiencing marital distress due to her husband's disability and his inability to contribute as much to the care of the children. Over the course of her involvement in the study, Patient 1 separated from her husband and moved out of the house, though she continued to be involved with her children on a daily basis. She was also experiencing a great deal of guilt over not being able to give as much attention to her other children because of the attention that was required by her son. She also experienced guilt, anxiety, and helplessness whenever her son's conditioned worsened. Attending college and taking a full course load added to her stress, guilt and anxiety.

During intake, Patient 1 received a primary diagnosis of Major Depressive Disorder with a secondary diagnosis of Generalized Anxiety Disorder. She had no history of substance abuse problems or psychotic symptoms. Patient 1 was taking antidepressant medication but reported that they were not effective. She agreed to maintain her current medication levels throughout the study without change. She was seeing a psychotherapist at the time of intake, however, the therapy that she was receiving did not qualify as Cognitive Behavioral Therapy. She agreed to forgo therapy

during the course of the study. The patient provided her own iPhone device for use during the study.

Patient 2. Patient 2 (P2) was a 20-year-old, single, heterosexual, European-American male. He was an undergraduate student at Penn State in his third year of higher education. He had broken up with his long-term girlfriend within the last year and was still struggling with the loss. His complaints included depressed mood, anhedonia, fatigue, sleep disturbances, and decreased ability to concentrate. During intake, the patient was diagnosed with Major Depressive Disorder. He had no history of substance abuse problems or psychotic symptoms, and had no previous experiences in psychotherapy. He had never taken psychotropic medications and did not begin medication during this course of treatment. The patient was provided with an iPod Touch device for use during the study.

Patient 3. Patient 3 (P3) was a 19-year-old, single, heterosexual, European-American male. He was an undergraduate student at Penn State in his second year of higher education. Patient 1 reported that he questioned his intellectual abilities and worried that he would not meet the minimum requirements necessary to be accepted into a graduate program in psychology. His complaints included depressed mood, anhedonia, fatigue, sleep disturbances, decreased ability to concentrate, and feelings of worthlessness. He reported having neither recurrent thoughts of death nor suicidal thoughts or intent. During intake, the patient was diagnosed with Major Depressive Disorder. He had no history of substance abuse problems or psychotic symptoms, and had no previous experiences in psychotherapy. He had never taken psychotropic medications and did not begin medication during this course of treatment. The patient

provided his own iPod Touch device for use during the study. A summary of each patient's characteristics is provided in **Table 1** on page 15.

Table 1: Patient Characteristics at the Time of Intake

Patient	Age	Sex	Marital Status	Device	Diagnosis	Severity
P1	41	Female	Married	iPhone (owned)	Major Depressive Disorder	Moderate
P2	20	Male	Single	iPod Touch (provided)	Major Depressive Disorder	Moderate
P3	19	Male	Single	iPod Touch (owned)	Major Depressive Disorder	Mild

Treatment

The treatment used in the present study was based on the cognitive restructuring technique of Cognitive Behavioral Therapy for the treatment of depression as described by Beck et al. (1979). The technique used consisted of the following basic steps: (1) detecting automatic thoughts, (2) examining and reality testing automatic thoughts, and (3) searching for alternative solutions.

The treatment was delivered through an application called eCBT Mood©, provided by MindApps, LLC[1], run on an iPhone or iPod Touch device. The program provides patients with a brief description of how thoughts, feelings, and behaviors interact from a CBT perspective. From the toolbox, patients have access to several modules to help them practice and master cognitive restructuring. The first module aids patients in determining the automatic thoughts they experience most frequently. A brief description of the distortion inherent in a given automatic thought is provided along with an example of that automatic thought. Patients are able to select whether each automatic thought occurs for them all of the time, some of the time, or not at all.

[1] eCBT Mood is a commercially available iPhone/iPod Touch application. MindApps, LLC provided a research version of the application that allowed the researches to gather more data than that collected by the commercially available version of the application.

A *Feelings and Thoughts Log* is available in the application's toolbox. This log allows patients to enter a brief description of an upsetting situation and to identify the automatic thoughts that occurred as a result of the situation. They are then able to rate their level of belief in the thought, identify the primary feeling that the thought produced, and rate the intensity of the feeling. After entering the above information, the application asks patients if they would like to continue to the next step of challenging their thoughts. If patients respond that they would like to continue, the application then assists them in challenging their automatic thoughts by providing guidance information on how to engage in the process. The information is tailored to address the specific distortion identified in the automatic thoughts. The application encourages patients to make different interpretations of the situation and to look for alternative explanations for it (**Table 2** provides examples of the text presented to the patient). After engaging in the task of cognitive restructuring for a self-determined amount of time, patients are then asked to reassess the intensity level of their feelings about the situation.

Table 2: Examples of Guidance Text from the Treatment Application

Automatic Thought	Guidance Text – Page 1	Guidance Text – Page 2
All-or-nothing	Avoid making black or white judgments. Most things are too complex to be reduced to black or white judgments. What is the gray area in this situation?	What's another way of looking at the situation that takes the gray area into account? Are you thinking about the situation in an extreme way? What is a more realistic way to look at the situation?
Picking out the negative	Shift your focus away from the negative. Focus on coping and resources you have, not on the problem itself. How have you handled situations in the past? Are there other possible outcomes to this situation?	Avoid magnifying words like 'terrible', 'awful', 'horrible', etc. How would an independent observer see the situation? Avoid phrases like 'I can't stand it'. Are you confusing a thought or feeling with a fact?

Jumping to conclusions	If you are assuming that people are reacting negatively to you, what is the evidence for and against this belief? Is the other person's reaction really about you? What are some other possible explanations for the person's reactions?	If you are making predictions about the future, what is the basis for the prediction? What is your evidence for or against your prediction? Is there really any benefit from making a prediction about the future? What are disadvantages in thinking this way?

The third module in the toolbox is the *Challenging Automatic Thoughts* module. In this module, the procedure is identical as that of the *Feelings and Thoughts Log* except that it automatically continues to the cognitive restructuring task rather than giving patients a choice of continuing or not.

Finally, the application provides patients with opportunities to assess their depression in two ways. The *Daily Mood Assessment* allows them to rate their moods on a daily basis. Based on the answers they provide to a series of questions, a depression score is calculated and presented to the participant in a graphical display so they can monitor their depression levels day-to-day.

Treatment response was defined as a reduction from the baseline score on the HDRS of 50% or greater at the end of the fifth week of treatment[2], whereas remission was defined as a score of 7 or lower.

Measures

Anxiety Disorders Interview Schedule, Fourth Edition. The Anxiety Disorders Interview Schedule, Fourth Edition (ADIS-IV; Brown, Di Nardo, & Barlow, 1994) is a semistructured clinical interview instrument for assessing symptomology associated with the various Axis I diagnostic categories of the *DSM-IV-TR* (American Psychiatric

[2] Analysis of treatment effectiveness was based on data collected after the first five weeks of participation in the study. Data from continued participation was not available at the time this report was prepared.

Association, 2000). The ADIS-IV was designed to assess for the presence of current DSM-IV anxiety, mood and substance-use disorders among adults as well as screen for the presence of psychotic and conversion disorders. The instrument includes a clinical severity rating (CSR) for each diagnosis received ranging from 0 to 8, with 4 being the diagnostic cutoff. The instrument is designed to facilitate differential diagnosis between DSM-IV disorders and provide categorical assessments. The ADIS-IV takes approximately 2–3 hours to complete, depending on the complexity of the pathology.

Although no psychometric data is not currently available for the ADIS-IV, data is available for the Lifetime Version of the instrument. All principal diagnoses were found to have good or excellent reliability with the exception of Dysthymia, which was found to have low inter-rater reliability ($\kappa = .22$ as principle diagnosis and $\kappa = .31$ as principle or additional diagnosis) (Brown, Di Nardo, Lehman, & Campbell, 2001). Inter-rater reliability for Major Depressive Disorder was good ($\kappa = .67$) as principle diagnosis and fair ($\kappa = .59$) as additional or principle diagnosis. For Alcohol and Substance Use Disorders, inter-rater reliability was excellent ($\kappa s = .82$ and .83, respectively) as lifetime diagnoses (Grisham, Brown, & Campbell, 2004). No known psychometric data is available for the inter-rater reliability of psychotic disorders. The ADIS-IV had even better inter-rater reliability when assessed dimensionally rather than categorically. For example, ratings of symptom severity for Major Depressive Disorder have been found to have very good reliability ($\kappa = .74$) (Grisham, Brown, & Campbell, 2004). No known psychometric data is currently available for test-retest reliability of the ADIS-IV. However, test-retest reliability of a previous version of the instrument, the ADIS-

Revised, was found to be moderate to excellent with correlation coefficients between .43 and .82 (Di Nardo, Moras, Barlow, Rapee, & Brown, 1993).

Automatic Thoughts Questionnaire-Revised. The Automatic Thoughts Questionnaire-Revised (ATQ-R; Kendall, Howard, & Hays, 1989) is a 40-item, self-report measure that assesses a respondent's depressogenic thought frequency. The ATQ-R is a revised version of the Automatic Thoughts Questionnaire, which is a widely accepted scale with good reliability and validity (Hill, Oei, & Hill, 1989). The authors report that the psychometric properties of the ATQ-R are comparable to those of the original ATQ, which indicate excellent internal consistency and good concurrent validity with measures of depression (Hollon & Kendall, 1980). The measure has been shown to have high internal consistency in psychiatric outpatients, yielding a coefficient alpha of .90 (Kendall, Howard, & Hays, 1989). The ATQ-R is commonly used in depression studies examining the impact of cognitive therapy and takes approximately 5–10 minutes to complete.

The ATQ-R includes ten additional positive self-statements. The positive self-statements account for significantly more variability ($p < .01$) than the negative self-statements alone, as indicated by a hierarchical multiple regression analysis (Kendall, Howard, & Hays, 1989). Each of the 40 self-statements is rated on a 5-point Likert scale indicating the frequency with which each thought occurred over the previous week. Ratings range from 1 (not at all) to 5 (all the time). The 30 negative self-statements (e.g. "I'm no good.") are summed to form a score determining the frequency with which those statements occurred during the previous week. The frequency of negative thoughts score ranges from 30–150. The 10 positive self-statements (e.g. "I feel fine.") are summed to

form a score determining the frequency with which those statements occurred during the previous week. Schwartz and Garamoni (1986, 1989) have suggested that a State of Mind (SOM) ratio is a better indicator of psychological adjustment, reflecting the relative balance between positive (P) and negative (N) thoughts. This ratio is calculated using the using the formula P/(P+N). Schwartz and Garamoni proposed that healthy psychological adjustment would produce SOM ranging from .56 to .68, with the optimal SOM being .618. They further hypothesized that deviations above and below this balance were related to various forms of psychopathology. SOM ratios lower than the healthy range are associated with depression and anxiety while SOM ratios higher than the healthy range are associated with mania. Research has supported the utility of the SOM model with depression (e.g., Kendall, Howard, & Hays, 1989).

Cognitive Bias Questionnaire. The Cognitive Bias Questionnaire (CBQ; Krantz & Hammen, 1979) is a 23-item, self-report measure used to assess negatively biased, self-referent information processing. The questionnaire includes six short scenarios followed by 3 or 4 multiple choice questions. Patients imagine themselves in each situation and then select one of four response options to the questions for each vignette. Each response is coded according to two dimensions: depressed versus nondepressed in tone and distorted versus nondistorted in terms of logical inflection from the scenario. Options for each question represent depressed–distorted (D-D), nondepressed–distorted (ND-D), depressed–nondistorted (D-ND), and nondepressed–nondistorted (ND-ND) cognitive styles. This study focused on the Depressed–Distorted subscale, which has exhibited good reliability and validity (Krantz & Hammen, 1979; Miller & Norman, 1986; Norman, Miller, & Klee, 1983). The CBQ takes approximately 15 minutes to complete

and has been shown to distinguish between depressed and nondepressed students and clinical patients (Krantz, & Hammen, 1979; Norman, Miller, & Klee, 1983).

Credibility/Expectancy Questionnaire. The Credibility/Expectancy Questionnaire (CEQ; Devilly & Borkovec, 2000) is a 6-item measure to assess the expectancy and credibility a patient has about the therapy he or she will receive. Four of the items are rated on a 9-point Likert scale while two of the items are rated from 0 to 100%. The measure is divided into two sections, one related to thinking and one related to feeling. The measure has been shown to derive two factors, a cognitively based credibility factor and an affectively based expectancy factor. The credibility factor is derived from three of the thinking items while the expectancy factor is derived from one of the thinking items and the two feeling items.

The CEQ has been shown to have good internal consistency. The expectancy factor yielded a coefficient alpha between .79 –.90 while the credibility factor yielded a coefficient alpha between .81–.86 and test–retest reliability (expectancy, r_{tt} = .82; credibility, r_{tt} = .75; Devilly & Borkovec, 2000). The scale as a whole yielded a coefficient alpha between .53 and .85.

Depression Anxiety Stress Scales. The Depression Anxiety Stress Scales (DASS; Lovibond & Lovibond, 1995) is a 42-item, self-report measure with 3 subscales that assess a participant's current negative emotional states of depression, anxiety and stress. Each of the sub-scales consists of 14 items rated on a scale of 0 (did not apply at all to me) to 3 (applied to me very much). Participants are asked to rate the extent to which they have experienced each state over the past week. Subscale scores range from 0 to 42.

Total scores can range from 0–126. Higher scores indicate higher levels of emotional distress. The DASS takes approximately 10–20 minutes to complete.

The DASS subscale and total scores have been shown to have high internal consistency as estimated using Cronbach's alpha. Coefficient alphas for the subscales are .947 for the depression scale, .897 for the anxiety scale, and .933 for the stress scale. The coefficient alpha is .966 for the total scale. The DASS also has high construct validity in the form of substantial correlations with measures of similar constructs (Crawford & Henry, 2003). The anxiety and depression subscales significantly differentiate between patients with anxiety diagnoses or depressive diagnoses (Antony et al., 1998).

Hamilton Depression Rating Scale. The Hamilton Depression Rating Scale (HDRS; Hamilton, 1960, 1967) is a commonly used interviewer -administered rating scale that assesses the severity of both physical and psychological aspects of depression. The HDRS is considered the ''gold standard'' in depression assessment and is the most widely used interviewer-administered assessment of depression severity (Nezu et al., 2002). It consists of 17 items that focus on symptoms of depression experienced over the past week. Total scores range from 0–51. Scores above 24 indicate severe depression, those from 17–23 indicate moderate depression, those from 8–16 indicate mild depression, and those from 0–7 indicate non-significant depression or an absence of depression. The HDRS takes approximately 30 minutes to conduct a clinical interview in order to obtain adequate information and approximately 10 minutes to complete the form. The HDRS has high inter-rater reliability and internal consistency and correlates highly with self-report measures of depressive symptoms (Nezu et al.; 2002).

Scale for Suicidal Ideation. The Scale for Suicidal Ideation (SSI; Beck, Kovacs, & Weissman, 1979) is a 19-item measure designed to quantify the intensity of current conscious suicide ideation in various dimensions of self-destructive thoughts or wishes: the extent of the wish to die, the desire to make an actual suicide attempt, and details of any plans; also internal deterrents to an active attempt, and subjective feelings of control and/or intent regarding a proposed attempt. Each of the 19 items consists of three alternative statements graded in intensity from 0 to 2, with the maximum total score being 38. The SSI has been found to have moderately high internal consistency and good concurrent and discriminant validity for psychiatric outpatients (Beck, Brown, & Steer, 1997). It takes approximately 5–15 to complete the scale. Weekly assessments using the SSI indicated that none of the participants in the study were experiencing suicidal ideation.

Procedure

The study began with an initial diagnostic interview which included a semi-structured interview using the Anxiety Disorders Interview Schedule for DSM-IV (ADIS-IV; Brown, Di Nardo, & Barlow, 1994) for determining psychiatric diagnoses. All assessments were administered by an upper level graduate student experienced in structured assessment. If the interviewee was diagnosed with Major Depressive Disorder and agreed to participate in the study, the HRSD was administered to determine the severity of the patient's depression. The patient was also instructed to complete a battery of online questionnaires before beginning treatment. The battery included the Automatic Thoughts Questionnaire-Revised (ATQ-R; Kendall, Howard, & Hays, 1989), the

Cognitive Bias Questionnaire (CBQ; Krantz & Hammen, 1979), the Depression Anxiety Stress Scales (DASS; Lovibond & Lovibond, 1995), and an Expectancy Questionnaire.

Treatment began with a half-hour training session that included the following components: (1) an explanation of the rationale behind using cognitive restructuring in the treatment of depression, (2) a definition of "cognition" and the influence of cognition on affect and behavior, (3) an introduction to automatic thoughts and their role in depression (4) an explanation of dysfunctional thoughts and a review of the various types of dysfunctional thoughts associated with depression, (5) an explanation the procedural steps involved in cognitive restructuring, (6) practice of the technique with an automatic thought generated by the patient during the training, and (7) installation of and practice with the application on the patient's device. Patients were told that the treatment protocol was designed to be self-directed and that they would not receive additional instruction on the cognitive restructuring technique or on using the application. The only questions that would be answered by the research team would be those related to technical difficulties with the application or device, if the patient was using a device provided by the research team.

At the completion of the training session, patients were instructed to use the application on a daily basis. During the first week of the study, patients were instructed to only complete the *Daily Mood Assessment* three times a day (morning, afternoon, and evening) and not to use the *Feelings and Thoughts Log* or the *Challenge Automatic Thoughts* module, thus establishing the first week as a baseline week. After the baseline week, the treatment phase began. During the treatment phase, patients were instructed to use the *Feelings and Thoughts Log* or the *Challenge Automatic Thoughts* module to

practice cognitive restructuring as often as possible. The patients were also instructed to continue completing the *Daily Mood Assessment* at least once a day.

At the end of the fourth week in the treatment phase, patients were given a second diagnostic interview. The second interview included an assessment with the ADIS-IV and the HDRS. At the time of the second interview, patients were instructed to complete another online battery of questionnaires that included all of the same questionnaires from the first assessment interview except the Expectancy Questionnaire. Patients were given the opportunity to conclude their participation in the study at that time or to continue in the treatment phase for another eight weeks. For those patients who decided to end their participation, a follow-up interview was conducted thirty days after the second interview. Patients who decided to remain in the study were instructed to continue using the application to practice cognitive restructuring and to complete the *Daily Mood Assessment* at least once a day. At the end of the additional eight weeks, patients were brought in for a third assessment interview similar to the second one. A follow-up interview was conducted thirty days after the third interview.

Throughout the length of the study, patients were contacted by telephone on a weekly basis. The weekly telephone calls, which took 5 minutes to complete, consisted of a suicide assessment using the Scale for Suicidal Ideation (SSI; Beck, Kovacs, & Weissman, 1979) and a check to see if patients had accessed any psychiatric services over the course of the week. Patients were also asked if they had used the application over the course of the week and if they were experiencing any technical problems with the application. Finally, patients were instructed to complete an online version of the DASS each week. Additional contact was provided by email, which included a hypertext

link to the DASS and a reminder to continue completing the *Daily Mood Assessment* every day.

Results

Credibility and Expectancy

Both Patient 2 and Patient 3 completed the CEQ after the training session at the pretreatment assessment. The first three questions of the CEQ are used to assess an individual's credibility in a treatment while the later three questions are used to assess an individual's expectations about the treatments potential effectiveness. Overall, it may be best to describe Patient 2's credibility in the treatment as moderate. For the question about the logic of the treatment, Patient 2 gave a rating of 8 (where 9 was the highest rating possible). However, he only gave a rating of 5 for the questions about how successfully he thought the treatment would be for him and how confident he was that he would recommend the treatment to a depressed friend. His expectancy about the success of the treatment would be described as low. Cognitively, he indicated that he expected to see a 40% improvement in his depression. Affectively, however, he indicted that he expected to see only a 20% improvement. In response to the question about how much he felt the treatment would really help to reduce his depression, he gave a rating of 3.

Patient 3, on the other hand, reported higher levels of credibility and expectancy on the CEQ. His ratings on the credibility questions were all high. He gave a rating of 9 to the logic of the treatment, and gave ratings of 8 to how successful he thought the treatment would be and to his confidence that he would recommend the treatment to a depressed friend. His ratings for expectancy overall were not as high as they were for

credibility. He did give a rating of 80% to the cognitively based question about how much improvement he expected to see by the end of treatment. On the more affectively based question about likely improvement, he only gave a rating of 60%. On the final question about how much he really felt the treatment would help reduce his depression, he gave a rating of 6. See **Table 3** for a summary of the responses to the CEQ for each patient.

Table 3: Responses to the CEQ by Patient 2 and Patient 3

CEQ Question	Patient 2	Patient 3
1. At this point, how logical does the treatment offered to you seem?	8	9
2. At this point, how successfully do you think this treatment will reduce your depression?	5	8
3. How confident would you be in recommending this treatment to a friend who experiences depression?	5	8
4. By the end of the treatment period, how much improvement in your depression do you think will occur?	40%	80%
5. At this point, how much do you really feel that this treatment will help you to reduce your depression?	3	6
6. By the end of the treatment period, how much improvement in your depression do you really feel will occur?	20%	60%

Hamilton Depression Rating Scale Analyses

As mentioned above, changes in HDRS scores between the pre-treatment assessment and the week 5 assessment were used to indicate a response to treatment. Both Patient 1 and Patient 2 each had pretreatment HDRS scores of 20 indicating moderate depression, while Patient 3 had a pretreatment score of 14 indicating mild depression (see **Figure 1** on page 28). At week 5, Patient 1 had an HDRS score of 2 and Patient 2 had an HDRS score of 7. Both scores fall into the range indicating non-

significant depression or an absence of depression. Patient 3's score on the HDRS did not change from pretreatment to week 5.

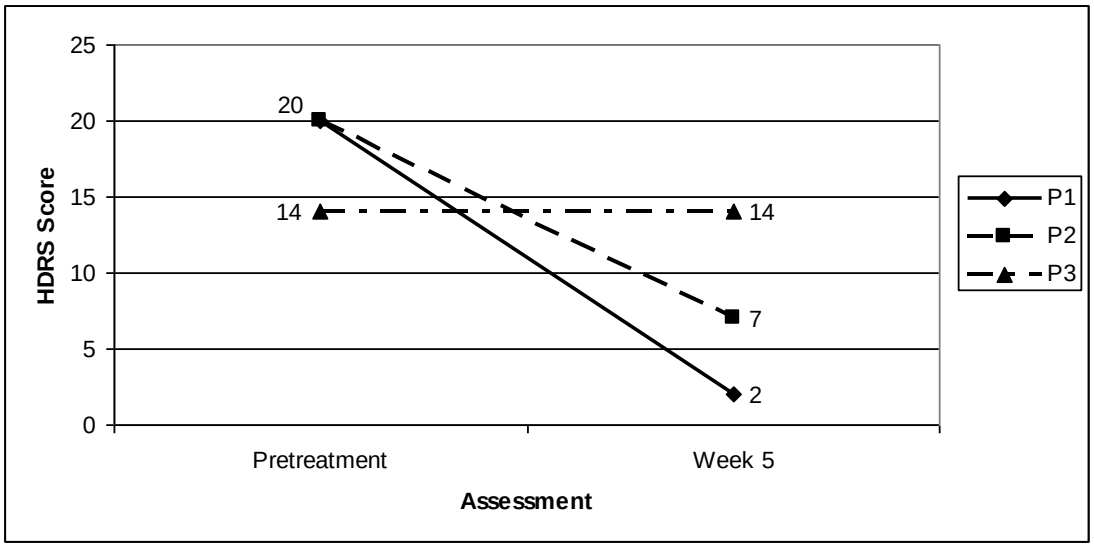

Figure 1: Hamilton Depression Rating Scale scores from pretreatment through week 5

There are two criteria for investigating clinical significance as proposed by Jacobson and Truax (1991). Clinical significance requires the achievement of statistically reliable change, as well as a meaningful reduction in symptoms so that the patient moves from a theoretical dysfunctional population into a functional or normal population. In order to meet the first criterion, reliability is determined by calculating a reliable change index (RCI). An RCI greater than 1.96 indicates that a change from pre-treatment to post-treatment reflect real change and is not attributable to random fluctuations in scores due to the imprecision of the measuring instrument. To meet this criterion on the HDRS, the change in score must be greater than 6 points (Ogles, Lambert, & Sawyer, 1995). A decrease of 18 over the course of treatment for Patient 1 and a decrease of 13 for Patient 2 indicate that the changes in the two patients can be

assumed to be indicative of real change rather than merely random fluctuations in the scores.

For the second criteria to be met, each individual patient's score at pre-treatment must be more than two standard deviations above the mean for a general or functional population. By the end of treatment, the individual means must move to within two standard deviations of the population mean. Ogles, Lambert, and Sawyer (1995) established the cutoff point for being within two standard deviations of the general population mean as 14.75 on the HDRS. Both Patient 1 and Patient 2 had a pretreatment HDRS scores above the cutoff (20). The week 5 HDRS scores of 2 and 7 for Patient 1 and Patient 2, respectively, were well below the cutoff. Therefore, the second criterion was met indicating that both patients moved from a dysfunctional condition to a functional condition.

Depression Anxiety Stress Scale Analyses

Patients were required to complete the DASS at the time of each assessment interview and on a weekly basis. Compliance with completing the DASS was inconsistent among the patients. Analyses are based on the data available for each patient.

DASS data was available for Patient 1 for pretreatment, week 4, and week 5. The data from the DASS was consistent with the findings from the HDRS in that the patient's reporting of her subjective experience of depression went from a dysfunctional status to a functional status. Her depression score at pretreatment was 41, was 29 at week4, and was 4 at Week 5. According to the DASS, a score of 41 put the patient in the "extremely

severe" range, by week 5 her score of 4 put her in the "normal" range (see **Figure 2**). A similar pattern of decline can be seen in the patient's anxiety and stress scores. She received an anxiety score of 28 at pretreatment and a score of 4 at week 5. For stress, she received a score of 37 at pretreatment and a score of 6 at week 5. For both anxiety and stress, the patient fell in the normal range.

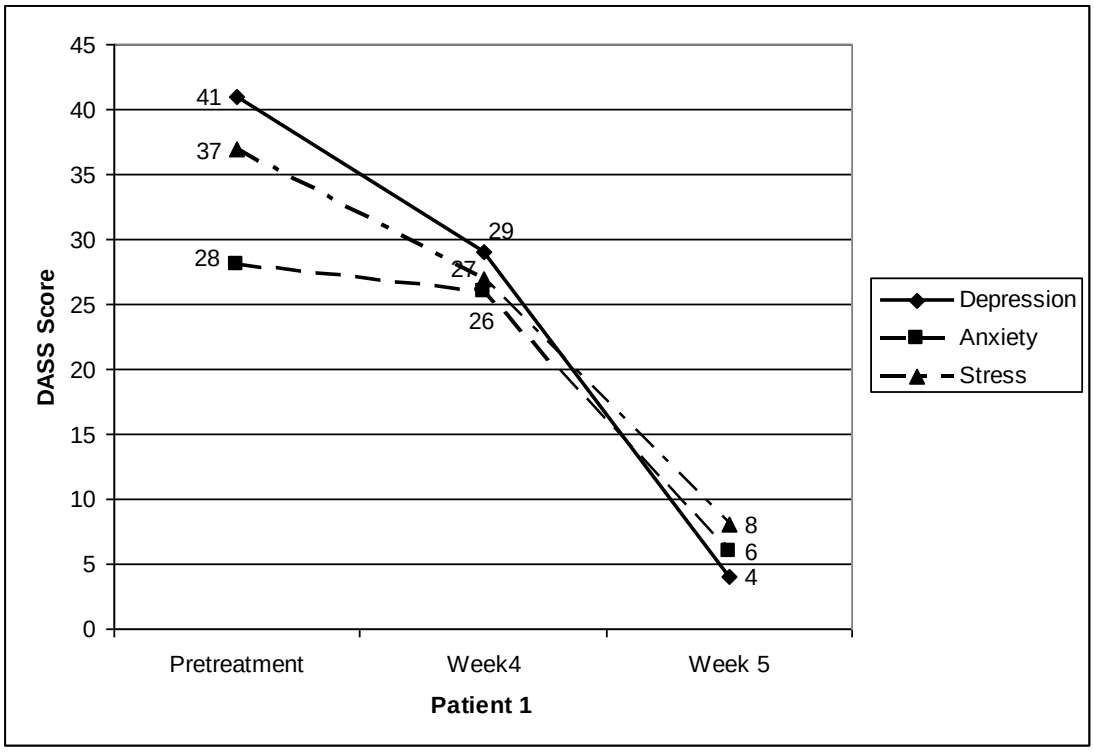

Figure 2: Depression Anxiety Stress Scale scores for Patient 1

DASS data was available for Patient 2 from pretreatment to week 5, with only data from week 4 missing. The patient's depression scale score at week 5 was not consistent with the findings of the HDRS. The report of his subjective experience of depression produced a score of 35 at pretreatment, putting the patient in the "extremely severe" range. At week 5, the patient remained in the "extremely severe" range with a score of 32 (see **Figure 3**). The patient saw a decline in his subjective experience of anxiety over the course of the five weeks. He received an anxiety scale score of 10

("moderate") at pretreatment and a score of 4 ("normal") at week 5. On the stress scale, the patient received the same score of 6 at pretreatment and at week 5. There was a rise and subsequent fall in his subject experience of stress that peeked at 14 at week 2. According to the DASS, the patient fell in the normal range on the stress scale even at its peek of 14.

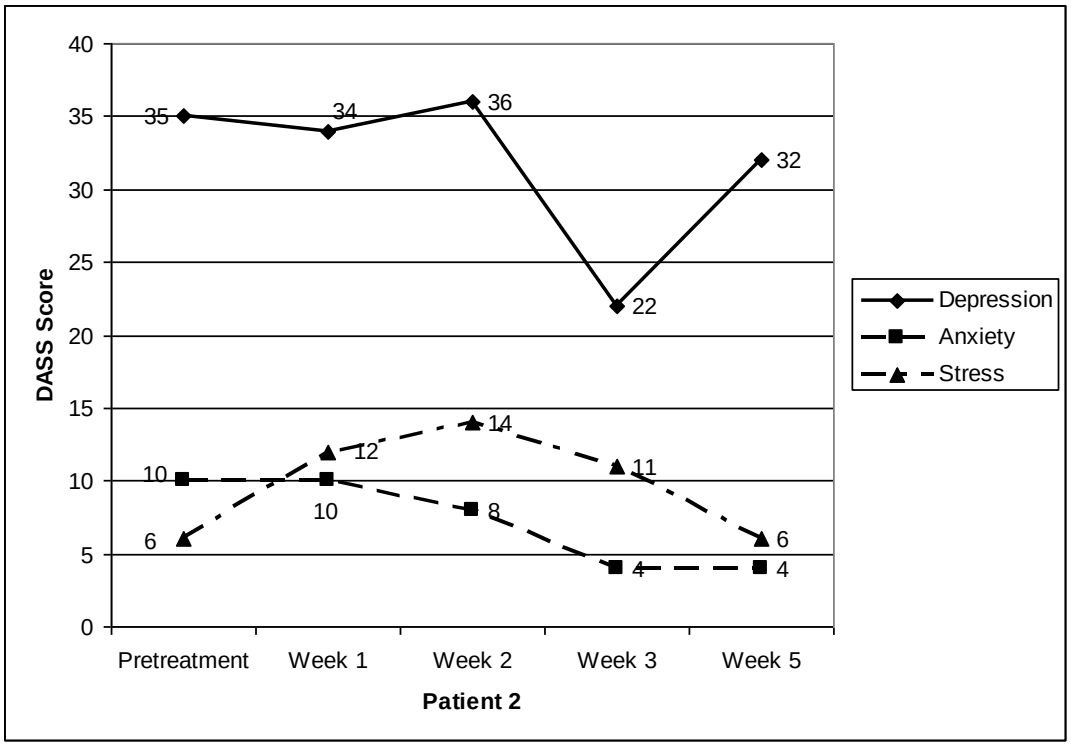

Figure 3: Depression Anxiety Stress Scale scores for Patient 2

DASS data was available for Patient 3 from pretreatment to week 3. The patient did not complete his week 4 DASS. The patient did attend his week 5 assessment interview, but did not complete the online measures, which included the DASS, at this time point. Repeated attempts to contact the patient were unsuccessful so it is not clear why he discontinued his participation. A likely hypothesis is that once he realized he would not be receiving additional research credit in order to fulfill a course requirement, he no longer wished to participate in the study.

At pretreatment, Patient 3's depression scale score was 25 ("severe"), which fell to 16 ("moderate") at week 1, then rose to 20 ("severe") at week 2, and fell again to 15 ("moderate") at week 3 (see **Figure 4**). The patient's anxiety scale scores declined over the 3 weeks from 15 ("severe") at pretreatment to 2 ("normal") at week 3. His scores on the stress scale were low, remaining in the "normal" range throughout the three weeks.

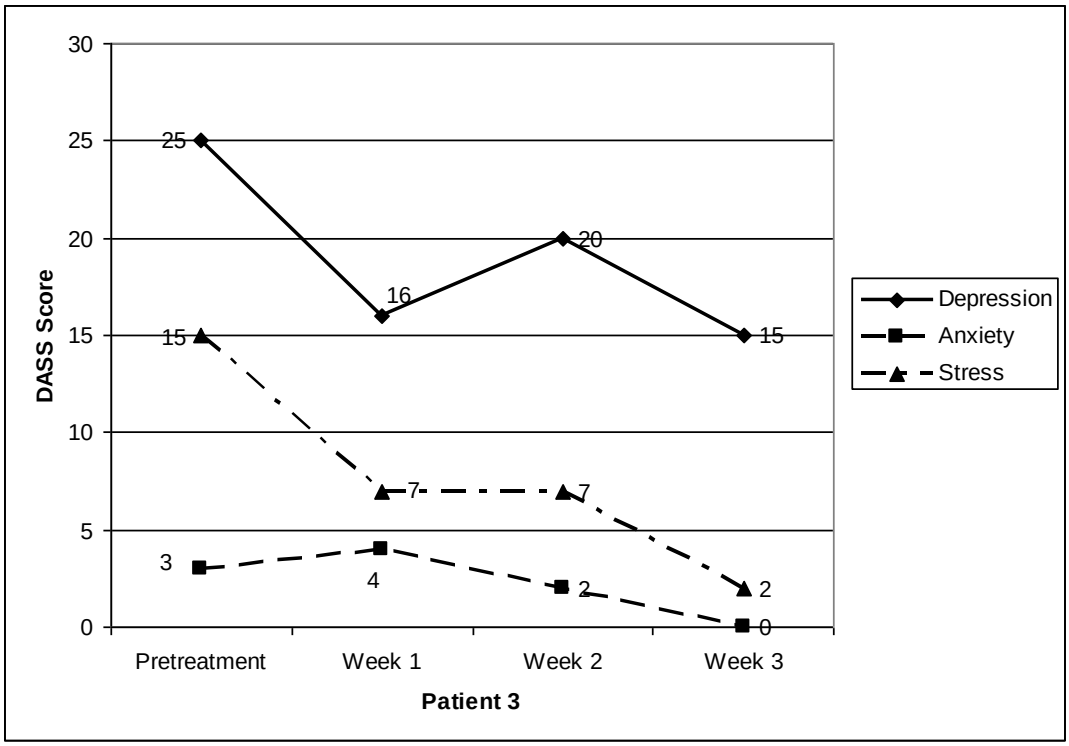

Figure 4: Depression Anxiety Stress Scale scores for Patient 3

Automatic Thoughts Questionnaire Analyses

Since Patient 3 did not complete his week 5 self-report measures, data from the ATQ-R was only available for Patient 1 and Patient 2 (see **Figure 5**). The SOM ratios for Patient 1 were .097 at pretreatment and .244 at week 5. These two ratios are very low compared to the .56 to .68 range that indicates healthy psychological adjustment as proposed by Schwartz and Garamoni (1989). The ratios indicate that the patient was

engaging in much more negative self-referent thinking than she was positive self-referent thinking even at week 5. However, the percent of change from pretreatment to week 5 was 152%, indicating that the patient was engaging in much more positive self-referent thinking at week 5 than she had been at pretreatment. The State of Mind (SOM) ratios for Patient 2 were .124 at pretreatment and .122 at week 5. These numbers are also very low, indicating a depressive state of mind with little change (in fact, a slight decrease) in the ratio of positive self-take to negative self-referent thinking the patient was experiencing over the course of the five weeks.

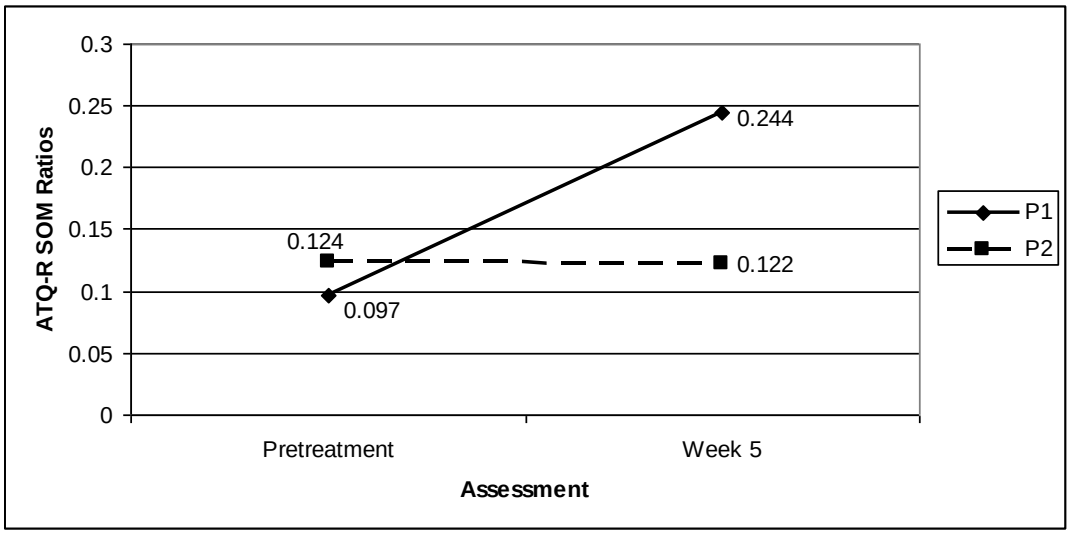

Figure 5: Automatic Thoughts Questionnaire SOM ratios at pretreatment and week 5

Cognitive Bias Questionnaire Analyses

Only Patient 2 successfully completed the CBQ at both time points so only his data can be considered (see Figure 6). As mentioned above, the current study focused on the depressed-distorted subscale, which has exhibited good reliability and validity (Krantz & Hammen, 1979; Miller & Norman, 1986; Miller, Norman, & Keitner, 1990; Norman, Miller, & Klee, 1983). Patient 1 received a score 8 on the depressed-distorted

subscale at pretreatment and a score of 9 at week 5. This indicates that the depressed-distorted cognitive bias increased for the patient over the course of the five weeks.

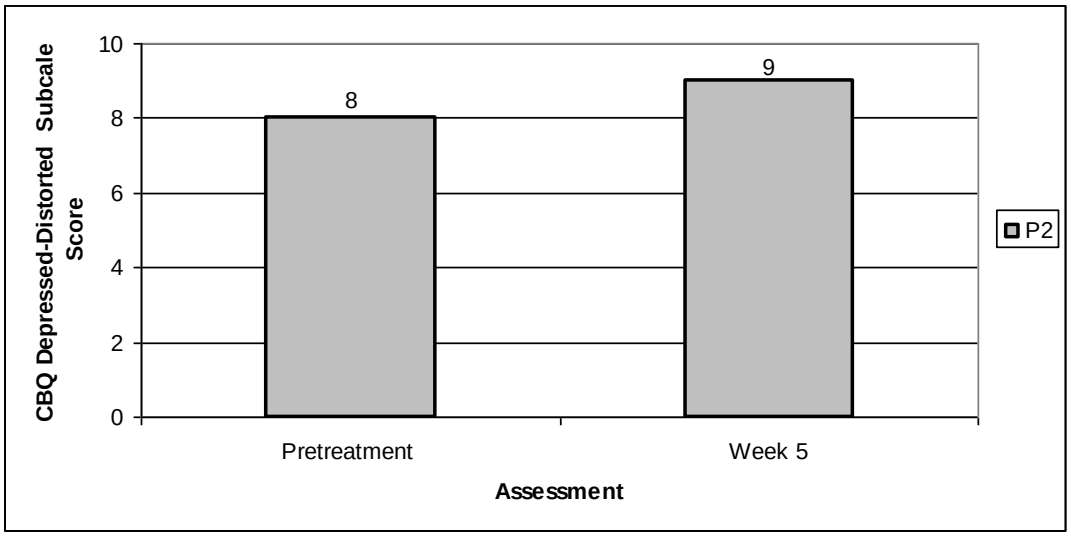

Figure 6: CBQ Depressed-Distorted Subscale Scores for Patient 2

Discussion

In conducting this study, we had two aims. First, we wanted to determine the feasibility of treating depression using a smartphone application. The treatment method implemented in the application was cognitive restructuring, an empirically support treatment method for treating depression (e.g. DeRubeis, Hollon, Amsterdam, Shelton, Young, & Salomon, et al., 2005; Kovacs, Rush, Beck, & Hollon, 1981). With access to the application on a daily basis, participants could engage in the treatment protocol whenever they chose. As such, our second aim of the study was to see if convenient access to the treatment via the smartphone would lead to diminished levels of depressive symptomatology.

Evidence for the Efficacy of a Smartphone-based Self-Guided Treatment for Depression

The results of the present study demonstrate that it is possible for a person with moderate depression to experience reductions in his or her symptoms using a smartphone application for treating depression. Pretreatment and week 5 HDRS scores showed a clinically significant treatment effect for two of the participants, according to the criteria established by Jacobson and Truax (1991). The HDRS scores of the third patient indicated no treatment effect at all. Whereas it was decided that change on the HDRS would be used to determine clinically significant treatment response, looking at the full data complicates the picture of treatment effect.

On weekly ratings of DASS scores, Patient 1 reported a decrease in her weekly depression, anxiety, and stress. These reports of a decline in her subjective experience of distress were in line with the reduction in her HDRS scores from pretreatment to week 5. These consistent declines in scores on both measures lend credibility to the assertion that she experienced clinically significant change. Additionally, when looking at the SOM ratios from the ATQ-R, we see some change in Patient 1's thinking style. Though her SOM ratio remained in depressed range, indicating much more negative thinking than positive thinking overall, the ratio positive thinking to negative thinking increased by a large amount from pretreatment. This increase indicates that Patient 1 was engaging in more positive self-referent thinking relative to negative self-referent thinking by week 5. Increasing positive, more realistic thinking is a goal of cognitive restructuring. That we see an increase in Patient 2's positive self-referent thinking as measured by the ATQ-R provides support for the idea that the patient was engaging in the cognitive restructuring

technique and that it was having an impact not only on her mood but also on her thinking style.

For Patient 2, however, the pattern of his DASS scores were not in line with his HDRS scores. His reports of his weekly experience of depression symptoms remained consistently in the severe range for the weeks in which data was available. Only in week 2 was there a notable decrease in the score of the depression scale to the moderate range. By week 5, the score was back in the severe range. When we look at Patient 2's SOM ratios from the ATQ-R, we do not see any meaningful change in the ratios from pretreatment to week 5. At most, a slight decrease in the score indicated less positive self-referent thinking relative to negative self-referent thinking. In looking at the data from the CBQ for Patient 2, we see that there was a slight increase in his score on the depressed-distorted dimension, indicating that his cognitive bias became more depressed and distorted from pretreatment to week 5.

How do we make sense of this seeming contraction between the HDRS and the DASS? When we look at the Patient 2's scoring on the HDRS, he indicates depressed mood and loss of interest associated with depression, but we see little or no indications of anxiety symptoms or other psychosomatic symptoms that are associated with both depression and anxiety. This corresponds with a low score in the normal range on the anxiety subscale of the DASS, indicating that the patient was not experience much anxiety, either affectively or physically. The fact that the patient's score on the DASS stress subscale, which asks about physiological arousal, irritability, and impatience, was in the normal range supports the observations from the HDRS and the DASS anxiety scale that he was not experiencing elevated levels of psychosomatic symptoms. What the

DASS measures more fully than the HDRS is the negative affective and cognitive symptoms of depression including dysphoria, hopelessness, lack of interest, devaluation of life, and self-deprecation (Lovibond & Lovibond, 1995). Given that the patient's SOM score on the ATQ-R indicated a positive-to-negative self-referent thinking style indicating depression and that the CBQ showed an increase in negative distortion of cognitive bias, it makes sense that the DASS depression score measuring negative affect would be elevated, and seemingly inconsistent with his HDRS score. Therefore, despite the decline in his HDRS scores from pretreatment to week 5, given the data from the other measures, we cannot make an unqualified assertion that Patient 2 experienced a clinically significant treatment effect in his symptoms of depression. It appears that this patient may have only benefitted in terms of his anxiety.

Given the lack of data available for Patient 3, we cannot say much about the outcomes of his participation in the study other than that his HDRS scores indicated that he did not experience any treatment outcome.

Participant Reaction to the Treatment Application

Reaction to the treatment application was positive overall. All three participants expressed satisfaction with the application. They found that it was easy learning how to use the application initially and found it was easy to use as they went through the task of challenging their negative thinking. All the participants found it comfortable using the application, commenting that it was quick and efficient. None of the participants provided any recommendations for improvements to the application when queried.

Patient 1 was most expressive in her satisfaction with the application itself and with the treatment protocol. She reported that challenging her negative thinking and finding more positive ways to think about the situations and experiences in her life had a significant impact. The patient stated that she used the application fairly frequently at the start of the treatment period but less often as time went on. Though she reported sporadic use of the application, she did say that she engaged in the cognitive restructuring technique more frequently on her own. She remarked that she noticed that she was thinking more positively in general, whether she was actually engaging in cognitive restructuring or not. She also remarked that she was more aware when she was engaging in negative thinking and would challenge herself to think more positively, even if she did not actually use the application to help her do it. When she did remember to use the application, she found that the instructive text helped her engage in the process more fully. Patient 1 did not complete the CEQ at the beginning of the study so we do not know how credible she found the treatment when it was initially explained to her or to what degree she expected it to be helpful. Of all the participants, she improved the most by week 5, as discussed above.

Patient 2 reported being satisfied with the application as well. He was not as satisfied with the treatment protocol, that is to say the cognitive restructuring technique. He did not find the technique helped him change his negative thinking style. He had tried using the application to challenge his negative thinking but became discouraged when he found that he did not feel much better after engaging in the task. As a result he began to use the application less and less. It is not clear how long he actually continued to use the application to help him challenge his negative thinking, though he did report completing

the *Daily Mood Assessment* nearly every day[3]. Given Patient 2's low expectancy ratings on the CEQ, it is not surprising that he did not continue to engage in the process after his initial attempts to engage in the process were not immediately successful and, hence, rewarding.

Patient 3 also reported being satisfied with the application. He was not as negative about the cognitive restructuring technique as was Patient 3, but he also reported that the technique had not produced the outcomes he had expected. It is not clear how frequently he used the application to help him practice the technique, but he also reported completing the *Daily Mood Assessment* nearly every day. Though Patient 3 gave higher expectancy ratings on the CEQ than did Patient 2, it may be that he also gave up on the process when his initial attempts at the technique were not successful.

Limitations and Recommendations for Future Studies

One key limitation of the current study was the difficulty experienced with the smartphone application. Many problems arose with the application including challenges installing the application on the participants' devices, instability of the application performance (i.e. ending suddenly while the user was in the middle of completing a module), and the strict controls over its devices and applications written for its devices by the manufacturer. The most significant limitation of the application was the loss of data occasioned by the expiration of a profile required by the device manufacturer as part of their approach to tightly control developer access to their device application platform. Daily Mood Assessment data and data from the two cognitive restructuring modules (the

[3] We can only mention what he self-reported about completing the Daily Mood Assessment because the data was lost due to technical issues.

Feelings and Thoughts Log and *Challenging Automatic Thoughts* module) were lost because of the expiration issue, making it impossible to assess daily usage of the intervention and daily fluctuations in participant mood. Future research is likely to be more successful with the use of devices and platforms that provide open access to software and hardware protocols.

More broadly, although promising, EMA and EMI are not yet standard clinical assessment and intervention tools for mood disorders and mood dysregulation (Ebner-Priemer, & Trull, 2009). There are no standard protocols available for use in research designs. Researchers must create their own electronic diary (e-dairy) questionnaires or their own electronic interventions. A first step for moving research further in this field will be the creation of standardized protocols that can be used to support the potential of smartphone technology to provide more ecologically valid assessment and intervention.

Based on the positive reactions of the participants to the smartphone application, it seems likely that people in this technology savvy society would be open to such treatment options. Dissatisfaction arose over the cognitive restructuring technique itself. One of the challenges of self-guided treatment is how to keep the individual engaged in the process even when it is difficult or their initial attempts are not successful. With traditional, psychotherapist delivered treatment the patient has someone to help them through those initial disappointing stages of learning a new coping technique. People who attempt to learn these new techniques on their own have no one to help them through their initial failed attempts. The application used in the current study did not include usability aids such as alarms to prompt the individual to use the application or messages tailored specifically to the individual to provide a more personalized experience. For

software applications to be successful for self-guided treatment, they will need to be designed to be virtual therapists with greater interactivity and providing more individualized treatment.

The most significant limitation of the current study is the low number of participants, which compromises external validity. Therefore, the preliminary data obtained should be replicated in other studies with larger samples. A first step would be to conduct an open trial design study with a larger number of participants. Further studies should involve randomized control designs including control groups or groups receiving treatment-as-usual in order to draw firmer conclusions about the efficacy of using smartphones in psychotherapy. Nevertheless, this is the first study of its kind that uses an application on a smartphone to provide an intervention for the treatment of depression. There has been a proliferation of applications that claim or imply that they are able to achieve results comparable to psychotherapy but there have been no studies confirming these claims. The field of clinical psychology is likely to see a rapid increase in the use of technology in both assessment and treatment. Smartphone devices will fill a vital niche in this area. It is necessary that there be more research using this technology not only in the area of mood disorders but also in all other areas in the field.

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