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Original Paper

Awareness, Access and Use of Internet Self-Help Websites for Depression by University Students

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Abstract

Background: University students have a higher prevalence rate of depression than the average 18 to 24 year old. Internet self-help has been demonstrated to be effective in decreasing self-rated measures of depression in this population, so it is important to explore the awareness, access and use of such self-help resources in this population.

Objective: The objective of this study is to explore university students' awareness, access and use of Internet self-help websites for depression and related problems.

Methods: A total of 2691 university students were surveyed at 3 time points.

Results: When asked about browsing behavior, 69.6% (1494/2146) of students reported using the Internet for entertainment. Most students were not familiar with self-help websites for emotional health, although this awareness increased as they completed further assessments. Most students considered user-friendliness, content and interactivity as very important in the design of a self-help website. After being exposed to a self-help website, more students reported visiting websites for emotional health than those who had not been exposed.

Conclusions: More students reported visiting self-help websites after becoming aware of such resources. Increased awareness of depression and related treatment resources may increase use of such resources. It is important to increase public awareness with the aim of increasing access to targeted strategies for young people.

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KEYWORDS

depression; awareness; Internet; self-help; university; students; eHealth; health promotion; prevention

Introduction

The purpose of this study is to explore university students' awareness, access and use of Internet self-help websites for depression and related problems in a sample of university students in the 18 to 24 year age group. This age group has a high prevalence of depression and university students have been found to have an even higher prevalence rate than the average 18 to 24 year old (20% compared with 10%, respectively) [1]. Furthermore, it has been shown that Internet self-help is effective in decreasing self-rated measures of depression in this population, so it is highly relevant to explore the awareness, access and use of such self-help resources in this population.

Awareness in the General Population

In exploring awareness of depression in the general population it was found that there are a growing number of public health campaigns that aim to increase awareness of depression and related issues (eg, beyondblue). Beyondblue is a National Depression Initiative in Australia that has a large advertising campaign on television, buses, letter box drops etc [2]; such health promotion strategies are common in similar campaigns worldwide [3]. The United States has a National Depression

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Screening Day which is part of the National Mental Illness Awareness Week that occurs each October [4]. In 1993 the National Public Education Campaign on Clinical Depression was launched and is sponsored by the Mental Health Association and over 100 professional and advocacy groups [5]. The American Medical Association is also working with the National Institute of Mental Health to increase awareness [6].

It has been reported that these campaigns enhance public education and awareness and improve professional recognition and management of depression [7]. Studies have shown that with regards to treatment, people who had sought help were less likely to find family and social support helpful and more likely to believe in medical interventions such as antidepressants. These postal survey participants rated holidays, massages and recreational activities as helpful [8]. This was similar to previous findings that showed prior treatment, higher education and greater episode length predicted treatment-seeking behavior, whereas non-treatment-seekers felt they could handle it themselves and either did not recognize or see depression as serious [9]. Professional treatment was often perceived as helpful, but rarely used [10]. Most people with symptoms of depression and anxiety access "simple self-help interventions". It is therefore important to explore awareness, access and use of such self-help interventions.

Awareness in the University Student Population

A Swiss study explored awareness of mental disorders in university students and found a wide variability in mental health literacy. For depression, however, they found that most students recognized the symptoms [11] and concluded that special attention should be paid towards the effects of gender and stereotypes on mental illness.

Health Information on the Internet

A National Survey in the United States has found that 80% of Internet users look for health information online, and that 21% look for depression, anxiety, stress or mental health information [12]. From the information they obtain on the Internet, 47% of consumers say that their findings influenced their decisions about treatment and care, prepared them to ask more questions or get a second opinion and influenced their decisions about whether or not to visit a doctor [13].

Web-based treatments and education about depression and anxiety have been cited as having the advantage of facilitating broader access for both sufferers who do not seek external help and for consumers who have access to Web-based guidelines [14].

People Do Not Seek Help

It was found that only 20.1% of 18 to 54 year olds with emotional disorders received treatment between 2001 and 2003 [15]. The National Finnish Health Care Survey revealed that of people suffering from a major depressive episode over the last 12 months, only 31% of men and 25% of women used any type of health care services, with people more likely to use services if they have suffered longer, had symptoms of greater severity and perceived disability [16].

University Students Do Not Seek Help

A study on the health service utilization of 2785 university students at a large public university in 2005 found that for these students, who have a similar profile to the national student population in the United States (ie. in a university environment "with free access to short-term psychotherapy and basic health services"), between 37% and 84% of students with apparent mental disorders did not receive treatment [17]. This highlights the need for new models of service delivery to be targeted at this population. The findings of this study are particularly relevant in the current context as university students in Australia have access to free basic health care services and most campuses have free and convenient counseling services. A study from Norway showed that students reported a need for help, but only one-third sought help from traditional methods [18]. This further highlights the need for new pathways to care. This is an interesting finding given that 25% to 35% of health professional students reported alarming symptoms of depression [19].

People Take Too Long to Get Help

Delays in seeking professional treatment are common, especially in those with short symptom duration and only a minority of people with disorders receive any treatment. Due to the high prevalence of depressive disorder, chronicity, early age of onset and resulting serious impairment, the World Health Organization advocates a need for early outreach and intervention programs, as well as quality assurance programs to investigate the problem of inadequate treatment [20].

The US National Comorbidity survey showed that over 80% of 15 to 54 year olds with a lifetime prevalence of Diagnostic and Statistical Manual of Mental Disorders-III-Revised (DSM-III-R) disorder eventually contact a health professional, but that it may take them more than 10 years, on average, to do so [21]. Most of these young people are unlikely to get professional help. Treatment contact delay was found to be between 6 and 14 years across a range of psychiatric disorders [22]. It was also found that only one-third of subjects with a current disorder reported contacting psychiatric services and only 16% continued this contact [23].

The Canadian National Mental Health Survey with 36,984 respondents found that only 32% of people with symptoms of mental disorder or substance dependencies saw or spoke to a health professional in the previous 12 months. They also found that teens and young adults (15 to 24 years) are least likely to use mental health services, despite a higher prevalence of mental health problems, with one survey finding that only 32% of those had talked to a health care professional in the previous 12-month period [24]. A survey of Australian youth found that they are similarly unlikely to seek professional help [25].

Improving Screening and Treatment

One of the strategies for overcoming barriers to seeking help for depression and anxiety is to improve screening and treatment [14]. Internet-based self-help programs delivering Cognitive Behavioral Therapy (CBT) to the individual and self-awareness may prove to be a way of overcoming this barrier as it serves to provide an accurate screening tool, as well as educating the user about depression and related disorders.

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Internet Self-Help

The availability of these services is one part of the spectrum of mental health service delivery. Initiatives to improve Internet service efficacy includes access and use of services. Assessing the current awareness, access, and use of such resources in order to inform health promotion strategies is the first step in this process.

Aim

The aim of this prospective study is to investigate awareness, access and use of Internet self-help in the university student population.

Methods

Awareness, Access and Use of Internet Self-Help in University Aged Students

Ethics approval from the University of Sydney and the University of Technology, Sydney (UTS) was granted in order to conduct the Awareness, Access and Use Prospective study. Deans of the UTS Faculties of Information Technology, Education, Law, Nursing and Science were supportive. From the University of Sydney, the Deans approached were from the Faculties of Science and Health Sciences; both were also supportive. Students from the Faculty of Science (at both universities) and from the Faculty of Health Sciences (University of Sydney) had the highest response rates. A pilot study was conducted in order to test cost, response rate and the feasibility of administering the large-scale prospective study at 3 time points across each university semester. The study ran for 2 years (equivalent to 4 university student semesters).

Data Collection

To test the aims of the study, a questionnaire was administered at 3 time points over a 2-month period to assess student responses at baseline (T1) and any subsequent changes (T2 and T3). The questionnaire asked students about their Internet access, the amount of time they spent online and whether it is for work and/or study or leisure purposes. It then progressed to Internet self-help in general and then about how familiar they were with or whether they had accessed or used an Internet self-help website for emotional health. The Awareness, Access and Use Questionnaire also asked them what they would consider important in a website, credibility, as well as what they thought of free versus fee-based self-help websites. This was the first part of a two-part questionnaire. The first part consisted of questions related to the Awareness, Access and Use of Internet self-help (this study), the second part is the Center for Epidemiological Studies-Depression Questionnaire (CES-D or CESD), which was part of another larger CyberPsychiatry Study [26]. The findings of that study are reported elsewhere [26].

The two-part questionnaire was administered at 3 time points, one month apart, during the university semester. The study was therefore designed to be conducted near the beginning, the middle and the end of the semester, but avoided the exam period. Questionnaires were distributed as close as possible to weeks 2, 6 and 10 of the 12-week university semester.

Once baseline was complete (T1), the questionnaire was next distributed at T2. At T2 students who scored greater than or equal to 16 on the CESD were randomized into one of two groups. The intervention group consisted of students being randomized to the self-help website, which in this study was Moodgym [27]. The control group students were randomized to an information package, which was a psychoeducational pamphlet accessed through the Internet via a hyperlink [28]. Those results are reported elsewhere [26]. It is worth noting that completing the CESD questionnaire at the same time and being randomized to either group may have improved their awareness, access and use over the study period (T2 and T3).

Measures

The datasheet design was pilot tested in focus groups to gain student feedback to improve the questionnaire. Suggestions were incorporated and the final questionnaire was then used as the study instrument. Questions used to facilitate this focus group were adapted from Morgan and Kruger's Focus Group Kit and Frazer and Lawley's Questionnaire Design [29,30]. The final survey instrument is shown in Multimedia Appendix 1.

Statistical Analysis

Descriptive statistics were obtained using data collected and input into a Microsoft Access database, cleansed using Microsoft Excel and analyzed using SPSS statistical software.

Results

The number of participants in the prospective Awareness, Access and Use of Internet Self-Help study after exclusions was 2970. Of those, 90.61% (2691/2970) were 18 to 24 years of age, of whom 79.75% (2146/2691) completed the questionnaire at T1, where over half (57.88%, 1242/2146) were female. Most of the students surveyed (81.97%, 1759/2146) were from UTS, with the Faculties of Information Technology, Science and Health Sciences having the highest numbers of participants.

The majority of students (77.26%, 1658/2146) had Internet access 24 hours a day, 7 days per week. Large proportions of students spent many hours on the Internet for personal use (Figure 1).

When asked about browsing behavior, 70% (1494/2146) of students reported using the Internet for entertainment, whereas 12% (255/2146) used it for health and well-being. As more than one choice was enabled on the Awareness, Access and Use Questionnaire, browsing topics do not equate to 100% (Figure 2).

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Figure 1. Number of hours per week students spend online for personal use.

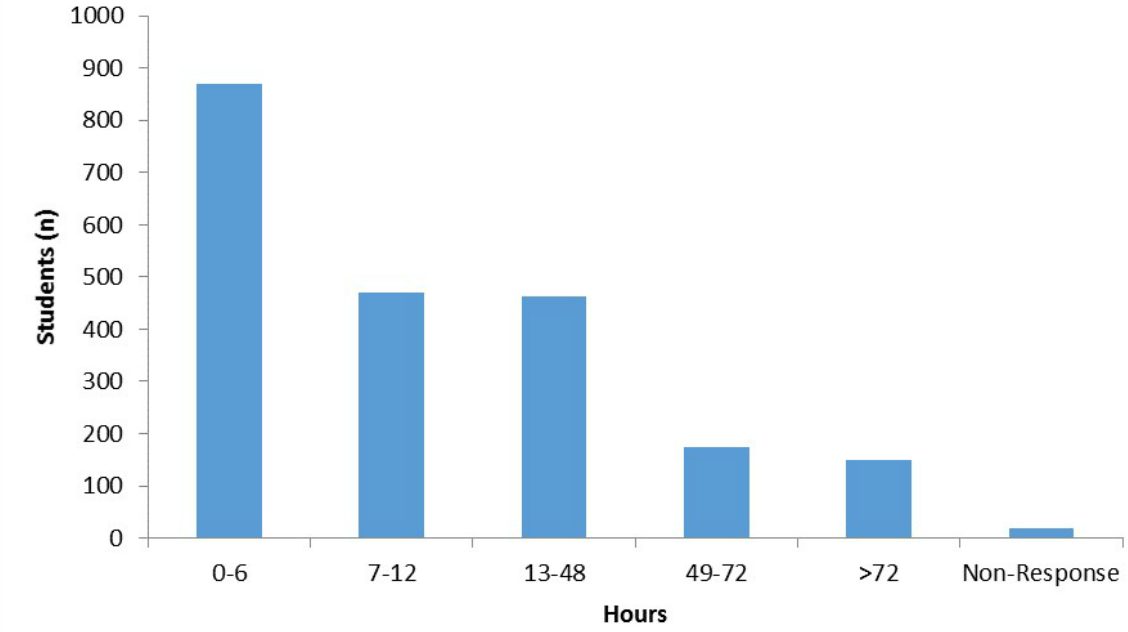
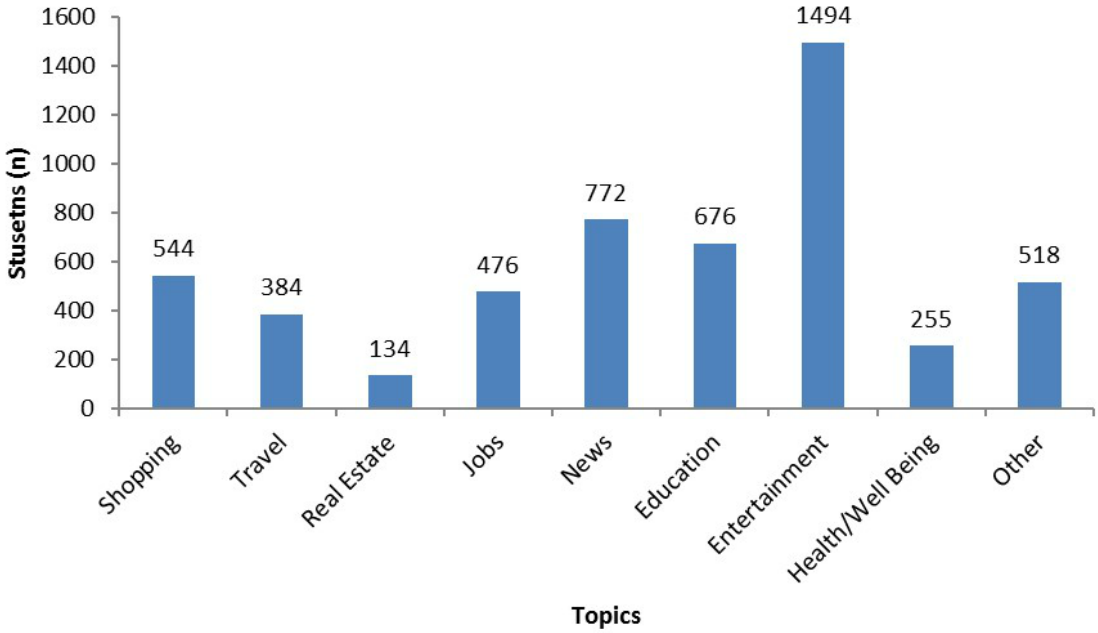


Figure 2. Topics browsed by students online.



When asked about their familiarity with self-help websites, 166 students named one, of which most (12.7%, 21/166) named beyondblue, 7 (4.2%, 7/166) named Kidshelpline, 3 (1.8%, 3/166) named MoodGym and 7 (4.2%, 7/166) named Reachout. In using health and well-being websites, 17 students (15.3%, 17/111) had browsed them before, 23 (20.7%, 23/111) had visited one for emotional health and 12 (10.8%, 12/111) had done so in the last 6 months. When asked whether they would pay to use a self-help website, 62.63% (1344/2146) of students said they would not use it unless it was for free. Detailed results are reported elsewhere [26]. It was found that 221 (10.30%, 221/2146) students had visited a self-help website for emotional health.

Website Qualities

Most responders always (21.48%, 461/2146), often (19.90%, 427/2146) and sometimes (14.40%, 309/2146) consider the credibility and professional authenticity (support or affiliation) of a self-help website, whilst only 3.03% (65/2146) said they never considered it. They rated self-help websites as very useful (7.18%, 154/2146) or of little use (16.31%, 350/2146), with 15 students (0.70%, 15/2146) rating them as harmful.

Most students consider user-friendliness, content and interactivity as very important in the design of a self-help website (Table 1). Therefore, websites need to contain good quality content, be user-friendly and interactive to be more likely to be accessed and used by students.

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Table 1. Self-help website characteristics of importance to students (N=2146).

Importance	Very, n (%)	Some, n (%)	Little, n (%)	None, n (%)	Not applicable, n (%)	Non-response, n (%)
Appearance	540 (25.2)	718 (33.5)	134 (6.2)	66 (3.1)	623 (29.0)	65 (3.0)
User-friendly	1127 (52.5)	265 (12.3)	35 (1.6)	46 (2.1)	609 (28.4)	64 (3.0)
Interactivity	839 (39.1)	480 (22.4)	86 (4.0)	42 (2.0)	628 (29.3)	71 (3.3)
Content	1183 (55.1)	207 (9.6)	34 (1.6)	41 (1.9)	610 (28.4)	71 (3.3)
Screening	542 (25.3)	639 (29.8)	212 (9.9)	50 (2.3)	635 (29.6)	68 (3.2)

Table 2. Internet self-help website use by CESD score at time point 2 (T2) followed through time.

	Time point 1, n (%)			Time point 2, n (%)			Time point 3, n (%)		
	CESD score <16	CESD score ≥16	Total	CESD score <16	CESD score ≥16	Total	CESD score <16	CESD score ≥16	Total
Browse health/ well-being	49 (6.6)	31 (4.2)	80 (10.8)	58 (7.8)	32 (4.3)	90 (12.1)	51 (6.9)	29 (3.9)	80 (10.8)
Visited for emotional health	36 (4.8)	33 (4.4)	69 (9.3)	38 (5.1)	41 (5.5)	79 (10.6)	43 (5.8)	58 (7.8)	101 (13.6)
Visited ≥1 in last 6 months	14 (1.9)	19 (2.6)	33 (4.4)	13 (1.7)	21 (2.8)	34 (4.6)	15 (2.0)	23 (3.1)	38 (5.1)

Use Over Time

Of the 2691 students (18-24 year olds) in the prospective study, 27.61% (743/2691) completed T1, T2 and T3. The Internet use questions and how they changed over time are shown in Table 2.

Discussion

Principal Findings

Overall, students indicated an awareness of and willingness to use Internet self-help. Increased activity in public health campaigns may have led to a heightened awareness of depression and related issues [31]. Previous studies have shown that a higher level of education predicted treatment-seeking behavior [9] and the results of this study may support those findings as university students have shown a willingness to access Internet self-help. This study took a selected population survey approach and did not address all 18 to 24 year old treatment-seeking behavior.

As 11.88% (255/2146) of students had accessed health and well-being specifically, this was an important finding as a previous study has shown that half (47%) of consumers said that health information on the Internet influenced their treatment decisions, prepared them to ask more questions and influenced their further help-seeking. This is important because Internet self-help may be a first step on the pathway to care for those who would otherwise not seek help or would take too long to do so. As a way of reaching out to young people and engaging them, Internet self-help for depression is in line with World Health Organization advice for early outreach and intervention programs.

Effective Internet-delivered CBT programs are not going to help people if they are not being used. The findings of this study show that as awareness through exposure increased, so did Internet access and use. It showed that approximately 1 in 10 students browse the Internet for health, well-being and emotional health and of those, half the students re-visit these websites regularly. As prevalence of depression is 20% in this population, it is promising that 10% of students are seeking health information on the Internet. Internet delivered CBT may therefore be an effective way of reaching out to those in need.

This study is not without its limitations. It would have been ideal to conduct the survey online as the topic is about online self-help; however, paper-based face-to-face surveys were chosen as they were expected to give a higher response rate. It is doubtful that an online survey would have obtained the same level of participation [26].

It is important for self-help Web surfers of low mood to be aware of the freely-available quality criteria in rating a website because the majority of students always (21.48%, 461/2146), often (19.90%, 427/2146) or sometimes (14.40%, 309/2146) consider the credibility of a self-help website, which is encouraging.

Conclusions

More students reported visiting self-help websites as their awareness of such resources increased. This is an indication that increased awareness of depression and related resources seems to increase use of such resources. It is important to increase public awareness so that targeted strategies, including those for young people will be more widely utilized. As this study shows that a proportion of students are aware of Internet self-help and that many students do access these resources or access them regularly, these early findings may be used as a basis for further research on help-seeking behavior.

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Authors' Contributions

GC designed and conducted the study, performed the statistical analysis and wrote the manuscript. NK and CT contributed to the design, interpretation of findings and writing of this manuscript.

Conflicts of Interest

None declared.

Multimedia Appendix 1

Internet Self-Help Awareness, Access and Use Questionnaire.

[PDF File (Adobe PDF File), 132KB - mental_v3i4e48_app1.pdf]

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Abbreviations

CBT: Cognitive Behavioral Therapy
CESD: Center for Epidemiological Studies -Depression
UTS: University of Technology, Sydney

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Original Paper

Ecological Momentary Assessment of Adolescent Problems, Coping Efficacy, and Mood States Using a Mobile Phone App: An Exploratory Study

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Abstract

Background: Mobile technologies have the potential to be used as innovative tools for conducting research on the mental health and well-being of young people. In particular, they have utility for carrying out ecological momentary assessment (EMA) research by capturing data from participants in real time as they go about their daily lives.

Objective: The aim of this study was to explore the utility of a mobile phone app as a means of collecting EMA data pertaining to mood, problems, and coping efficacy in a school-based sample of Irish young people.

Methods: The study included a total of 208 participants who were aged 15-18 years, 64% female (113/208), recruited from second-level schools in Ireland, and who downloaded the CopeSmart mobile phone app as part of a randomized controlled trial. On the app, participants initially responded to 5 single-item measures of key protective factors in youth mental health (formal help-seeking, informal help-seeking, sleep, exercise, and sense of belonging). They were then encouraged to use the app daily to input data relating to mood states (happiness, sadness, anger, stress, and worry), daily problems, and coping self-efficacy. The app automatically collected data pertaining to user engagement over the course of the 28-day intervention period. Students also completed pen and paper questionnaires containing standardized measures of emotional distress (Depression, Anxiety, and Stress Scale; DASS-21), well-being (World Health Organization Well-Being Index; WHO-5), and coping (Coping Strategies Inventory; CSI).

Results: On average the participants completed 18% (5/28) of daily ratings, and engagement levels did not differ across gender, age, school, socioeconomic status, ethnicity, or nationality. On a scale of 1 to 10, happiness was consistently the highest rated mood state (overall mean 6.56), and anger was consistently the lowest (overall mean 2.11). Pearson correlations revealed that average daily ratings of emotional states were associated with standardized measures of emotional distress ($r_{happiness}$=–.45, $r_{sadness}$=.51, r_{anger}=.32, r_{stress}=.41, r_{worry}=.48) and well-being ($r_{happiness}$=.39, $r_{sadness}$ =–.43, r_{anger}=–.27, r_{stress}=–.35, r_{worry}=–.33). Inferential statistics indicated that single-item indicators of key protective factors were related to emotional distress, well-being, and average daily mood states, as measured by EMA ratings. Hierarchical regressions revealed that greater daily problems were associated with more negative daily mood ratings (all at the P<.001 level); however, when coping efficacy was taken into account, the relationship between problems and happiness, sadness, and anger became negligible.

Conclusions: While engagement with the app was low, overall the EMA data collected in this exploratory study appeared valid and provided useful insights into the relationships between daily problems, coping efficacy, and mood states. Future research should explore ways to increase engagement with EMA mobile phone apps in adolescent populations to maximize the amount of data captured by these tools.

Trial Registration: Clinicaltrials.gov NCT02265978; http://clinicaltrials.gov/ct2/show/NCT02265978 (Archived by WebCite at http://www.webcitation.org/6mMeYqseA).

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KEYWORDS

adolescent; affect; ecological momentary assessment; mobile apps

Introduction

Mobile technologies have the potential to be used as innovative tools for conducting research on the mental health and well-being of young people. In particular, they have utility for carrying out ecological momentary assessment (EMA) [1] or experience sampling methods [2]. These methodological terms (hereafter denoted as EMA) refer to the process of capturing data from participants in real time as they go about their daily lives [1-3] and are especially useful for exploring dynamic constructs such as symptoms of psychopathology and affective states, which tend to fluctuate over time [2,4].

A key advantage of EMA is that it addresses the limitations presented by retrospective measures of behaviors and experiences. Autobiographical memory is considered to be a representation of experience, largely reconstructed through the use of heuristic strategies, which can cause recall to become biased [1]. For example, the availability heuristic postulates that individuals judge events to be more frequent if they are easily retrievable from memory [5]. This heuristic produces accurate estimates of frequency in cases where an event is easily retrievable due to familiarity with that event. However, biases can occur when events are easily retrievable for other reasons (eg, because they occurred recently or because they were emotionally salient), which may result in overestimation of their frequency [1]. Another limitation of autobiographical memory is the potential for memories of a situation to be unconsciously distorted based on preexisting expectancies, thoughts, and beliefs about that situation [1,6]. In a research context, this can affect the validity of retrospective measures of behaviors and affective states, particularly where such measures have not been well validated in the population under study. For example, research suggests that participants tend to overestimate intensity and duration of symptoms in recall-based measures [1]. EMA overcomes these issues by assessing participants' states in real time as they are occurring, thus providing more reliable and ecologically valid measurements.

EMA is not new to social research [2]. In past studies, young people have been given pencil and paper diaries to complete real-time measures of behaviors and moods [7-9]. However, these methods raised concerns around compliance, whereby participants would not complete measures at the correct time and would "backfill" them on a later occasion, or, in some cases, would fill in measures ahead of time rendering the data invalid [10]. Advances in mobile technologies have resulted in a means of addressing this issue due to the increasing availability of electronic methods of data collection, such as mobile phones, which provide time and date stamps for data entered by participants.

Indeed, mobile phones have the potential to be a particularly valuable means of collecting EMA data. These technologies are now almost ubiquitous, with ownership of smartphones (ie, mobile phones that can connect to data networks such as the Internet) almost doubling among American adults between 2011 and 2015 [11], and adolescent smartphone ownership is estimated at between 75% and 86% in the developed world [11-13]. Research also suggests that smartphone ownership is not restricted by socioeconomic status [14]. Thus, they represent a widely available and highly accessible medium for capturing data about diverse populations. Furthermore, as individuals are used to carrying their phones around with them, the likelihood of missing entries due to participants forgetting to bring an additional research device with them is reduced. Mobile phones also have value as being potentially very cost-effective data collection tools, as they are highly scalable. Although initial investment may be required to develop the data collection software platform, it is much simpler to subsequently customize that platform to capture different types of data and answer different research questions [15]. Furthermore, researchers no longer need to purchase mobile devices for participants, as software applications—more commonly known as mobile phone apps [16]—for collecting data can be downloaded directly onto participants' personal mobile phone devices. Thus, collecting data from large numbers of participants is unlikely to entail additional costs, making large-scale projects a more accessible and feasible option for researchers.

Recent years have seen frequent use of mobile-based EMA methods in studies with young people, particularly in relation to health behaviors such as medication adherence [17], smoking [18], and eating behaviors [19]. EMA methods have also been increasingly used to study emotional states in adolescents with clinically diagnosed mental health problems such as mood and anxiety disorders [3,20-22]. However, fewer studies have been conducted on the utility of electronic EMA methods to capture data pertaining to mood (ie, the experience of a current emotion such as happiness, sadness, anger, and so forth) and coping efficacy in a general, nonclinical adolescent population.

A pilot study by Abbot et al explored the feasibility of using EMA with a school-based sample of 40 Australian adolescents to capture data pertaining to their contextual environment, behaviors, and mood states [2]. They reported that not only was this method of capturing data feasible, but the young people involved in the study found the use of a mobile phone as a means of data collection to be particularly engaging. However, they did not report details of engagement or attrition. Furthermore, due to the small sample size, their analyses were only descriptive, and they did not examine the validity of the EMA data captured.

Another small-scale feasibility study was conducted by Garcia et al. They used EMA to collect data pertaining to daily activities, behaviors, and attitudes among 24 female Latina adolescents in the United States via mobile phones [23]. They tested 2 methods of EMA: one where participants were required to respond as quickly as possible to questions sent via text message (signal-based assessment) and one where participants

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were instructed to respond to text message–based questions whenever they wanted, but to provide unprompted open-ended texts describing how they felt during events that occurred in their daily lives (event-based assessment). They ran numerous rounds of data collection, with participants experiencing both methods at some point during the study. They found that compliance rates varied across both methods, with signal-based sampling inducing a higher compliance rate (average percentage of texts responded to was 79%) than event-based sampling (average percentage of texts responded to was 54%). However, their analyses were limited to examining compliance rates, and they did not present details of the actual EMA responses captured. Furthermore, the homogeneity of the sample (all Latina females) limits the generalizability of their findings.

Another example of a mobile phone-based method of mood-related EMA is Kauer et al's intervention, Mobiletype [24]. This was a targeted mobile phone app, where Australian adolescents (N=68) with elevated levels of depression monitored their mood, stress, coping strategies, activities, eating, sleeping, exercise, and substance use. They found that engagement was moderate with participants completing EMA ratings 3-4 times per day on an average of 17-18 days within the 4-week intervention period, demonstrating the feasibility of this tool in a sample of adolescents experiencing depressive symptoms. However, the focus of their study was on evaluating the effectiveness of the app as an intervention. Thus, they did not report details of the EMA responses or examine their validity in comparison to standardized measures.

Overall, EMA has potential to provide an innovative, ecologically valid means of capturing detailed data about young people's real-world experiences in their natural environments. Given the elevated prevalence of emotional problems experienced during adolescence [25,26], this is a particularly salient time to examine individuals' daily experience of mood, problems, and coping efficacy. In light of the advantages of mobile phones as highly accessible and cost-effective tools for EMA research, it is important to explore their potential feasibility for studying such constructs in young people.

However, while small-scale studies have suggested the feasibility of mobile phone–based EMA pertaining to mental health in small adolescent samples [2,23,24], actual analyses of the EMA data captured in these studies has been limited or nonexistent and the validity of this data has not been explored. There has been increased recognition in recent years of the importance of promoting well-being in the general population of young people, in order to maximize beneficial outcomes, rather than just focusing on treating symptoms in young people already experiencing clinical levels of distress. Thus, it is important that we study the use of EMA in community-based adolescent samples. This is important for establishing the validity of such data and determining what it can tell us about young people's daily experience of mood, problems, and coping efficacy, which will help inform the design and delivery of resources to support young people's day-to-day well-being.

The aim of this study was to address the gap in the literature by exploring the utility of a mobile phone app as a means of collecting EMA data pertaining to mood, problems, and coping efficacy in a school-based sample of young people. The app used to collect data in our study was CopeSmart . This app was designed as a mental health intervention promoting emotional self-monitoring and positive coping strategies in adolescents [27]. As part of the intervention, users were encouraged to engage in self-monitoring by inputting EMA data to the app pertaining to their daily experience of problems, coping efficacy, and mood states. A more detailed description of the full app content is presented in Kenny, Dooley, and Fitzgerald [27].

As this study was exploratory, specific hypotheses were not generated. However, the researchers were interested in answering the following 4 general questions:

- First, the researchers were interested in exploring: (1) To what extent do participants engage with the EMA component of the app?
- Second, the researchers aimed to explore the validity of the data by testing: (2) Are EMA responses correlated with standardized measures of mental health and coping?
- As EMAs are completed during participants' daily lives, it is intuitive that measures used should be brief in order to maximize participants' responses. Thus, the researchers were interested in evaluating the use of single-item measures of key protective factors in youth mental health (described below) by assessing: (3) Are brief single-item measures of key protective factors related to adolescents' daily mood states?
- Finally, research suggests that experiencing daily stressors, such as negative events and problems, is associated with lower positive mood and higher negative mood during adolescence [28,29]. Studies also indicate that coping effectively with these stressors is associated with more positive mood outcomes in young people [30-32]. The EMA data collected by the app in this study offered a highly ecologically valid means of generating insight into the relationships between these variables in an adolescent sample. Thus, the researchers were interested in exploring (4) What is the relationship between daily problems, coping efficacy, and mood states in young people, as measured by EMA data?

Methods

Participants

The study included a total of 208 participants, 64% females (133/208), aged 15-18 years (mean 15.98, SD 0.70), recruited from 10 schools in the Republic of Ireland, and for whom mobile phone app data were captured as part of an effectiveness evaluation of the CopeSmart app intervention to be presented in a separate paper (Clinicaltrials.gov NCT02265978). In terms of nationality, 95% of the sample (197/208) were Irish and the remaining 5% were foreign nationals. In terms of ethnicity, 97% (202/208) identified as white, 0.5% (1/208) identified as Asian, and 1.5% (3/208) identified as black or "other." In terms of socioeconomic status, 37% (77/208) attended schools that were considered to be socially or economically disadvantaged based on nationally established governmental criteria [33].

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Measures

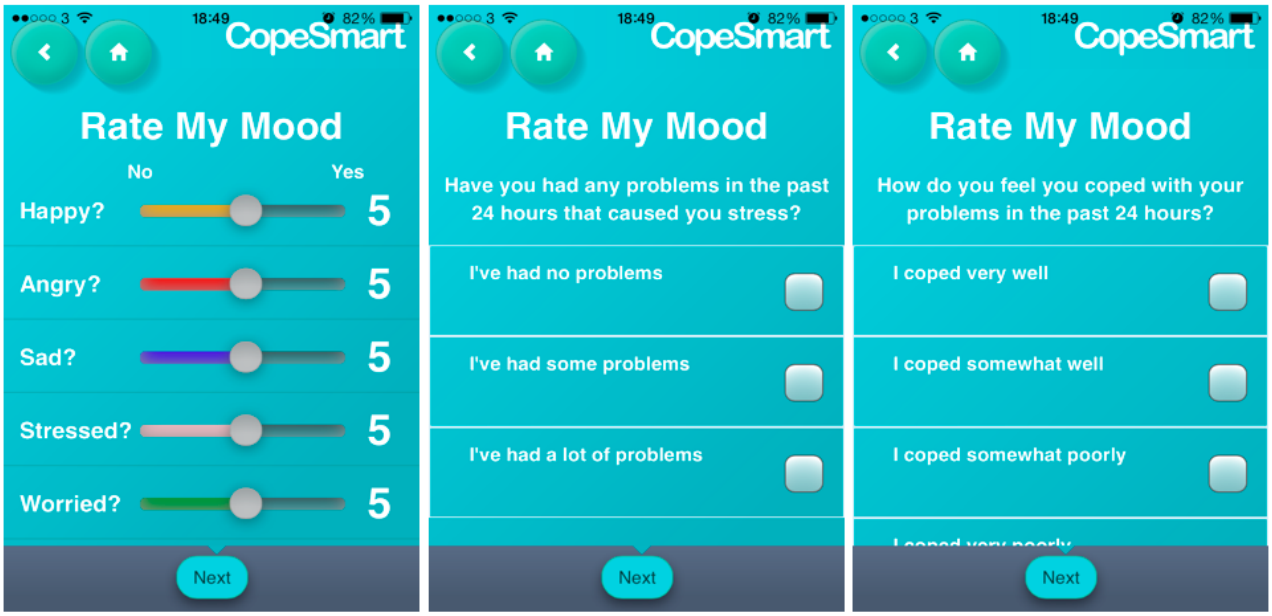
EMA Data

The CopeSmart app contained a self-monitoring component where users recorded information about their mood states, problems, and coping efficacy (See Figure 1 for sample screenshots). The 3 types of self-report EMA data collected were as follows:

- Mood states: Participants recorded how happy, angry, sad, stressed, or worried they felt using a sliding scale ranging from 1 to 10. When users initially navigated to this page of the app, the sliders were by default centered in the middle of the scale and it was up to the users to slide them up or down to select the value of their mood rating.
- Experience of problems: Participants recorded their experience of problems in the last 24 hours (response options: "I've had no problems," "I've had some problems," "I've had a lot of problems").
- Coping efficacy: Participants reported how well they felt they coped with these problems (response options: "I coped very well," "I coped somewhat well," "I coped somewhat poorly," "I coped very poorly").

Data relating to user's engagement with the app (ie, how frequently they logged onto the app) were also captured. All EMA data were uploaded to a back-end server when the device came into contact with a wireless Internet connection.

Figure 1. Sample screenshots from the ecological monetary assessment (EMA) component of the CopeSmart app.



Standardized Psychometric Scales

The Depression, Anxiety, and Stress Scale (DASS-21)—Short Version

The DASS-21 [34] is a 21 item self-report measure that assesses overall levels of psychological distress. It comprises 3 subscales representing 3 negative emotional states: depression, anxiety, and stress. Responses are made on a 4-point Likert scale based on the participants' experiences of the past week, ranging from "Did Not Apply To Me At All" to "Applied To Me Most Of The Time." Higher scores indicate higher levels of distress. The DASS-21 has shown convergent validity with other measures of negative affect [35], and it has been found to have a high level of internal reliability as an overall measure of distress (alpha=.93-.94) in adolescent samples [36,37] (this study, alpha=.92).

World Health Organization Well-Being Index (WHO-5)

The WHO-5 [38] is a brief 5-item self-report instrument developed from the World Health Organization-Ten Well-Being Index [39,40]. It is a unidimensional measure of positive psychological well-being containing 5 positively worded items pertaining to general well-being. Participants rate the degree to which they have experienced each of these positive feelings in the last 2 weeks, on a 6-point scale ranging from "At No Time" to "All of the Time," with higher scores indicating higher levels of well-being. The scale's 1-factor structure has been confirmed, and satisfactory concurrent validity has been established with other mental health measures [41,42]. It has been shown to consistently display a high level of internal reliability (alpha=.82-.89) in adolescent samples [41,43] (this study, alpha=.85).

The Coping Strategies Inventory (CSI)—Short Form

The 32-item short version of the self-report CSI [44] was designed to assess coping skills in young people on multiple levels. Partially derived from the Folkman and Lazarus (1980) Ways of Coping Scale, the measure assesses both positive "engagement" coping strategies and negative "disengagement" coping strategies. Participants were asked to indicate how much they used these strategies to cope with problems on 5-point scale ranging from "Never" to "Very Often," with higher scores indicating more frequent use of that coping strategy. The CSI has shown satisfactory internal consistency (alpha=.69-.94) [44,45] and good test-retest reliability (r=.67-.83) in young adults [44] and concurrent validity with other measures of

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coping [46] (this study, $alpha_{engagement}$=.89, $alpha_{disengagement}$=.86).

Well-Being Indicator Items

When participants initially downloaded the app, they were asked 5 single-item "well-being indicator" questions pertaining to known protective factors for mental health outcomes in young people. These were informal help-seeking, formal help-seeking, physical activity, sleep, and sense of connectedness.

Informal Help-Seeking

Informal help-seeking was assessed by asking participants "When you have problems do you usually talk about then with anyone?'' to which they could respond either "yes" or "no." Talking about problems has been linked to more positive mental health outcomes in young people [47-49], and this particular item has previously been shown to a key indicator of mental health status in a sample of Irish adolescents [25].

Formal Help-Seeking

Formal help-seeking is associated with lower levels of distress in young people [50,51], and in this study, it was assessed using an item adapted from Saunders et al [52] that has previously been used in an Irish adolescent samples [25]. This item is based on the idea of formal help-seeking as a 3-stage process that involves identifying oneself as having a serious problem, recognizing that professional help is required, and actively seeking help [51]. Participants were asked "Have you had any serious problems in the last month?" Response options were "I've had few or no problems," "I've had some problems, but I did not feel I needed professional help," "I've had some problems but I did not seek professional help although I thought I needed it," and "I've had some problems and I did seek professional help."

Physical Activity

Besides promoting physical well-being, engagement in physical activity has been continuously linked with more positive mental health outcomes among adolescents [53-55]. The World Health Organization's [56] Global Recommendations on Physical Activity for Health advise that, for optimum physical and mental health, children and adolescents should engage in at least sixty minutes of moderate-to-vigorous physical activity daily. Engagement in physical activity in this study was assessed using a single-item measure, devised and validated in an adolescent population [57]. Participants were given the statement "Physical activity is any activity that increases your heart rate and makes you a little out of breath e.g. running, fast walking, cycling, dancing etc." and asked "On a usual week, how many days are you physically active for a total of at least 60 minutes per day?"

Sleep

A recent systematic review by Shochat et al [58] identified insufficient sleep as having a strong bidirectional relationship with depression during adolescence, as well as being linked to anxiety, poor psychosocial function, and poor perceived mental health. The National Sleep Foundation [59] ascertains that adolescents need between 8 and 10 hours of sleep each night for optimal functioning. Thus, in this study, participants were asked "During the past month, how many hours of sleep did you get on average per night?"

Sense of Connectedness

Finally, feeling a sense of connectedness and belonging to the people around oneself is considered to be a fundamental psychological need [60] and is associated with lower levels of depressive symptoms [61,62] and higher levels of well-being among young people [60]. In this study, it was measured by asking participants "Please indicate how much the following statement applies to you: I feel a sense of connectedness and belonging to people around me." Responses were made on a 4-point scale ranging from "None of the time" to "All of the time."

Procedure

Ethical approval for this study was granted by the Human Research Ethics Committee—Humanities in the authors' university (reference number: HS-13-45-Kenny-Dooley). Data collection took place between October 2014 and May 2015. Presented here is an overview of the procedure relevant to this study; a more detailed description of the full sampling, recruitment, and randomization procedure for the trial will be presented in a separate paper.

Initially, principals and guidance counselors of second-level schools in the Republic of Ireland were contacted. The nature of the study and what would be involved if the school decided to participate was described to them. In schools that agreed to take part, potential participants were provided with information sheets and consent forms for themselves and their parents or guardians. Participation was voluntary, and monetary incentives to take part were not offered. Students who returned signed parental consent forms were eligible to take part and were required to sign assent forms prior to participation.

Schools were randomly assigned to either the intervention or control condition. Students in schools assigned to the intervention condition completed pen-and-paper questionnaires. These contained items pertaining to demographic information and the standardized psychometric measures detailed earlier. They were then given instructions for how to download and use the CopeSmart app and asked to try to engage with it once a day over the course of the following 4 weeks. Students in schools assigned to the control condition completed the same questionnaires but received no intervention, and are not included in the analyses for this study.

In order to link their questionnaire responses with their app data over time, students were required to generate a personalized 9-digit Anonymous Identification Code, designed to make sure that their information would remain anonymous to the researchers. They recorded this on their pen-and-paper questionnaire and input it to the app upon initial download.

By default the app was set to prompt participants to complete EMA mood ratings at 8 p.m. each evening. Users were provided with the option to subsequently change the time at which they received these notifications if they wished. Users were also free to access the other components of the app (such as viewing their

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mood rating history) at their leisure, even if they had not completed an EMA rating that day.

Analyses

Responses from pen-and-paper questionnaires were input to SPSS version 20.0.0 (IBM). Mobile phone app data (ie, participants' EMA ratings and details of their engagement levels with the app) were downloaded to Microsoft Excel and then transferred into SPSS. All analyses were run using SPSS. Basic descriptive and inferential statistics were run to explore participants' engagement with the app and whether engagement levels differed across demographic variables. Pearson correlations were conducted to test the relationship between EMA ratings and standardized measures of mental health and coping efficacy. Various inferential analyses were used to examine whether mental health indicator variables were linked to mental health outcomes. Where multiple comparisons were conducted simultaneously, the rough false discovery rate correction was used to control for increased chance of Type 1 error occurring [63] using the formula [(n+1)/2n] x (.05), where n is the number of tests. In cases where post-hoc analyses were required for significant one-way analysis of variance (ANOVA), Scheffe post-hoc analyses were carried out if homogeneity of variance (HOV) was observed, and Dunnet C analyses were carried out if HOV was not observed. Correlations and regressions were used to explore relationships between problems, coping efficacy, and mood as measured by EMA.

Results

To What Extent Do Participants Engage With the EMA Component of the App?

Of the 208 participants who downloaded the app, no EMA data were recorded for 28% (58/208) of participants, a single EMA entry was recorded for 10% of participants (21/208), and repeated EMA data were present for 62% (129/208) of participants. In cases where participants completed EMA ratings more than once during the course of a given day, their mood ratings were averaged to provide a single score for each mood state for that particular 24-hour period. In cases where they had multiple responses to the problems and coping EMA items within 1 day, their last entry for that day was taken as the best representation of whether they had experienced problems in the last 24 hours and how well they felt that they had coped with them.

The number of days on which participants completed ratings ranged from 0 to 24, and engagement levels did not differ across gender, age, school socioeconomic status, ethnicity, or nationality. On average, among the 208 participants, users only completed ratings on 5 days (SD 5.44) within the 28-day intervention period, corresponding to an average engagement rate of 18% (calculated as 5 days, expressed as a percentage of 28 days). Looking to general app usage data indicated no substantial difference between the number of days on which participants accessed the app (mean 5, SD 5.52) and the number of days on which they completed EMA ratings, suggesting that participants likely completed EMA ratings every time they used the app. The number of participants who completed EMA ratings each day continually declined over the course of the 28 days; Multimedia Appendix 1 presents a chart depicting the number of participants who completed EMA ratings on each day of the intervention period. In terms of daily mood ratings, happiness was consistently the highest rated mood state (overall mean 6.56), and anger was consistently the lowest rated (overall mean 2.11). Generally sadness (overall mean 2.63) was rated lower than both worry (overall mean 3.45) and stress (overall mean 3.57), whereas worry and stress often overlapped with each other in terms of how highly they were rated throughout the intervention period. Multimedia Appendix 2 presents a chart depicting average EMA mood rating scores on each day of the intervention period.

Are EMA Responses Correlated With Standardized Measures of Mental Health and Coping?

EMA ratings of participants' daily problems ratings were coded 1 ("I've had no problems"), 2 ("I've had some problems"), or 3 ("I've had a lot of problems"). These daily ratings were summed to give an overall score, which was divided by the number of daily ratings the participant completed, in order to obtain an average daily problem score for each individual. Higher scores indicated greater daily experience of problems.

Similarly, participants' EMA ratings of how well they felt they had coped with problems were coded 1 ("I coped very poorly"), 2 ("I coped somewhat poorly"), 3 ("I coped somewhat well"), or 4 ("I coped very well"). These ratings were summed to give an overall score and then divided by the number of days on which the participant completed a daily rating in order to give an average daily coping self-efficacy score for each individual. Higher scores indicated more effective coping.

For each of the 5 moods (happy, sad, angry, stressed, and worried), an average EMA mood score for each participant was computed by summing all of their ratings for that mood and dividing it by the number of days on which they completed ratings (descriptive statistics for these are presented in Table 1). As skewness and kurtosis values for all variables fell within an acceptable range [64], they were considered to approximate normality and parametric statistics were used in further analyses.

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Table 1. Descriptive statistics for average ecological momentary assessment (EMA) variables.

Variable	Overall mean (SD)	Skewness	Kurtosis
Average problems	1.65 (0.45)	0.30	−0.26
Average coping efficacy	3.17 (0.63)	−0.79	0.94
Average sadness	2.74 (2.17)	0.81	0.63
Average happiness	6.36 (1.84)	−0.22	0.48
Average anger	2.40 (1.99)	1.15	1.86
Average stress	3.89 (2.46)	0.20	−0.72
Average worry	3.39 (2.31)	0.38	−0.44

Participants' average daily experience of problems was positively correlated with negative coping strategies (as measured by the CSI; r=.31, P<.001), but was not correlated with positive coping strategies, as measured by the CSI. Participants' perceived coping efficacy in relation to these problems was positively associated with positive coping strategies (r=.29, P<.001) and negatively associated with negative coping strategies (r=-.27, P<.001).

Average daily happiness was negatively correlated with emotional distress, as measured by the DASS-21 (r=–.45, P<.001), and positively correlated with well-being, as measured by the WHO-5 (r=.39, P<.001). Average daily negative emotions (sadness, anger, stress, and worry) were all significantly positively associated with distress ($r_{sadness}$=.51, P<.001; r_{anger}=.32, P<.001; r_{stress}=.41, P<.001; r_{worry}=.48, P<.001) and negatively correlated with well-being ($r_{sadness}$=–.43, P<.001; r_{anger}=–.27, P=.001; r_{stress}=–.35, P<.001; r_{worry}=–.33, P<.001).

Are Brief Single-Item Measures of Key Protective Factors Related to Daily Mood States?

Informal Help-Seeking

About 55% (114/208) of participants reported that when they had problems they usually talked about them with someone. The remaining 45% (94/208) reported that they did not talk about their problems. A series of t tests revealed that those who reported that they talked about their problems displayed significantly lower levels of average daily anger $t_{109.27}$=–2.26, P=.03 ($mean_{talk}$=2.07, SD 1.97 vs $mean_{donotalk}$ =2.83, SD 2.35) and significantly higher average daily happiness t_{148}=2.48, P=.01 ($mean_{talk}$=6.69, SD 1.60 vs $mean_{donotalk}$=5.95, SD 2.04). There were no differences between the 2 groups in terms of daily sadness, stress, or worry.

Formal Help-Seeking

Overall, 49% of participants (101/208) had few or no problems, 36% (76/208) had some problems but did not feel they needed professional help, 10% (20/208) had some problems, felt they needed professional help, but did not seek it, and 5% (11/208) had problems and did seek professional help. Table 2 presents the results of One-way ANOVAs assessing whether participants who categorized themselves into different formal help-seeking categories differed in terms of daily mood states, as assessed by EMA.

Findings revealed that those who categorized themselves as having no problems reported less negative daily mood states than those who categorized themselves as having problems. Additionally, those who categorized themselves as having problems, but who did not feel they needed to seek help reported significantly lower daily sadness than those who categorized themselves as having problems and needing help. Among those who categorized themselves as needing help, no differences were evident between those who had sought and those who had not sought professional help.

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Table 2. One-way analysis of variances (ANOVAs) examining differences between formal help-seeking groups in terms of average daily mood states.

Average EMA[a] rating	Few or no problems, mean (SD)	Some problems, did not need help, mean (SD)	Some problems, needed help, did not seek it, mean (SD)	Some problems, sought professional help, mean (SD)	*F*	*P* [b]	Post-hoc (Scheffe)
Happy	7.12 (1.64)	5.67 (1.64)	4.97 (1.87)	6.31 (1.59)	12.0[c]	<.001	1>2,3
Sad	1.78 (1.83)	3.36 (1.89)	5.03 (2.08)	3.29 (1.97)	16.98[c]	<.001	1<2,3; 2<3
Angry	1.85 (1.86)	2.94 (1.87)	2.94 (2.41)	3.18 (1.93)	4.25[d]	.007	1<2
Stressed	2.81 (2.34)	4.61 (2.17)	5.98 (1.76)	5.13 (1.57)	14.0[c]	<.001	1<2,3,4
Worried	2.35 (2.18)	4.13 (2.02)	5.07 (1.48)	5.03 (2.05)	14.15[d]	<.001	1<2,3,4

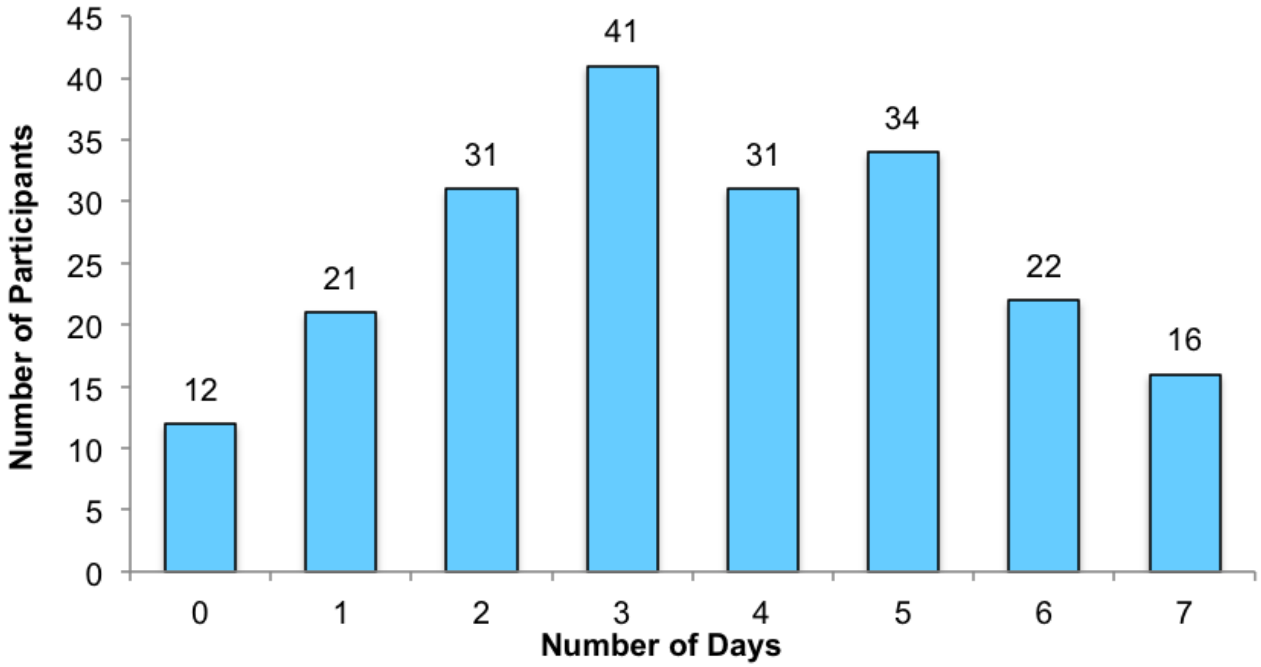
[a]EMA: ecological monetary assessment.

[b]Alpha set at .028 in line with rough false discovery rate.

[c]Significant at the $P<.001$ level.

[d]Significant at the $P<.028$ level.

Figure 2. Days physically active in a typical week as reported by participants.



Physical Activity

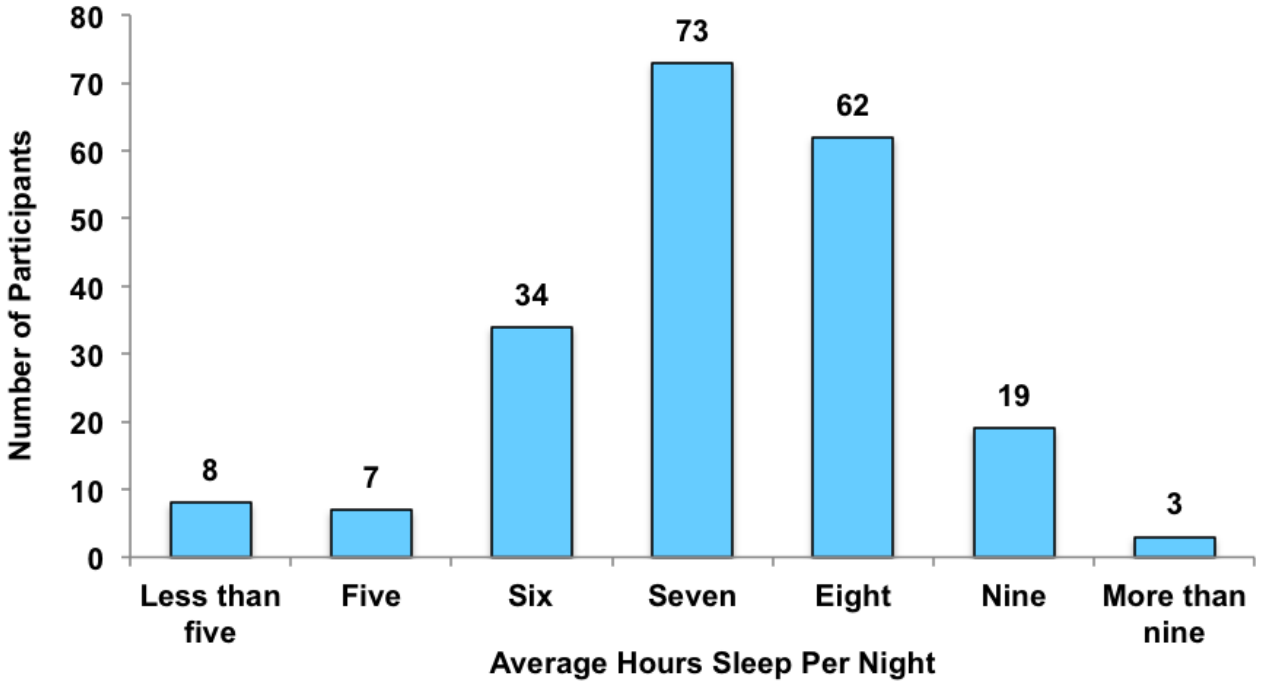
Figure 2 illustrates the typical weekly activity levels reported by participants. Pearson correlations revealed no relationships between the average number of days on which participants were physically active and average EMA mood ratings.

Sleep

Figure 3 illustrates participants' average hours sleep per night over the course of the previous month (data were missing for 2 participants). Overall participants reported an average of 7.09 hours sleep (SD 1.60) per night. Independent *t*-tests (detailed in Table 3) were conducted examining differences between those who reported getting sufficient sleep (84/206) and those who did not (122/206). Sufficient sleep was defined as ≥8 hours in line with the National Sleep Foundation guidelines [59]. Findings revealed that adolescents who did not get sufficient sleep reported higher average daily sadness, anger, and worry and lower daily happiness.

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Figure 3. Participants' average hours sleep per night.



Sense of Connectedness

Exactly half of participants (104/208) reported that they felt a sense of connectedness and belonging to those around them a lot or all of the time. The other half of participants reported that they felt this only some or none of the time. Table 3 presents the results of independent *t* tests examining differences between those who felt a sense of connectedness a lot or all of the time and those who felt this some or none of the time. Those who felt connectedness a lot or all of the time reported significant higher daily happiness and significantly lower daily sadness, anger, stress, and worry.

Table 3. *t* tests examining differences in average daily mood ratings across sleep groups and sense of connectedness groups.

Variable	Mean (SD)	Mean (SD)	*t*	*P* [a]
Sleep	Insufficient sleep (<8 hours)	Sufficient sleep (≥8 hours)		
Happy	5.91 (1.77)	6.92 (1.79)	–3.43[b]	.001
Sad	3.22 (2.15)	2.16 (2.06)	3.06[b]	.003
Angry	2.73 (2.07)	1.99 (1.83)	2.29[b]	.02
Stressed	4.19 (2.22)	3.51 (2.70)	1.65	.10
Worried	3.78 (2.31)	2.90 (2.24)	2.36[b]	.02
Sense of connectedness	Some or none of the time	A lot or all of the time		
Happy	5.96 (1.83)	6.82 (1.75)	–2.92[b]	.004
Sad	3.39 (2.27)	2.00 (1.79)	4.13[c]	<.001
Angry	3.03 (2.17)	1.69 (1.49)	4.46[c]	<.001
Stressed	4.48 (2.35)	3.21 (2.43)	3.24[b]	.001
Worried	4.13 (2.45)	2.54 (1.82)	4.57[c]	<.001

[a]Alpha set at .028 in line with rough false discovery rate.

[b]Significant at the *P*<.028 level.

[c]Significant at the *P*<.001 level.

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What Is the Relationship Between Daily Problems, Coping, and Mood in Young People, as Measured by EMA Data?

As illustrated in Table 4, average happiness scores were negatively correlated with average sadness, anger, stress, and worry scores, and all negative mood scores were positively correlated with each other. Experience of daily problems was negatively correlated with happiness and significantly positively correlated with negative emotions of sadness, anger, stress, and worry. In contrast, higher coping efficacy was positively correlated with happiness and negatively correlated with sadness, anger, stress, and worry.

Table 4. Correlations between average mood, problems, and coping efficacy.

Variable[a]	1	2	3	4	5	6
1. Happy						
2. Sad	–.56					
3. Angry	–.45	.68				
4. Stressed	.42	.63	.48			
5. Worried	.40	.70	.52	.81		
6. Problems	.45	.45	.44	.60	.59	
7. Coping	.56	.56	.48	.56	.55	.70

[a]Alpha set at .026 in line with the rough false discovery rate. All correlations were significant at the $P<.001$ level.

To further explore these associations, a series of hierarchical linear regression were run (presented in Table 5), examining whether daily problems and coping efficacy predicted each of the 5 average mood states. Experience of problems was entered at Step 1, and coping efficacy was added at Step 2. Daily problems significantly predicted all mood states at Step 1, and for all analyses, the percentage variance explained increased from Step 1 to Step 2. At Step 2, daily problems became an insignificant predictor of happiness, sadness, and anger when coping efficacy was added to the model. In contrast, daily problems remained a significant predictor of stress and worry when coping efficacy was added. Coping efficacy significantly predicted all 5 mood states at Step 2.

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Table 5. Hierarchical regressions predicting average mood.

Outcome	Adjusted r^2	Predictor	Unstandardized coefficient, B	Standard error	β	P [a]
Happy						
Step 1	.19	Problems	–1.84	0.30	–.45[b]	<.001
Step 2	.31	Problems	–0.43	0.40	–.10	.28
		Coping efficacy	1.41	0.28	.49[b]	<.001
Sad						
Step 1	.20	Problems	2.20	0.36	.45[b]	<.001
Step 2	.31	Problems	0.56	0.47	.17	.23
		Coping efficacy	–1.63	0.33	–.48[b]	<.001
Angry						
Step 1	.19	Problems	1.96	0.33	.43[b]	<.001
Step 2	.24	Problems	0.86	0.45	.19	.06
		Coping efficacy	–1.09	0.32	–.35[c]	.001
Stressed						
Step 1	.36	Problems	3.32	0.36	.60[b]	<.001
Step 2	.39	Problems	2.30	0.50	.42[b]	<.001
		Coping efficacy	–1.03	0.35	–.27[c]	. 004
Worried						
Step 1	.35	Problems	3.08	0.34	.59[b]	<.001
Step 2	.38	Problems	2.14	0.47	. 41[b]	<.001
		Coping efficacy	–0.94	0.33	–.26[c]	.005

[a]Alpha set at .028 in line with rough false discovery rate.

[b]Significant at the P<.001 level.

[c]Significant at the P<.028 level.

Discussion

Principal Findings

The aim of this study was to explore the use of a mobile phone app as a means of collecting EMA data pertaining to adolescent mood, problems, and coping in a school-based sample of young people. The researchers were interested in answering 4 broad questions, each of which is discussed below.

To What Extent Do Participants Engage With the EMA Component of the App?

Engagement with the EMA component of the app was low compared with previous studies. For example, Kauer et al's study reported that participants completed ratings on an average of 18 days during the 4-week intervention period [24], which was markedly higher compared with this study where participants completed ratings on an average of 5 days within the 28-day intervention period. However, in Kauer's study, participants were given individualized summary reports of their data by their general practitioner at the end of the intervention period. This might have served as a motivational factor for adolescents to engage, either because they were interested in reviewing their data over time with a health professional or because they knew their general practitioner would be able to see their level of engagement and wanted to appear compliant. Similarly, Garcia et al reported an average response rate of 54% for EMA sampling using a similar methodology [23], compared with the average response rate of 18% obtained in this study, However, it is noteworthy that an incentive to engage was provided in Garcia's study, whereby a higher level of engagement increased the number of entries they were given into a prize draw to win an iPod touch.

While participants were aware in this study that their EMA data would be recorded and accessible to the researchers, it was not emphasized that the main focus of the app was to collect information; the app was primarily presented to young people as an intervention as opposed to a data collection tool. It is possible that in studies where young people are aware of the importance of their data input toward achieving the research objective, engagement levels may be higher. For example, in Kauer et al's study [24], participants were aware that their data were being collected, and that they would be able to review this

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with their general practitioner and receive a summary report on their data at the end of the study, which might have acted as an incentive for engagement. Thus, further research is necessary to establish response rate norms for adolescent populations using mobile phone EMA methodologies.

Are EMA Responses Correlated With Standardized Measures of Mental Health and Coping?

Higher daily experience of problems was linked to more negative coping (as measured using a standardized instrument), suggesting that those who experience more problems or stressful events are more likely to engage in dysfunctional, avoidant coping strategies, in line with previous research [65-67]. However, a greater perceived ability to deal with daily problems was associated with higher levels of positive coping and lower levels of negative coping (as measured using a standardized instrument). This indicated that those who perceived themselves as dealing better with the problems they faced on a daily basis were using more positive coping strategies and less negative coping strategies, suggesting that this was a valid measure of coping self-efficacy. Similarly, as EMA mood ratings were correlated with standardized measures of distress and well-being, it suggested they had validity as indicators of adolescent mental health status.

Are Brief Single-Item Measures of Key Protective Factors Related to Daily Mood States?

Findings indicated that the protective factors informal help-seeking, formal help-seeking, sleep, and sense of connectedness were associated with average daily mood states.

In terms of informal help-seeking, those who reported that they did not talk about their problems had more negative daily mood, which is consistent with previous research linking informal help-seeking and mental health [25,47-49]. Discussing problems may be considered a support-seeking coping strategy, which is likely to improve outcomes for young people by (1) providing them with instrumental help in addressing the source of their problems or in positively adapting to the situation, or (2) providing them with advice and support in taking steps toward achieving these goals themselves. To help promote talking about problems among adolescents, steps should be taken to ensure that school guidance counsellors have a high level of availability and that students know how to approach them confidentially in relation to problems they may be experiencing.

In terms of formal help-seeking, young people who identified themselves as having no problems unsurprisingly reported the least negative daily mood states. Interestingly, among those who reported that they had some problems, those who felt that they did not need help reported lower daily sadness than those who felt that they did need help, suggesting that young people have a good awareness of whether or not they need to seek help. This is in line with Rickwood et al's [50] conceptualization of help-seeking as a process, which begins with the recognition that a problem exists for which help is required. Among those who reported a need to seek help, no significant difference emerged between those who had sought help and those who had not. Nonetheless, there was a trend toward lower stress and sadness and greater happiness among those who had sought help, indicating that seeking help is likely to be instigating some beneficial effects. However, there may be many uncontrolled factors at play, for example, severity of distress [68] or type of professional help obtained, that are known to affect outcomes of seeking professional help [69] which may explain why we do not see a statistically significant difference between those who have sought help and those who have not. These were beyond the scope of the analyses in this study but should be taken into account in future research.

Getting sufficient sleep was linked with more positive daily mood states, in line with literature in this area [58]. This indicates an important link between controllable health behavior and mood, and efforts should be made to promote sufficient sleep in young people. For example, parents can encourage appropriate bed times for adolescents on week-nights. At a policy level, education around sleep hygiene should be implemented into the SPHE (Social, Personal, and Health Education) curriculum for adolescents. Furthermore, consideration should be given to implementing later school start times in post-primary schools, which has been shown to be linked to a multitude of academic and well-being benefits for young people [70,71] by allowing them to get more sleep. Surprisingly, no correlation emerged between physical activity and daily mood states; however, the reason for this is unclear. There is evidence to suggest that adolescents may significantly overestimate their level of physical activity in research contexts [72], thus including some objective measure of physical activity (eg, mobile phone accelerometer data) would be useful in future research.

Finally, feeling a sense of connectedness and belonging was linked to more positive mental health outcomes for young people, in line with previous research [60-62]. Evidence suggests that this link between sense of belonging and mental health outcomes is likely to be bidirectional [60]. For example, rejection or exclusion from one's social network means that one's fundamental human need for connectedness is not met and is linked to increased symptoms of distress in adolescents [36,73]. However, young people who have mental health difficulties may experience cognitive distortions, which can cause them to view their interpersonal relationships in a more negative light [74,75], resulting in a diminished sense of belonging. Although sense of belonging is not as directly controllable as sleep and exercise, it can still be promoted in school, incorporating features that have been linked to increased sense of belonging among students, including appropriate policies and structures to prevent bullying, peer support programs, and extracurricular activities [76].

Overall, findings suggest that 4 of these brief items have good utility as indicators of the mental health status of an adolescent. This provides promise for the use of these items as a brief screening tool for young people. This may be useful as part of assessments in contexts where adolescents may not want to complete long measures of mental health outcomes, but where it would be useful for the clinician to have an overview of their mental health status, such as during general practitioner visits.

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What Is the Relationship Between Daily Problems, Coping, and Mood in Young People, as Measured by EMA Data?

Higher daily problems predicted lower happiness and higher negative affect, indicating that the more daily problems a young person experienced, the poorer their average daily mood was. This was consistent with previous research indicating that experience of negative daily events was associated with increased negative and decreased positive affect in adolescents [28,29]. In contrast, perceived coping efficacy was linked to greater happiness and lower negative affect, indicating that those who felt they had coped better with their problems experienced a more positive average daily mood.

However, coping efficacy did not moderate the relationship between problems and stress or worry. This suggested that even if young people were coping well, higher instances of daily problems were still associated with increased stress and worry. In contrast, coping efficacy did moderate the relationship between problems and happiness, sadness and anger, whereby when coping efficacy was taken into account, the relationship between problems and these mood states became negligible. Again, this was consistent with previous research indicating that coping effectively with problems was associated with more positive mood outcomes [30-32]. This is an important finding, as although we cannot prevent young people from experiencing problems in their lives, promoting the use of effective coping strategies among young people may help to offset the sadness and anger associated with the experience of such problems.

Strengths and Limitations

To the authors' knowledge this was the first study to explore the use of a mobile phone app as a method of EMA in a sample of Irish adolescents. A key strength of this study was the use of an electronic method of implementing EMA. This helped avoid problems associated with pen-and-paper EMA methods, such as falsifying the times at which EMA ratings were completed [10]; thus, increasing the ecological validity of the data captured.

In terms of limitations, the low level of app engagement was a significant issue. Interestingly, the level of engagement did not differ across key demographic variables, suggesting that the EMA analyses were unlikely to be biased in this regard. However, the low engagement levels observed pose a concern for future studies aiming to test hypotheses using adolescent EMA data collected via mobile phones. For example, unless a large number of participants are recruited, nonengagement and attrition over the course of the data collection period may result in an underpowered study. Furthermore, low levels of engagement over the course of study will result in high volumes of missing data, which pose a range of challenges to the data analyses [77,78]. Thus, despite its benefit in terms of ecological validity [1], caution must be exerted when considering the use of EMA with adolescents. In particular, advance considerations should be given to possible means of maximizing engagement such as personalized feedback from the app based on participants' EMA responses [79] or, like in Kauer et al's study, the provision of a summary report for participants at the end of the data collection period [24].

Future research should also give consideration to alternative methods of mobile phone EMA data collection. For example, advances in technology allow mobile phones to capture sensor data, such as Bentley et al's Health Mashups app [80]. This app captured sensor data from users' phones including their daily step count, sleep patterns, and GPS location in order to infer their patterns of health behaviors. It would be useful for future research to examine the validity and reliability of this type of sensor data, which does not require a high level of active engagement from participants in comparison to EMA self-report data.

Another potential issue in this study was that in the mood-rating section of the app, the sliding scale values were by default centered in the middle of the scale (at a value of 5). This meant it was possible that some users might have passively selected "Next" without moving the sliders to change the value, simply to complete the process of submitting an EMA rating rather than actively and accurately rating their mood. While it is unlikely that users navigated to this page unless they had the intention of completing a genuine mood rating, this still should be acknowledged as a potential design limitation of the app in this study.

It is also possible that the awareness that researchers were monitoring their app data might have resulted in participants using their phones differently to how they would if they were not being monitored, leading to response biases, such as socially desirable responding [81]. However, the researchers made an effort to emphasize the anonymous and confidential nature of the data to help avoid this.

Finally, it should be acknowledged that this was an exploratory study that employed simplistic analyses techniques. Thus, caution should be exerted in interpreting the generalizability of these findings. Future research is needed using more sophisticated analytical methods to explore EMA data captured over multiple time points, such as multilevel modeling, in order to robustly establish the validity of these findings in the population. The use of such techniques will also provide opportunities to model young people's mood trajectories over time and test how these trajectories may be related to various demographic and well-being indicator variables.

Conclusions

This study addressed a gap in the literature by exploring the validity and utility of mental health–related EMA data captured via mobile phone in a community sample of adolescents. Findings indicated a low level of engagement, suggesting that careful consideration must be given to ways of promoting participant engagement in order to maximize the amount of data obtained and ensure that the potential of these technologies is being sufficiently exploited. Despite the low engagement levels, analyses suggested that the data obtained were valid, correlating with standardized measures of coping, distress, and well-being. Analyses also revealed that EMA data can provide useful insights into the link between daily experience of problems, coping efficacy, and mood states in young people. These preliminary findings suggest that mobile phones have potential as valid and useful tools for EMA research in youth mental

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health. However, future research is required to robustly establish the validity of these findings among young people.

Acknowledgments

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Conflicts of Interest

None declared.

Multimedia Appendix 1

Number of participants who completed ecological momentary assessment (EMA) ratings on each day of the intervention period.

[PDF File (Adobe PDF File), 46KB - mental_v3i4e51_app1.pdf]

Multimedia Appendix 2

Average ecological momentary assessment (EMA) mood rating scores on each day of the intervention period.

[PDF File (Adobe PDF File), 47KB - mental_v3i4e51_app2.pdf]

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Abbreviations

ANOVA: analysis of variance
CSI: Coping Strategies Inventory
DASS-21: Depression, Anxiety, and Stress Scale
EMA: ecological momentary assessment
HOV: homogeneity of variance
WHO-5: World Health Organization Well-Being Index

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Original Paper

Creating Live Interactions to Mitigate Barriers (CLIMB): A Mobile Intervention to Improve Social Functioning in People With Chronic Psychotic Disorders

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Abstract

Background: Numerous psychosocial interventions for individuals with chronic psychotic disorders (CPD) have shown positive effects on social cognitive and functional outcome measures. However, access to and engagement with these interventions remains limited. This is partly because these interventions require specially trained therapists, are not available in all clinical settings, and have a high scheduling burden for participants, usually requiring a commitment of several weeks. Delivering interventions remotely via mobile devices may facilitate access, improve scheduling flexibility, and decrease participant burden, thus improving adherence to intervention requirements. To address these needs, we designed the Creating Live Interactions to Mitigate Barriers (CLIMB) digital intervention, which aims to enhance social functioning in people with CPD. CLIMB consists of two treatment components: a computerized social cognition training (SCT) program and optimized remote group therapy (ORGT). ORGT is an innovative treatment that combines remote group therapy with group texting (short message service, SMS).

Objectives: The objectives of this single-arm study were to investigate the feasibility of delivering 6 weeks of CLIMB to people with CPD and explore the initial effects on outcomes.

Methods: Participants were recruited, screened and enrolled via the Internet, and delivered assessments and interventions remotely using provided tablets (iPads). Participants were asked to complete 18 hours of SCT and to attend 6 remote group therapy sessions. To assess feasibility, adherence to study procedures, attrition rates, engagement metrics, and acceptability of the intervention were evaluated. Changes on measures of social cognition, quality of life, and symptoms were also explored.

Results: In total, 27 participants were enrolled over 12 months. Remote assessments were completed successfully on 96% (26/27) of the enrolled participants. Retention in the 6-week trial was 78% (21/27). Of all the iPads used, 95% (22/23) were returned undamaged at the end of the intervention. Participants on average attended 84% of the group therapy sessions, completed a median of 9.5 hours of SCT, and posted a median of 5.2 messages per week on the group text chat. Participants rated CLIMB in the medium range in usability, acceptability, enjoyment, and perceived benefit. Participants showed significant improvements in emotion identification abilities for prosodic happiness (P=.001), prosodic happiness intensity (P=.04), and facial anger (P=.04), with large within-group effect sizes (d=.60 to d=.86). Trend-level improvements were observed on aspects of quality of life (P values less than .09). No improvements were observed for symptoms.

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Conclusions: It is feasible and acceptable to remotely deliver an intervention aimed at enhancing social functioning in people with CPD using mobile devices. This approach may represent a scalable method to increase treatment access and adherence. Our pilot data also demonstrate within-group gains in some aspects of social cognition after 6 weeks of CLIMB. Future randomized controlled studies in larger samples should evaluate the extent to which CLIMB significantly improves social cognition, symptoms, and quality of life in CPD.

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KEYWORDS

psychosis; social cognition; digital health; mobile health

Introduction

Individuals with chronic psychotic disorders (CPD) struggle with poor social functioning, namely in their ability to engage in social interactions and to create meaningful relationships [1]. Contributors to poor social functioning in CPD include pervasive impairments in social cognition [2], including the perception, interpretation and processing of socially-relevant information [3]. For example, individuals with CPD show impairments in gaze perception [4], emotion perception [5,6], social cue perception [7], theory of mind [8], attribution style [9] and empathy [10]. Impairments across all of these core domains of social cognition persist throughout the course of the illness and have been linked to low occupational status, impaired community functioning, reduced capabilities for independent living, high relapse rates and reduced quality of life [1,11-14]. As a result, integrating treatments for social cognition into psychosocial interventions may be critical to improving social functioning for individuals with CPD [15].

Among the various interventions developed to improve social cognition over the past two decades (for a review, see [16]), integrated psychological therapy (IPT) [17] and cognitive enhancement therapy (CET) [18] are two models that emphasize that treatments for social cognition should take place within a meaningful social context so that patients can practice the trained social cognitive abilities in supervised real-world social situations [19]. The goal of this approach is to increase the likelihood of skill transfer to everyday life settings and to promote successful participation in real-world social situations. For example, in CET, computer-based training of social cognition is integrated with group work on social skills development. In these weekly groups, patients with CPD practice structured social interactions, solve real-life social dilemmas, do appraisal of affect and social contexts, initiate and maintain conversations and receive feedback from other patients and coaches. Integrating the group sessions has been shown to be critically important for CET to generalize to real-life accomplishments in social and occupational roles [18], although a recent study suggests that combining elements of computer-based cognitive training and social skills groups did not induce greater benefits than cognitive training alone [20]. Finally, group-based interventions are known to sustain engagement and to reduce stigma and isolation [21-23].

Research overall demonstrates positive effects of these group-based integrated interventions on social cognitive and functional outcome measures [17,18]. Unfortunately, several factors limit access to and engagement with these treatments. First, many of these interventions are currently offered in only a few specialized programs, and may not be accessible to people who live in rural or under-resourced areas [24]. Second, these programs require specially trained therapists, who may not be available in all clinical settings [25]. Third, these interventions have a high scheduling burden, usually requiring a commitment of several months (and up to two years), in-person weekly visits to clinics and the organization of patient groups for program delivery. This scheduling burden can become untenable for people who are employed, have caregiver demands, have other responsibilities to manage or are without transportation. Lastly, some individuals with CPD hesitate to approach traditional mental health treatment settings because of stigma, which interferes with help-seeking behaviors [26].

Recent advances in digital technology and mobile platforms can help overcome these limitations by supporting the delivery of interventions remotely to individuals with CPD who are unable or unwilling to come in to the clinic, and do not own or have easy access to Internet-connected computers. Mobile interventions offer several benefits compared to in-person approaches. First, they enable scheduling flexibility and decrease scheduling burdens, thus facilitating accessibility and compliance with intervention requirements and ultimately increasing cost-effectiveness [27]. Second, digital technology can enrich the quality of treatment by incorporating innovative methods of communication, and by making treatment adaptive and responsive to dynamic, ecologically valid, real-time data [28]. Third, mobile interventions delivered in real-time may be accessed with greater frequency than in-person treatment approaches for brief therapeutic interactions that help consolidate support and maintain inter-session continuity [29]. Fourth, delivering the intervention in real-world settings may support the retention, reinforcement and successful generalization of trained skills [30]. Finally, mobile interventions can include opportunities for remote social engagement, like text-based motivation coaching from trained therapists or social networking via direct peer-to-peer messaging [30].

Guided by these principles, we designed Creating Live Interactions to Mitigate Barriers (CLIMB), a mobile psychosocial intervention that aims to enhance social functioning in people with CPD. CLIMB consists of the following two treatment components: (1) computerized social cognition training (SCT) exercises, and (2) optimized remote group therapy (ORGT). In line with the principles of IPT and CET, we opted for a hybrid approach, blending a structured training of social cognitive abilities (SCT) with an intervention that combines weekly group teletherapy with group texting (short

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message service, SMS) (ORGT). The principal goal of CLIMB is to enhance social functioning by driving improvements in social cognition, quality of life and clinical symptoms. However, in this open-label pilot study, our main objective is to validate the feasibility of the mobile intervention approach in people with CPD. Over the course of 12 months, we delivered CLIMB for 6 weeks via loaned tablets (iPads) to 27 participants recruited remotely from various locations in the United States and Canada. We evaluated adherence with study procedures, attrition rates, engagement metrics and acceptability of the intervention. In addition, we explored the effects of 6 weeks of CLIMB on measures of social cognition, quality of life and clinical symptoms. Finally, we explored possible predictors of engagement with treatment components, and examined whether engagement influenced changes in outcome measures.

Methods

Intervention Design

CLIMB consists of novel treatment components consisting of SCT exercises and ORGT.

Social Cognitive Training Exercises

The SCT computerized exercises used in the study are a subset of the social cognitive training suite called SocialVille, developed by Nahum et al, which aims to treat social cognition deficits targeting the impaired brain systems underlying social cognition [31]. The rationale for the training exercises has been reported elsewhere [31]. Briefly, the exercises harness the principles of brain plasticity, employing speeded, accurate and increasingly more challenging discriminations of socially-relevant information (eg, eye gazes, emotional faces, prosody, social situations). Participants progress through each exercise in a defined order of difficulty, generally moving from more simple levels (eg, easy to discriminate stimulus types, less response options) to more complex levels (eg, greater rule complexity, greater similarity between stimuli, etc). A single-arm open-label feasibility study of SocialVille delivered remotely to a small sample of young adults with psychosis found high adherence with the training requirements, and significant improvements on untrained measures of social cognition, social functioning, motivation and reward sensitivity [31].

The SCT exercises chosen in CLIMB target gaze perception, visual emotion perception, prosody, theory of mind, affective memory and attribution bias, as these core domains of social cognition are pervasively impaired in CPD and underlie most critical factors of real-world functioning including decreased quality of life and poorer community and occupational functioning [1,11-14]. A full description of the exercises is provided in Multimedia Appendix 1. The exercises are personalized, in that (1) the level of training difficulty and progression for each exercise is individually adaptive to ensure that each user is appropriately challenged; (2) although the total number of levels to be completed for each exercise is fixed and equal for all participants, they can choose any 4 of the 7 exercises to complete on every session; (3) participants can dynamically set the desired number of sessions to complete every week and monitor their progress in real-time; and (4) summary screens including game metrics (points) and exercise metrics (progress) are shown to the participant at the end of each level.

Optimized Remote Group Therapy

ORGT is an innovative integrated treatment approach that uses mobile technology to implement weekly group teletherapy sessions with group texting. In line with current recommendations for group therapy in CPD, individuals are grouped into cohorts of 3 to 6, within a similar age range (within 5 years) [32,33]. A master's level clinician leads the group teletherapy sessions and a moderator assists participants during ORGT by facilitating and organizing the sessions and by leading the group text chat.

Group Teletherapy Sessions

Participants attend weekly, 60-minute group teletherapy sessions. Sessions are based on recovery-model principles [34] and on the Raise Early Treatment Program Manual [35]. Prior to beginning the first group therapy session, two online surveys that assess current social difficulties and preference for topics to be discussed during the group teletherapy sessions are administered. The clinician evaluates data from these surveys to familiarize herself with the patient-centered goals. In the first session, after introductions, the clinician teaches Specific, Meaningful, Agreed Upon, Realistic, Timely (SMART) goals [36]. For every session, participants set a SMART goal appropriate to their level of recovery. The following sessions start with an initial check-in (approximately 10 minutes) where participants report on the SMART goal that they attempted during the week. This is followed by psycho-education and a discussion of shared experiences (approximately 15 minutes). Here, the clinician lets participants pick a topic. The topics covered include how to make friends, how to improve social skills, how to improve motivation, how to identify a relapse and how to succeed in a job or at school. Participants discuss the topic while the clinician moderates the conversation and invites participation by all members of the group. The clinician also contributes by sharing information, such as feedback on the importance of reciprocity in social relationships or ways to motivate yourself with rewards. The next segment of the session is dedicated to learning or practicing a skill (approximately 15 minutes). The skills covered include a variety of mindfulness techniques, social skills training and relapse prevention planning. Finally, participants set a personalized SMART goal for the upcoming session (approximately 10 minutes).

Group Text Chat

The group text chat is used between video calls to optimize group teletherapy by maintaining inter-treatment session continuity with participants, by helping engage them in study procedures and by offering more opportunities for social engagement and peer support. The clinician and the moderator use the group text chat to (1) supplement group teletherapy sessions by sending links and articles about information and topics discussed during the video calls; (2) notify the group of study updates; (3) remind the group of scheduled sessions and training requirements; and (4) message participants for remote technical support and solution-focused problem-solving. The moderator encourages participants to use the group text chat to share personal artistic projects with the group through links,

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videos, pictures, drawings, poems and quotes. The clinician and moderator promote a non-stigmatizing approach to psychotic experiences.

Feasibility Trial

Recruitment and Enrollment

For the pilot feasibility trial, study participants were recruited online: information about the study aims and procedures was posted on Craigslist, Reddit, the National Alliance on Mental Illness newsletter and our study website. Interested individuals contacted research staff via phone call, text or email. During the initial phone screening, study personnel verified that potential participants met the following inclusion criteria: (1) prior clinical diagnosis of schizophrenia, schizoaffective disorder or bipolar disorder with psychotic features, (2) age 18 to 65 years, (3) no neurological disorder or history of traumatic brain injury, (4) no substance dependence or serious substance use in the past 6 months, (5) current treatment with a mental health care provider, (6) no hospitalization in the last 3 months and no changes in psychiatric medications for at least 1 month, (7) visual, auditory and motor capacity to use an iPad, and (8) access to an Internet-connected device with a camera/webcam and an active email account. This last criterion was required in order to sign the consent form digitally and to undergo the eligibility diagnostic interview before iPad shipment.

After the initial phone screening, study personnel provided informed consent documents to participants remotely using Qualtrics (Provo, Utah, USA). Following the initial screening and consent, participants underwent a diagnostic evaluation using the Structured Clinical Interview for the Diagnostic and Statistical Manual of Mental Disorders-IV Text Revision (DSM-IV-TR) (SCID) [37], which was administered remotely by graduate-level psychology students, using the Health Insurance Portability and Accountability Act (HIPAA) compliant video-calling software Vsee (Vsee Lab, LLC, Sunnyvale, California, USA). Participants who met DSM-IV-TR criteria for schizophrenia, schizoaffective disorder or bipolar disorder (psychotic disorders) with psychotic features were enrolled in the study.

Study Procedures

The study procedures are depicted in Figure 1. After enrollment, participants were given the opportunity to use their own iPad or to receive a study iPad via the mail that will be loaned to them for the duration of the trial. Study apps were preinstalled on the loaned iPads before shipment. Next, a one-on-one phone call was arranged to orient participants to the various apps. Enrolled participants were then placed on a waiting list and as soon as at least 3 individuals of similar age were enrolled and ready to participate in the trial, the cohort was assembled and underwent the assessment battery remotely using iPads. Once all cohort participants completed the assessment battery, they were engaged in the intervention for 6 weeks.

ORGT was delivered through Google Hangouts, a free platform that offers group-based videoconferencing, text chats and multimodal file sharing. At the beginning of the intervention, the moderator created a Hangouts group open to the clinician, moderator and cohort participants, and contacted the participants on the group text chat to explain her role. In the group text chat, the moderator introduced each participant to each other and to the clinician, informed them of the privacy practices in the apps and encouraged them to be respectful of their peers' privacy. Next, the moderator invited participants to attend weekly, 60-minute group teletherapy sessions conducted through Google Hangouts video calls. In order to find a time that worked for everyone, the clinician, moderator and cohort participants indicated their availability using an online poll. During the 6 weeks of the intervention, the moderator was available online 8 hours a day, and kept the chat active in between sessions by contacting the group on a daily basis. Finally, all Hangouts interactions were archived and securely saved on Research Electronic Data Capture (REDCap), a HIPAA-compliant database.

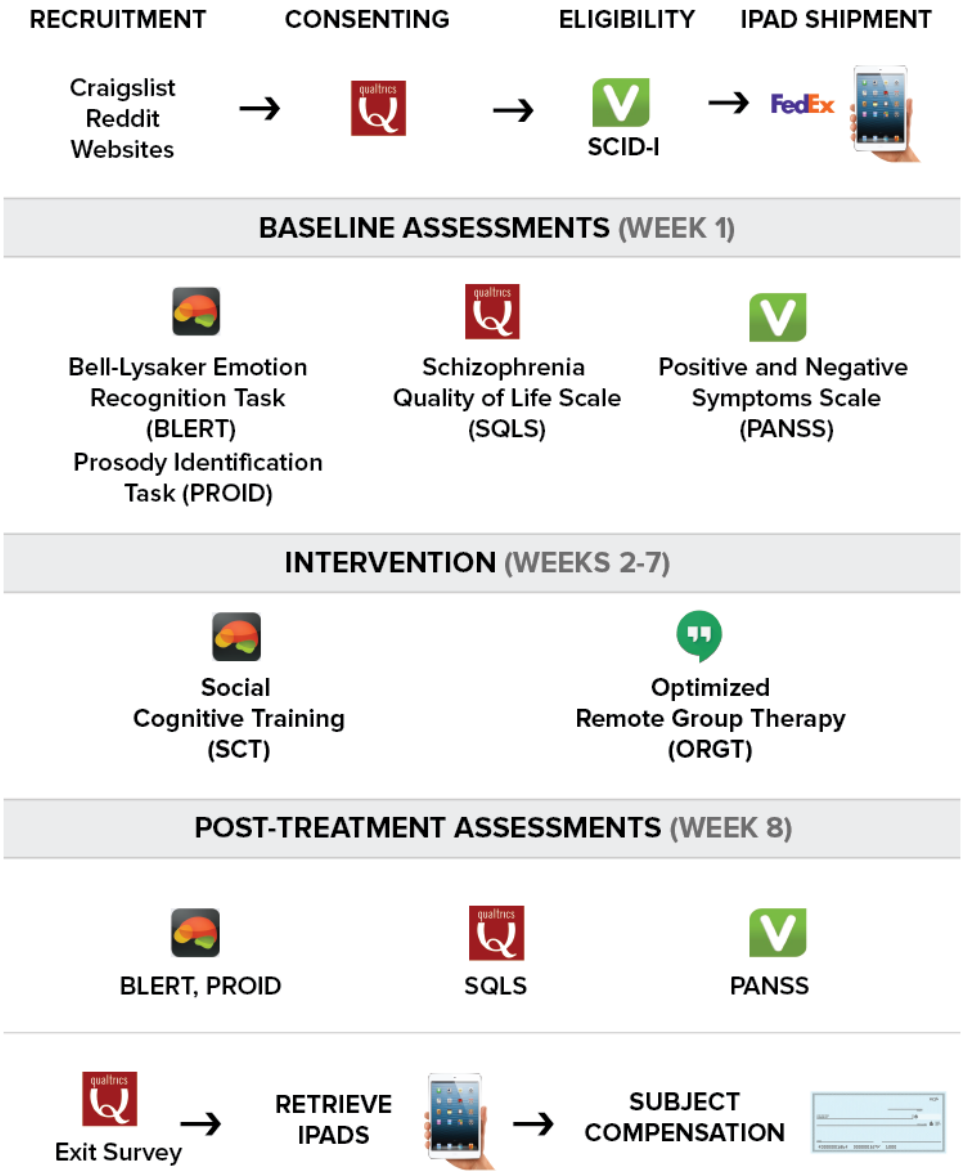
The SCT program was delivered through the BrainHQ-Research app and was provided free of charge by Posit Science Inc. Participants were encouraged to complete 18 hours of SCT over the course of 6 weeks, preferably for 3 hours a week. In each training session, participants engaged with 4 different exercises, performing each exercise for about 7.5 minutes. To access the SCT program, participants logged into BrainHQ-Research using a unique study-provided login that contained no personally identifiable information. The moderator tracked user performance and treatment compliance remotely using a secure online portal. Weekly one-on-one phone calls were scheduled to discuss with participants their compliance with SCT requirements. Individualized motivational interviewing techniques were used when necessary to increase training frequency and structure training schedules [38]. For participants who completed less than 1 hour of SCT in the previous week, check ins were intensified up to 3 times a week. While in the intervention, participants continued to receive treatment by their outside providers (eg, psychoeducation, psychotherapy, adjustments in medications as clinically indicated).

Within 1 week after finishing the intervention, participants were asked to complete the assessment battery on iPads. Finally, they were asked to fill out an online exit survey in which they rated enjoyment, ease of use, perceived benefits and ease of fit into daily schedule.

If participants returned loaned iPads undamaged and fully functional, they were provided monetary compensation for participating in the study via a mailed check. Participants who completed all study procedures successfully earned US $285. Participants were paid US $5 for each completed hour of SCT and each ORGT video call attended, and US $15 per hour for assessments. Participants were not compensated for their participation in the group text chat.

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Figure 1. Creating Live Interactions to Mitigate Barriers (CLIMB) study procedures.



Study participants were recruited online from various platforms and websites. After the phone screening, they signed informed consent documents digitally using Qualtrics. Next, they underwent a remote diagnostic evaluation (SCID), which was administered using the video-calling software Vsee. Once enrolled, participants received via mail an iPad, through which they completed an assessment battery. Next, they engaged in the CLIMB intervention for 6 weeks. CLIMB consists of a SCT program and ORGT. Within 1 week after finishing the intervention, participants completed the assessment battery on the iPad. Finally, they filled out an online exit survey. Upon the redelivery of the loaned iPad, they received compensation via check.

Assessments

Social Cognition

We assessed social cognition by means of the Prosody Identification Task (PROID) [39], and the Bell-Lysaker Emotion Recognition Test (BLERT) [40], two well-validated computerized tasks. These tasks measure two of the constructs that were trained, but distinct and independent from the specific SCT exercises used in the intervention. PROID is a vocal identification task that assesses a subject's ability to perceive and discriminate emotion in the speech of others. The test consists of 21 sentences of neutral content that are spoken aloud by male and female speakers to convey 1 of 7 different emotions (happiness, sadness, anger, fear, surprise, disgust and no emotion), as well as utterances with no emotional expressions. Participants first identify the emotional expression of each utterance and then rate the utterance's emotional intensity on a scale from 1 (very low intensity) to 9 (very high intensity). BLERT is an affect recognition task consisting of 21 short video clips in which an actor performs 1 of 3 dialogues while portraying 1 of 7 different emotions. Participants choose which of the 7 emotions listed on the screen best describes the affective quality enacted by the actor. For both tasks, trial-by-trial accuracy data are factorized for each emotion separately, and an overall accuracy score is also provided. iOS versions of BLERT and PROID were developed using original stimulus sets provided by the authors, embedded in the

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BrainHQ-Research app and administered without remote supervision. Alternate forms of PROID and BLERT were counterbalanced before and after the intervention.

Quality of Life

Quality of life was evaluated by means of the Schizophrenia Quality of Life Scale (SQLS) self-report questionnaire. SQLS is a 30-item questionnaire that requires a 7-day retrospective self-assessment of quality of life [41]. Results are scored using a 5-point Likert-type scale ranging from 1 ("Never") to 5 ("Always"). Total score ranges from 30 (best status as measured on the SQLS) to 150 (the worst status as measured on the SQLS). The scale comprises the "Psychosocial," "Motivation and Energy," and "Symptoms and Side-Effects" subscales, with the purpose of indicating the extent of difficulty on each domain. The "Psychosocial" subscale (15 items) addresses various emotional problems, for example, feeling lonely, depressed or hopeless, as well as feelings of difficulty mixing in social situations and feeling worried about the future. The "Motivation and Energy" subscale (7 items) addresses various problems of motivation and activity, such as lacking the will to do things, while the "Symptoms and Side-Effects" subscale (8 items) addresses issues such as sleep disturbance, blurred vision, dizziness, muscle twitches and dry mouth, which can be caused by medications. The SQLS was digitized and completed without supervision through iPads using Qualtrics.

Clinical Symptoms

Clinical symptoms were assessed using the Positive and Negative Syndrome Scale (PANSS) [42]. From the PANSS scores, 6 symptom dimensions were derived: Positive, Negative, Disorganized, Excitement, Depression and Anxiety, and Other [43]. PANSS were conducted over Vsee by graduate-level psychology students trained on manual assessment procedures and observed by expert clinical supervisors. A large body of literature suggests that assessment via videoconferencing in patients with CPD is equivalent to in-person and is tolerated and well-accepted [44].

Data Analysis Plan

To investigate the feasibility of CLIMB, descriptive statistics for recruitment, enrolment and retention rates, successful completion of remote assessments and iPad return rate were examined. Based on previous studies, we hypothesized that at least 75% of enrolled participants would complete the intervention [31], and that at least 85% of devices would be returned undamaged [45].

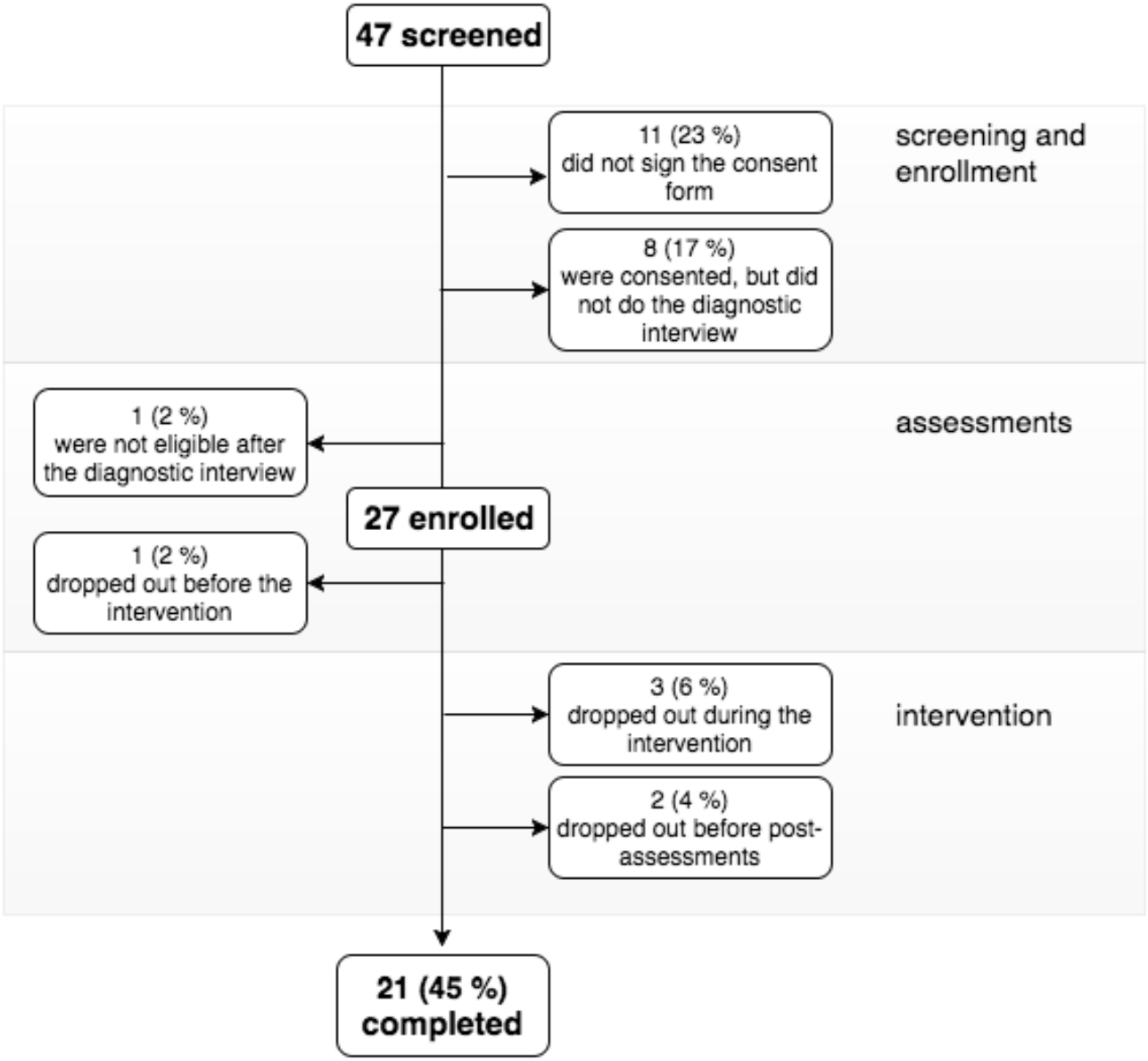
To investigate engagement in CLIMB, descriptive statistics for hours of SCT completed over the course of 6 weeks, attendance rate for group teletherapy and number of group chat messages and words were examined. Based on previous studies, we hypothesized that participants would complete at least 1 hour of SCT per week [31], participate in 80% of the group teletherapy sessions [22], and send at least 8 messages per week [30].

To investigate the acceptability of CLIMB, descriptive statistics from the CLIMB exit survey ratings for overall enjoyment, ease of use, ease of fit into daily schedule and perceived benefits were examined. We hypothesized ratings of at least 3 on the 5-point Likert scale items [31].

To explore the initial effects of CLIMB on study outcomes, we performed analyses on data obtained from all enrolled participants (N=27). Because we were interested in examining the ecological feasibility of CLIMB, we did not restrict the analyses only to participants who adhered to all intervention recommendations. Post-intervention data were not collected on 6 enrolled participants who dropped out at various stages of the intervention (see Figure 2). All outcome variables were normally distributed. Pre- to post-changes in outcome measures were examined using paired sample *t* tests. Within-group effect sizes (Cohen's *d*) were computed using the mean change scores (post-treatment minus baseline) and the change score standard deviations. Because there were inter-individual differences in terms of engagement with each treatment component, and some engagement metrics were not normally distributed, we used non parametric correlations to test whether (1) engagement metrics were correlated; (2) demographic variables, symptoms or quality of life correlated with engagement metrics; and (3) changes in outcome scores correlated with engagement metrics. In the cases of significant pre- to post-changes and/or significant associations of these changes with engagement metrics, we used repeated measures linear mixed modeling with a diagonal covariance structure to determine whether changes in outcome measures were influenced by engagement with the intervention. Given the study attrition rate (22%), maximum likelihood (ML) estimation was used. Because we had baseline measurements for all participants, and the amount of missing data was relatively modest, it is likely that the missing at random assumption for ML was met, suggesting that it is unlikely the model results would have significantly changed had dropouts been able to be followed.

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Figure 2. Consolidated Standards of Reporting Trials (CONSORT) flow diagram for Creating Live Interactions to Mitigate Barriers (CLIMB).



Results

Feasibility of Study Procedures

The Consolidated Standards of Reporting Trials (CONSORT) diagram of the study is shown in Figure 2. A total of 47 volunteer participants from 31 different states passed the phone screening over the course of 12 months (June 2015 to June 2016). Of these, 11 (23%, 11/47) never signed the consent form, 8 (17%, 8/47) were consented but did not participate in the SCID interview, and 1 (2%, 1/47) did not qualify after the SCID, leaving 27 participants enrolled in the study. Of these, 21 (78%, 21/27) completed all study procedures, 1 (3%, 1/27) dropped out during baseline assessments, 3 (11%, 3/27) dropped out during the intervention, and 2 (7%, 2/27) dropped out before post-treatment assessments. The reasons provided for dropping out included increased stress at work (n=1), symptom exacerbation (n=1), boredom (n=2), and unknown reasons (n=2). Over the course of 12 months, 7 cohorts were assembled.

All phone-screened participants reported being comfortable using an iPad; 85% (40/47) had easy and regular access to wireless fidelity (WiFi), 72% (34/47) had a desktop or laptop computer in their home and 70% (33/47) had their own mobile phone with app capabilities (smartphone). The demographic information and access to mental health services for enrolled participants (N=27) is displayed in Table 1 and the geographic distribution of enrolled participants is shown in Figure 3.

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Table 1. Demographic and baseline clinical and functional characteristics for the enrolled participants (N=27).

Characteristic	Mean (SD) or n (%)
Sex, n (%)	
Female	10 (37%)
Male	17 (63%)
Age (years), mean (SD)	28.1 (6.4)
Duration of illness (years), mean (SD)	7.0 (4.4)
Number of previous hospitalizations, mean (SD)	4.6 (4.0)
PANSS[a] total score, mean (SD)	59.2 (15.6)
SQLS[b] total score, mean (SD)	82.0 (15.9)
Education, n (%)	
Drop-out in high school	1 (4%)
High school degree	4 (15%)
Currently pursuing a college degree	11 (41%)
Drop-out during college	8 (30%)
College degree	3 (11%)
Medications, n (%)	
Taking antipsychotics	25 (93%)
Unmedicated	2 (7%)
Diagnosis, n (%)	
Schizophrenia	9 (33%)
Schizoaffective	15 (56%)
Bipolar disorder with psychosis	3 (11%)
Access to mental health services, n (%)	
Seeing a psychiatrist	18 (67%)
Seeing a case manager or nurse practitioner	7 (26%)
Seeing a psychotherapist	7 (26%)

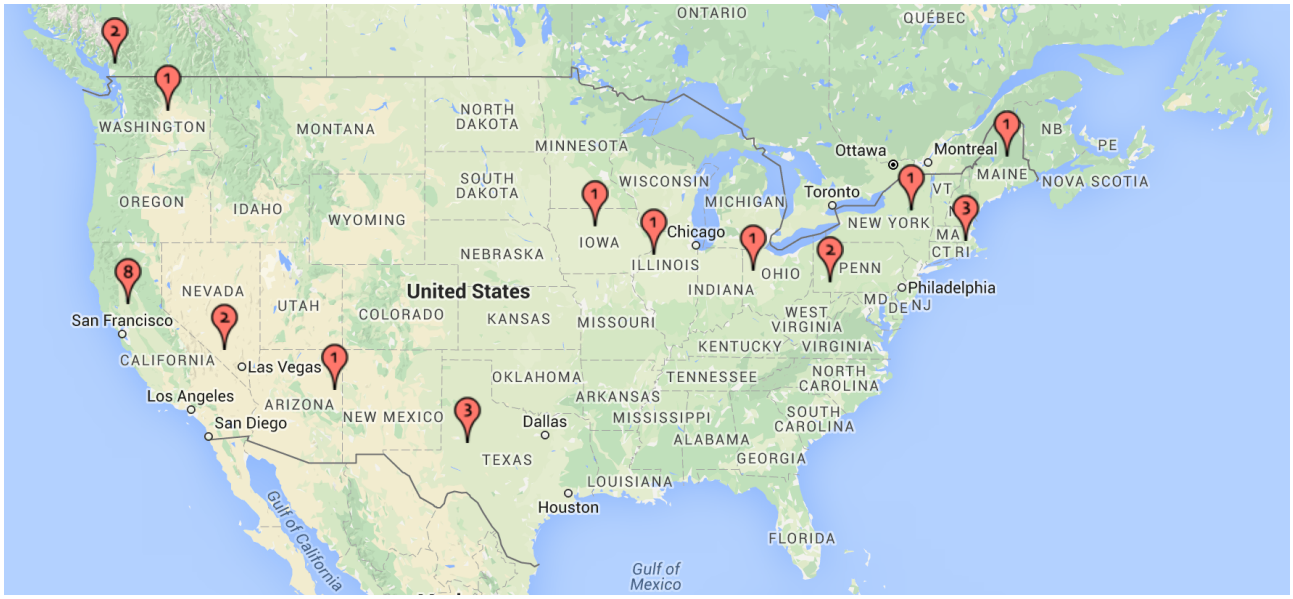
[a]PANSS: Positive and Negative Symptoms Scale.

[b]SQLS: Schizophrenia Quality of Life Scale.

Of the enrolled individuals, 4 (15%, 4/27) already had iPads. Consequently, iPads were shipped to 23 participants. Of those, 21 (91%, 21/23) were returned undamaged and fully functional, 1 (4%, 1/23) was initially withheld by an individual who dropped out of the study (and was retrieved with the help of the local police) and the final 1 (4%, 1/23) was never returned and was rendered unusable through remote deactivation. The administration of SCID interviews over Vsee was completed successfully with all enrolled participants. Of the enrolled individuals, 26 (96%, 26/27) completed the baseline assessment battery on iPads successfully, providing valid BLERT, PROID, SQLS and PANSS data.

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Figure 3. Geographic distribution of enrolled participants (N=27).



Engagement With Social Cognition Training and Optimized Remote Group Therapy

Participants were asked to complete 18 hours of SCT over the course of 6 weeks, but showed highly variable engagement, with a median of 9.5 hours of SCT completed (semi interquartile range of 6.3). In total, 6 participants (22%, 6/27) completed greater than 16 hours, requiring only brief weekly check ins; 8 (30%, 8/27) required regular weekly check ins and additional text reminders, and completed at least 6 hours; 8 (30%, 8/27) required intensive monitoring multiple times a week and trained 1 to 5 hours; and 4 (15%, 4/27) trained less than 1 hour and eventually dropped out, in spite of intensive monitoring. In addition, 46% (12/26) of participants completed less than 1 hour a week of training during the intervention. For a distribution of SCT hours, see Multimedia Appendix 2.

Participants attended on average 5.2 (SD 2.0) ORGT teletherapy sessions over the course of 6 weeks. Therefore, the average attendance rate for ORGT video calls was 84% (SD 28%). The participants' self-assessment of social difficulties and preference about topics to be discussed during the group teletherapy sessions are shown in Multimedia Appendices 3 and 4. More than 40% of the participants endorsed lack of energy, social isolation, social and emotional withdrawal and general expectancy of failure. The topics that ranked as very interesting by at least 50% of the participants were, in order of preference, improving social engagement, improving speech activity, improving social cognitive skills, learning about identification of stressors and training problem solving skills.

Engagement with the ORGT group text chat was variable. Over the 6 weeks of the intervention, the total number of messages posted in the group chat by all cohort users (moderator and participants) averaged across all cohorts, was 1201 (SD 2013). The median number of messages posted by each participant per week across all participants, was 5.2, with a semi interquartile range of 12.8. The median number of words sent per participant per week was 37, with a semi interquartile range of 200. The median length of a message was 9.4 words, with a semi interquartile range of 5.1. We also calculated the ratio of moderator messages to participant messages. For instance, a ratio of 2:1 would mean that for every 2 messages sent from the moderator to participants in the group chat, each participant would post 1 message. When averaging across cohorts, we found a mean ratio of 0.97:1 (SD 0.30). The ratio reflects similar degrees of contribution to the group chat from the moderator and participants.

The attendance rate for group teletherapy positively correlated with hours of SCT completed (r=.484, P=.01), and with average number of words per message per participant (r=.44, P=.04). However, hours of SCT did not correlate with any ORGT messages and/or words metrics (all P values greater than .20).

At a qualitative level, we observed a wide range of contributions to ORGT: approximately 30% of participants were proactive during the group teletherapy sessions and sent text messages multiple times a week to the group chat, showing curiosity and appreciation, and engaging other participants in dynamic interactions; approximately 30% contributed only after encouragement from the clinician/moderator during the group teletherapy sessions and in the group text chat; and approximately 20% showed minimal contribution during the group teletherapy sessions, and left most engagement attempts in the group text chat unaddressed. Finally, original multimedia content was created by participants during the intervention and shared through Hangouts [46,47].

Acceptability of Creating Live Interactions to Mitigate Barriers (CLIMB)

Upon study completion participants completed an online exit survey to rate their experience with CLIMB. The first component of the survey was a 23-item questionnaire that asked participants to indicate how much of the time they felt that each statement was true, using a 5-point Likert scale with 1 corresponding to "none of the time" and 5 to "all of the time." Items were grouped into 4 categories, and the following averaged ratings were obtained: (1) Enjoyment/Satisfaction had a rating of 2.99 (SD 1.09), where 3 corresponds to half of the

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time; (2) Program Clarity/Ease of Use had a rating of 4.18 (SD 0.90); where 4 corresponds to most of the time; (3) Ease of Fit had a rating of 2.91 (SD 1.20); and (4) Perceived Benefits had a rating of 3.25 (SD 1.18). The complete list of items is included in Multimedia Appendix 5.

Finally, participants indicated what they liked best about the program and what kept them from adhering to CLIMB according to the recommended schedule. In summary, participants enjoyed participating in the ORGT group teletherapy sessions because of the positive, non-stigmatizing experience of social support from staff and peers during the sessions. They also appreciated being able to access the intervention from home, and speaking with other participants from a safe and protected environment. Internet technical difficulties, symptom exacerbation, low perceived value of the treatment, motivational deficits, employment burden and lack of time were self-reported as reasons for low engagement with CLIMB.

Exploratory Outcomes

Significant improvements were found in pre- to post-measures of identification of vocal emotional prosody for happiness (P=.001) and happiness intensity (P=.04), as indexed by PROID (see Table 2). Participants also showed significant improvements in their ability to detect anger in a video vignette (P=.04), as indexed by BLERT. For these outcomes, effect sizes were large (d=.60 to d=.86). Trend-level improvements were observed on the SQLS total score, and "Psychosocial" (P=.09) and "Motivation and Energy" (P=.06) subscales. No significant changes were observed for PANSS ratings.

Table 2. Pre- to post-changes and effect sizes for outcome measures in study completers (N=21).

Outcome measure	Baseline, mean (SD)	Post, mean (SD)	Paired samples, *t* (sig)	Effect size, *d*
PROID[a] accuracy in detecting, %				
Happiness	0.35 (0.20)	0.54 (0.25)	–4.06 (0.00)	.86
Happiness intensity	0.37 (0.18)	0.52 (0.27)	–2.26 (0.04)	.68
Overall	0.58 (0.14)	0.59 (0.14)	–0.63 (0.54)	.11
BLERT[b] accuracy for detection (%)				
Anger	0.78 (0.30)	0.92 (0.15)	–2.26 (0.04)	.60
Overall	0.72 (0.18)	0.80 (0.19)	–1.60 (0.13)	.42
SQLS[c]				
Psychosocial	44.59 (9.58)	40.88 (10.71)	1.83 (0.09)	.36
Symptoms and side effects	18.65 (5.01)	18.18 (4.49)	0.48 (0.64)	.10
Motivation and energy	20.12 (3.55)	18.76 (3.70)	2.04 (0.06)	.37
Total score	83.35 (16.22)	77.82 (17.14)	1.76 (0.10)	.33
PANSS[d]				
Negative symptoms	2.33 (1.02)	2.63 (0.98)	–2.07 (0.09)	–.29
Total score	60.81 (16.23)	61.05 (9.97)	–0.08 (0.94)	–.02

[a]PROID: Prosody Identification Task.

[b]BLERT: Bell-Lysaker Emotion Recognition Test.

[c]SQLS: Schizophrenia Quality of Life Scale.

[d]PANSS: Positive and Negative Symptoms Scale.

Less severe negative symptoms at baseline correlated with total number of words (r=–.497, P=.022) and messages (r=–.479, P=.028) posted per participant on the group text chat during the 6 weeks of the intervention. In addition, total number of words posted per participant on the group text chat correlated with shorter duration of illness (r=–.497, P=.022). Post-intervention outcomes were not inter-correlated. We found positive associations at trend level between hours of SCT completed and gains in total SQLS (r=.448, P=.071), SQLS "Psychosocial" (r=.455, P=.067) and SQLS "Motivation and Energy" (r=.460, P=.063). The results from the linear mixed models are shown in Multimedia Appendix 6. Hours of SCT did not have significant effects on the pre- to post-changes in the linear mixed models.

Discussion

Principal Findings

In this study, we tested the feasibility of CLIMB, a mobile psychosocial intervention designed to enhance social functioning in people with CPD. Using Internet-connected iPads, we delivered CLIMB for 6 weeks to people with CPD recruited remotely from 31 locations throughout the United States and Canada. We found that CLIMB is a highly feasible intervention with high enrolment, retention, iPad return and remote assessment completion rates. In particular, the attrition and device return rates in our study are similar to other studies testing mobile phone apps in patients with psychotic disorders [29,45]. Taken together, these findings indicate that delivering

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assessments and treatments remotely to people with CPD using mobile platforms is highly feasible.

In line with other mobile interventions for serious mental illness[48], engagement with the CLIMB treatment components was variable. The attendance rate for ORGT group teletherapy sessions was high (84%, SD 28%), and comparable to that of in-person group therapy approaches [22]. Despite significant efforts to monitor, support and keep participants engaged in SCT, 46% (12/26) of participants completed less than 1 hour a week of training during the intervention. One possible explanation of this differential engagement is that completion of SCT exercises requires sustained effort, focused attention and active planning and engagement by the user, whereas participation in ORGT may be less effortful, more directly rewarding and require less actively focused attention. Similar to previous studies [30], participants engaged in ORGT group text chatting multiple days a week. There were, nonetheless, inter-individual qualitative differences in terms of contribution such that some individuals engaged actively in text-based conversations with the group and shared original content (short videos, pictures, drawings, poems), while the majority of the users contributed marginally or minimally to the group text chat. This heterogeneity may partially be explained by the fact that contributions to the group text chat were not compensated. Baseline characteristics likely account for these inter-individual differences, where we found that participants with shorter duration of illness and fewer negative symptoms posted more words in the group text chat, though they did not complete more hours of SCT or showed higher attendance rate in the group teletherapy sessions. These findings suggest that the group text chat is a desired modality of social engagement particularly for individuals recently diagnosed with a psychotic disorder who have less severe negative symptoms. Interestingly, the higher attendance rate in ORGT group teletherapy sessions was associated with more hours of SCT and longer messages in the group text chat, whereas hours of SCT did not correlate with group text chat metrics, possibly suggesting that engagement in remote video calls had a positive effect on engagement in the other components of treatment.

The overall acceptability of CLIMB was medium, as reflected in the satisfaction ratings endorsed in the exit survey about ease of use and perceived benefits, as well as the retention rate. Participants valued the ease of use of the CLIMB apps, the ability to access the intervention from a safe and protected environment, and they felt comfortable and accepted when sharing subjective experiences with staff and other participants. Finally, 5 (19%, 5/27) participants provided unsolicited qualitative feedback about their participation (for representative excerpts, see Multimedia Appendix 7). Qualitative and quantitative data about acceptability collected from study participants in this pilot will inform future iterations on intervention development and optimization to meet the expectations and preferences of prospective service users.

We also examined the effect of 6 weeks of CLIMB on outcomes. We found significant pre- to post-intervention improvements on specific aspects of social cognition (prosody identification of happiness and recognition of anger) with large effect sizes, and trend-level improvements on quality of life self-reports, with medium effect sizes for the “Psychosocial” and “Motivation and Energy” subscales. Although there are currently no rigorous studies testing remote SCT in CPD, our within-group effect sizes for social cognition outcomes are comparable to recent reports of in-person SCT [16]. Improvements in quality of life self-reports showed trend-level relationships with hours of SCT completed. An appropriately powered, randomized controlled trial is required to determine whether CLIMB induces improvements in social cognitive outcomes, clinical symptoms, and quality of life.

Limitations

Our study had several limitations. We recruited exclusively using the Internet, which most likely biases the sample, making it not representative of the larger population of individuals living with CPD. More than 70% of participants who passed the phone screening had a mobile phone, a desktop and/or laptop computer in their home and regular access to WiFi, whereas a recent meta-analysis found that mobile phone ownership among people with CPD was only 35% [49]. However, several lines of evidence now indicate that people with CPD already use their mobile devices to manage their illness and promote their recovery, and that mobile devices are an acceptable mental health method to deliver innovative interventions to people with CPD. For example, in surveys of mobile interventions acceptability, over half of the patients with CPD responded in favor of using mobile devices for tracking and/or monitoring their mental health, and for facilitating patient contact with health professionals [49]. As well, a large sample of individuals with CPD surveyed online reported that Web-based technology helped with identifying coping strategies and connecting for support with family and friends [50]. In addition, a convenient sample of young people recruited from two specialized early intervention programs for psychosis manifested interest in using the Internet, social media and mobile technologies for receiving mental health-related services [51]. Finally, a recent comprehensive review found high acceptability of delivered online and mobile interventions for serious mental illness, particularly when participants were provided remote online support, with the majority of studies reporting no effects of age, sex, educational level or clinical characteristics on acceptability [48]. While these findings provide evidence that acceptability is unlikely to represent a barrier to the implementation of CLIMB in mental health care settings, more problematic is the generalizability of the findings about intervention use, as less tech-oriented individuals with CPD may still find the approach acceptable, but not sufficiently engaging.

Two other factors contributed to the sampling bias. In order to be enrolled in the study, participants had to have awareness of their illness and be receiving mental health care. In our sample, 93% (25/27) of study participants were taking antipsychotic medications and 67% (18/27) were seeing a psychiatrist. These rates of mental health care use are much higher than the general CPD population in the United States, where at least 40% of people with CPD have no contact with mental health services [52]. As CLIMB has been designed to meet the needs of those who are unable or unwilling to come in to mental health clinics to access treatments for social functioning, future research will seek to recruit a mixed sample of service users directly drawn

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from diverse community-based settings and non-service users in order to examine engagement patterns on a more representative sample of patients with CPD. As inadequate engagement may detrimentally impact efficacy, dose-response studies will also be conducted to determine the necessary intervention duration and intensity to drive meaningful improvements in outcomes.

While it is true that the high recruitment and retention rates found in the study are likely the result of the sampling bias that may limit the generalizability of the findings and the ability to draw conclusions about the scalability potential of CLIMB, our sample nonetheless reflects a segment of younger individuals with CPD who are technology oriented, actively engaged in their recovery and treatment and for whom digital platforms seem to be a preferable intervention delivery modality [51].

Since the goal of this pilot study was to assess the feasibility of delivering CLIMB remotely and not its efficacy, we did not include a control group. We also did not place restrictions on medication regimens during study participation. Therefore, we cannot rule out non-specific effects of study participation and medication effects on the observed improvements on proximal measures of social cognition. In addition, the fact that participants were provided remuneration for each ORGT session attended and each hour of SCT completed, likely biased the data about engagement and adherence. Therefore, our results may not translate to real-world settings where this payment schedule may not be provided. Cost-effectiveness analyses and focus groups will be conducted to devise scalable solutions for sustained engagement that match users' preferences and expectations. Finally, the current support protocol may be manageable for CLIMB moderators when serving small cohorts of patients, but may require significant adaptations to disseminate effectively.

Conclusions

We demonstrated that it is feasible to target improvements in social cognition in people with CPD using an innovative and scalable treatment package that is delivered remotely, and that combines structured training of social cognitive abilities with a group-based, multimodal, ecological psychotherapeutic intervention. Future efficacy studies will evaluate the degree of improvement in various domains, including social functioning, social cognition, clinical symptoms and quality of life.

More importantly, results from this study indicate that it is feasible and acceptable to engage people with CPD in remote assessments and treatment using mobile devices. This has important implications in terms of access, engagement and dissemination of mental health services. First, providers will be able to interact with mobile interventions to monitor patient status remotely and provide inter-session extended support, at minimal costs and without requiring local infrastructures. Second, patients living in under-resourced areas who are unable or unwilling to come in to the clinic can benefit from specialized treatment options that may not be available locally. If successful, this approach has far-reaching implications for public health. As our knowledge of how to deliver effective treatments using remote digital technology grows, we will be able to reduce disparities in mental health outcomes, and promote equity in access to mental health care.

Acknowledgments

The authors thank Kevin Delucchi for his statistical consultation. They also thank Charlie Ward, Ken Casaletto and Sophia Quraishi, members of the CLIMB lab at University of California, San Francisco (UCSF) for their dedicated efforts and contributions to achieving the reported results. Finally, the authors also thank the patients for participating in the study. This publication was supported by the National Center for Advancing Translational Sciences, National Institutes of Health, through UCSF-CTSI Grant Number UL1 TR000004. Its contents are solely the responsibility of the authors and do not necessarily represent the official views of the NIH.

Conflicts of Interest

The cognitive training software, BrainHQ-Research, used in this study was supplied free of charge by Posit Science. Dr Vinogradov is a site primary investigator on a *Small Business Innovation Research* (SBIR) grant to Posit Science, a company with a commercial interest in the cognitive training software used in these studies. Dr Nahum was an employee of Posit Science at the time of the study and is the developer of the SocialVille program. None of the other authors have any financial interest in Posit Science. All authors declare no other conflicts of interest.

Multimedia Appendix 1

Descriptions of the social cognitive training (SCT) exercises.

[PDF File (Adobe PDF File), 354KB - mental_v3i4e52_app1.pdf]

Multimedia Appendix 2

Distribution of hours of social cognitive training completed over the course of 6 weeks (n=26). Each bar represents a Creating Live Interactions to Mitigate Barriers (CLIMB) participant.

[PDF File (Adobe PDF File), 53KB - mental_v3i4e52_app2.pdf]

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Multimedia Appendix 3

Results from the online survey administered at baseline to assess current social difficulties.

[PDF File (Adobe PDF File), 152KB - mental_v3i4e52_app3.pdf]

Multimedia Appendix 4

Results from the online survey administered at baseline to review preferences for topics to be discussed during optimized remote group therapy (ORGT) sessions.

[PDF File (Adobe PDF File), 150KB - mental_v3i4e52_app4.pdf]

Multimedia Appendix 5

Quantitative data from the online exit survey. A 5-point Likert scale was used to determine how much of the time participants felt that each statement was true with 1 corresponding to none of the time, 2 to a little bit of the time, 3 to about half the time, 4 to most of the time, and 5 to all of the time (n=21).

[PDF File (Adobe PDF File), 151KB - mental_v3i4e52_app5.pdf]

Multimedia Appendix 6

Linear mixed models for outcome variables adjusting for hours of social cognition training (SCT) and using maximum likelihood (ML) estimation (N=27).

[PDF File (Adobe PDF File), 149KB - mental_v3i4e52_app6.pdf]

Multimedia Appendix 7

Excerpts of feedback provided by Creating Live Interactions to Mitigate Barriers (CLIMB) participants.

[PDF File (Adobe PDF File), 214KB - mental_v3i4e52_app7.pdf]

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Abbreviations

BLERT: Bell-Lysaker Emotion Recognition Test
CET: cognitive enhancement therapy
CLIMB: Creating Live Interactions to Mitigate Barriers
DSM-IV-TR: Statistical Manual of Mental Disorders-IV Text Revision
HIPAA: Health Insurance Portability and Accountability Act
IPT: integrated psychological therapy
ML: maximum likelihood
ORGT: optimized remote group therapy
PANSS: Positive and Negative Symptoms Scale
PROID: Prosody Identification Task
SCID: Structured Clinical Interview for the DSM-IV-TR
SCT: social cognition training

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SMART: Specific, Meaningful, Agreed Upon, Realistic, Timely
SQLS: Schizophrenia Quality of Life Scale
WiFi: wireless fidelity

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Original Paper

Development of a Mobile Phone App to Support Self-Monitoring of Emotional Well-Being: A Mental Health Digital Innovation

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Abstract

Background: Emotional well-being is a primary component of mental health and well-being. Monitoring changes in emotional state daily over extended periods is, however, difficult using traditional methodologies. Providing mental health support is also challenging when approximately only 1 in 2 people with mental health issues seek professional help. Mobile phone technology offers a sustainable means of enhancing self-management of emotional well-being.

Objective: This paper aims to describe the development of a mobile phone tool designed to monitor emotional changes in a natural everyday context and in real time.

Methods: This evidence-informed mobile phone app monitors emotional mental health and well-being, and it provides links to mental health organization websites and resources. The app obtains data via self-report psychological questionnaires, experience sampling methodology (ESM), and automated behavioral data collection.

Results: Feedback from 11 individuals (age range 16-52 years; 4 males, 7 females), who tested the app over 30 days, confirmed via survey and focus group methods that the app was functional and usable.

Conclusions: Recommendations for future researchers and developers of mental health apps to be used for research are also presented. The methodology described in this paper offers a powerful tool for a range of potential mental health research studies and provides a valuable standard against which development of future mental health apps should be considered.

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KEYWORDS

eHealth; emotions; mental health; mobile phone; feedback

Introduction

Background

Emotional well-being is broadly defined [1] as, "a positive sense of well-being and an underlying belief in our own and others' dignity and worth" by the Mental Health Foundation (p. 8). Consistent with dual models of well-being, it encompasses both positive functioning (happiness, a sense of control and self-efficacy, and social connectedness) and an absence of stress and depression [2,3]. Monitoring changes in emotional well-being is fundamental to mental health, with increases in emotional well-being associated with resilience, creative thinking, social connectivity, and physical health [4-9]. In

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contrast, significant and sustained decreases in emotional well-being are associated with the development of affective disorders such as depression and anxiety, and reduced physical health [4,5,7].

Monitoring for such changes is crucial for early detection of mental health problems. Rapid response to early risk indicators is one of the key predictors of better health outcomes, enabling preventative health approaches to be initiated early [10]. Regular monitoring of emotional health indices is therefore recommended by various national guidelines [11,12]. In practice, however, it remains difficult for clinicians or professional mental health service providers to obtain frequent monitoring in real time [13,14]. A priority challenge facing the health care system is to achieve practicable and sustainable means of supporting self-management of health and well-being. Self-monitoring is a particularly attractive goal for mental health care, given that many individuals with mental health needs do not seek professional health care support [15-17]. In addition, self-monitoring may develop an individual's insight into their need to seek help. In particular, young people consistently indicate that they prefer nonprofessional or self-managed strategies for addressing mental health issues [18,19]. Obtaining temporally sensitive (eg, daily) information on significant changes in emotional state has the potential to profoundly improve the capacity to promote emotional health [12].

Experience sampling methodologies (ESMs), or ecological momentary assessments, involve the systematic collection of self-report data from individuals at multiple time points throughout their everyday lives [20]. ESMs have been used to monitor changes in affective state, and to predict mental health with success to a certain extent [21,22]. In particular, the variability in emotional state over time provides more substantial information for understanding the causes and nature of psychopathology than do cross-sectional "snapshot" assessments. For example, when sampled multiple times a day for 6 days, negative affect was found to vary more in patients diagnosed with major depressive disorder than that in controls across the day [23]. ESM assessments in individuals diagnosed with panic disorder also revealed that the expectation of a panic attack was a significant precursor for the occurrence of a panic attack [24]. Ben-Zeev et al [25] also found that patients diagnosed with a major depressive disorder retrospectively reported higher levels of symptoms relating to anhedonia, suicidality, and sadness than captured in their ESM reports, highlighting the biases of traditional survey methods. To date, however, it has been methodologically difficult and obtrusive to obtain temporally regular and precise measures of emotional state [21]. The resources required to obtain such information repeatedly over lengthy time frames have made such an intensive monitoring prohibitive. In addition, the use of palm pilots and pagers (which were never as familiar to users as mobile phones have become) to prompt users for this information can be intrusive, and makes it less likely that users will continue to use this form of monitoring for extended periods [26].

Mobile phone technology offers an unprecedented opportunity to unobtrusively track everyday behavior and changes in emotional state, all in real time [27,28]. Mobile phone health tools also offer the potential of immediate response to the outcome of this monitoring via delivery of mental health information contingent on changes in real-time emotional state [29]. This technology has not yet been fully leveraged for these purposes, despite mobile phones being one of the few pieces of technology that most people carry on their person every day [30]. This pervasiveness means that mobile phones offer a highly natural and regular means by which information on emotional state could be obtained. Mobile phones now penetrate 77%, 72%, and 68% of the Australian, US, and UK population, respectively [31], and are a cost-effective means of seeking help for mental health issues that may overcome socioeconomic and geographic boundaries [32,33].

Mobile phone health technology holds great potential for facilitating the management of emotional health through its ability to deliver flexible, user-oriented intervention and self-management tools; a feature particularly relevant for young people who often report fear of stigma associated with seeking professional services for sensitive mental health issues [34,35]. In a 2010 study, 76% of an Australian sample reported being interested in using mobile phones to monitor and manage their own mental health [32]. A large number of mobile phone apps are currently available that claim to promote mental health and well-being [36,37] and a subset of these also attempt to track mood or emotional state over time. However, empirical support for the efficacy of these apps is extremely limited [36]. For instance, in a systematic review of 5464 mental health app abstracts, less than 5 apps were found to have experimental evidence [37]. In addition, a few have capitalized on the benefits enabled by the mobile phone technology such as experience sampling and automated data collection in identifying and evaluating potential time-sensitive behavioral indicators of mental health change [36].

Of the mobile phone mental health programs that have utilized ESM to track mood over time, several favorable outcomes have been reported. For example, Reid et al [28,38] found that the majority of their adolescent sample using the mobile phone-based mental health app, *mobiletype*, completed their self-assessments, and that the use of the app increased the practitioners' understanding of their patients' mental health. Harrison et al [29] reported that the use of the mobile phone accessed Web-based cognitive behavioral therapy (CBT) course *MyCompass* for 6 weeks significantly reduced symptoms of depression and anxiety and improved self-efficacy. One of the barriers to sustainability of user engagement in such programs, however, is that they require extensive voluntary input from the user. When evaluated, a common theme is initial compliance, followed by high dropout and poor self-reporting rates (eg, less than 10% of the sample trialing *MyCompass* reported using it every day) [29]. Reasons for discontinued use include problems understanding how to use the program, invasiveness of the questions, the need for repetitive completion of questionnaires, insufficient personalization of the mental health advice, and little motivation to engage with the program [28,29].

An innovative way to meet this challenge is to monitor indices of emotional health using methods that require minimal insight or subjective report from the user. Mobile phones contain a range of embedded sensors and features, including accelerometers and global positioning systems and apps, which

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can automatically record information about a user's behavior [39]. Two recent studies have obtained a combination of data from mobile phones in an attempt to predict participants' self-reported mood. LiKamWa et al [40] found that up to 93% of mood scores were accurately predicted by social activity, physical activity, and general mobile phone use data collected from mobile phones. Asselbergs et al [41] attempted to predict self-reported mood of 27 participants from metadata of 6 mobile phone indices (phone calls, text messages, screen time, app usage, accelerometer, and phone camera events). Although the accuracy of the models was no greater than models obtained without mobile phone data, the methodology was demonstrated to be technically feasible and to hold promise. The authors recommended that inclusion of more meaningful or relevant features from mobile phone data may be the key to improving prediction.

Interestingly, young people use mobile phones for music listening, fitness, and social networking more than any other demographic [42], and these are among the most effective strategies for optimizing emotional health [43-46]. For example, the frequency of app-switching and the content of social network messages were found to predict depression [43] even prior to its onset [47]. Music listening patterns also appear to predict emotional health [48-50] and given that approximately two thirds of music listening by young people is via mobile devices such as mobile phones [31], it is surprising that relatively few apps have attempted to use music for this purpose [27]. Vocal expression too has been found to be a useful index of emotional state [51,52]. Short voice samples have been found to demonstrate 70% accuracy for simple affect recognition [53]. Monitoring a combination of behavioral indices such as physical activity, online social interactions, and music choices therefore offers a promising means of nonintrusive but sensitive assessment of affective state. Advances in statistical methods available through machine learning also enable powerful analysis of this more complex level of individualized multilevel modeling [52,54].

Another limitation of most mental health apps currently available is that they tend to simplify the emotional well-being spectrum, with positive and negative affect anchors on a unidimensional rating scale. Contemporary conceptualizations of well-being however clearly show that optimal "emotional health and well-being" does not emerge from an absence of affective disorder alone, but also requires a state of positive functioning [2,55,56]. Although positive and negative emotional functioning are correlated, there is substantial evidence that they are orthogonal constructs [57]. Mobile phone technology that differentiates the quadrants created by categorizing according to mental illness or languishing and mental health or flourishing [3,55] is therefore encouraged.

Objective

In this paper, we capitalized on the extraordinary role that mobile phones play in people's lives to develop a tool that has the potential to significantly extend the understanding of emotional health and well-being. The aim of this paper was to describe the design of the mobile phone app, *MoodPrism*, which was developed to monitor emotional well-being in context and in real time, and provide personalized feedback on the full spectrum of emotional well-being. The paper describes in detail the design and data collection functions of the app, which were incorporated to address major challenges for mental health research and practice, and presents feedback from a small sample of trial users (beta-testers), which tested the functionality and usability of the app.

Methods

Design and Development of the App

MoodPrism was designed and developed in collaboration with a commercial digital creation studio, Two Bulls (Melbourne, Australia). The app was prepared for both the iOS and Android mobile phone platforms and was distributed by the Web-based Apple and Google Play stores, respectively. The term "*MoodPrism*" was selected to reflect its primary purpose of collecting emotional state data across the entire spectrum of emotional health and well-being and converting this into an array of color-coded feedback to the user.

The development of *MoodPrism* involved designing 3 different methods of data collection within the software: (1) automated monitoring of selected online behavior, (2) experience sampling of emotional well-being self-reports, and (3) psychological assessment questionnaires. automated monitoring of selected online behavior, experience sampling of emotional well-being self-reports, and psychological assessment questionnaires. This triangulation of data collection is considered crucial for advancing the measurement of emotional state [58]. As part of the sign-up procedure to the app, permissions for sensitive data had to be obtained. Incentives to continue collecting data over an extended period were also generated.

The development of *MoodPrism* was completed in March 2015. The required forms of data collection were achieved by developing a suite of app components, which were then collated into a cohesive app. The outcomes of this development process are described in the following.

Sign Up

As part of the sign-up procedure for the app, options were offered to users to provide the app with access to social networking and music apps as well as general (postcode) location. These data were then collected continuously and without the need for user input over the month's research period. After sign up and consent procedures, *MoodPrism* administered the initial surveys that could be completed in multiple sittings and required 30-60 min in total to complete. The participants were then requested to use the app for at least thirty days, during which they would be prompted daily to answer a set of short questions, and weekly to complete a short audio recording. If they were unable to respond to daily prompts, *MoodPrism* advised they could complete them at a time of their convenience till midnight that day, or alternatively to ignore them. At the end of the 30 days, users were invited to complete a final set of surveys, which in total required 15-30 min to complete.

Users were incentivized to continue using *MoodPrism* through 3 strategies. First, daily mood and mental health feedback was provided to the user, with additional feedback unlocked after

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sustained use (Multimedia Appendix 2). This promoted engagement by rewarding users and encouraging feelings of achievement, adhering to principles of gamification [59], which is recommended in mental health apps [36]. Second, completion of daily reports as well as the final surveys generated entries into a draw for 1 of the 4 $AU100 (approximately US $75) gift vouchers. Third, users were informed that their data were contributing to research into the value of mobile phone apps for monitoring mental health and well-being.

Automated Monitoring

MoodPrism acted as a portal for data accessed via several mobile phone sensors and apps. Two validated predictors of emotional state change were targeted: music use and web-based social network site activity. As a part of the sign-up process, users were invited to give permission for the app to access Facebook, Twitter, the user's music library, and location (postcode only).

Facebook, Twitter, and music use data were collected once every 24 h, and the information collected is provided in Multimedia Appendix 1. Data were accessed from Facebook and Twitter through their relevant application programming interfaces (APIs). This allows third-party access to selected data collected by both Facebook and Twitter. Facebook and Twitter content was analyzed automatically and locally on the user's phone using several linguistic dictionaries from the Linguistic Inquiry and Word Count (LIWC) [60]. Summaries were obtained for frequencies of emotion words, which were supplemented with a range of emoticons and Internet slang expressions for emotions. Social words and personal pronoun counts were also obtained. A word count for the target categories in the dictionary was extracted and these counts were uploaded to the server. This was repeated every 24 h to collect the posts that occured across the duration of *MoodPrism* use. The post content temporarily stored by *MoodPrism* was then deleted.

Experience Sampling

MoodPrism utilized ESM to deliver a short set of questions to users daily (Figure 1). Prompts were delivered at a quasi-random time between user-defined hours (eg, 9:00 am-9:00 pm) for 30 days.

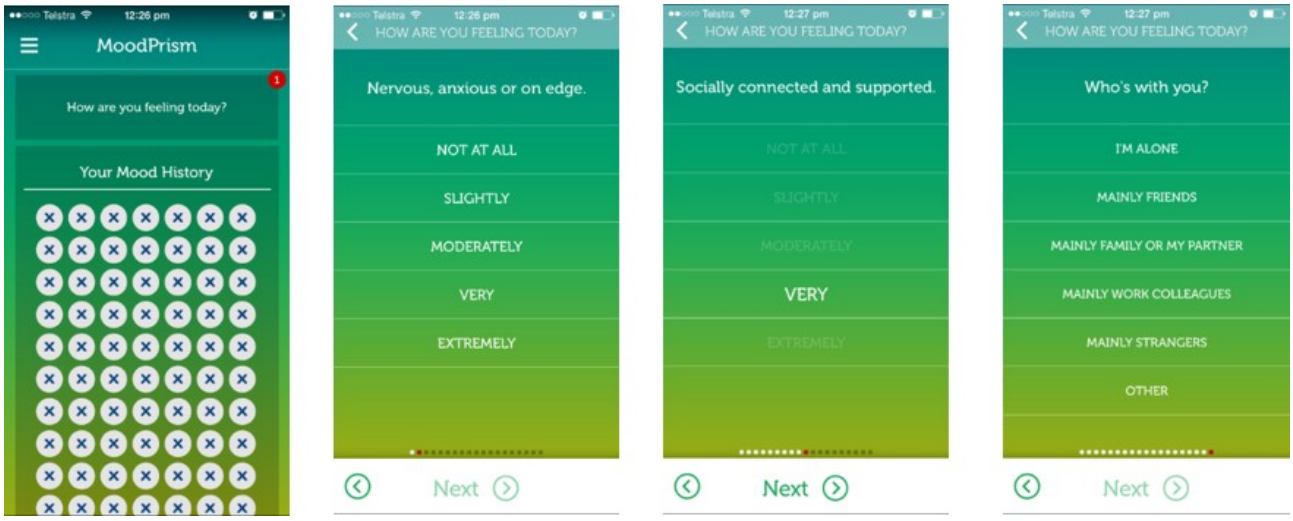
The questions captured a real-time assessment of the user's emotional well-being, event-related experiences, and their context. Emotional state questions comprised 4 questions on psychological illhealth (depression and anxiety), 4 on emotional state (positive and negative affect, arousal, and control), and 4 on positive functioning (social connection, motivation, meaning, and self-esteem). Positive and negative event-related experiences were assessed by the type of event experienced and a rating of the event's affective strength (from "slightly" to "extremely positive or negative"). The type of event was selected from a range of options drawn from stressor event questionnaires [61-65] and modified as a short list of the most common event domains (eg, school or work, physical health, material possessions, or social experience domain). Context was assessed via 2 questions, 1 for social context (who the user was with at the time of the report) and environmental context (where they were at the time of the report). Specific questions are given in Table 1.

In addition, a weekly prompt was delivered that requested a short voice recording to serve as an implicit measure of emotional state [51,53]. Users were prompted to read a standardized piece of text at the start and the end of the recording, and within that window to describe freely how they were feeling at that time.

Psychological Assessment Questionnaires

A number of questionnaires were available for completion at the onset of the app use, providing baseline measures of emotional well-being as well as data on potential moderators or confounding variables (see Figure 2). These questionnaires were categorized into survey "blocks" and displayed on the *MoodPrism* homescreen until their completion. This served to organize the questionnaires into manageable chunks for users to complete in their own time. A subset of these questionnaires was also delivered at the end of the month-long period to enable assessment of whether the app may have affected the well-being measures. A description of these questionnaires was provided in Table 2.

Figure 1. Screen shots from app showing experience sampling method.



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Figure 2. Screenshots showing examples of longer psychological questionnaires.

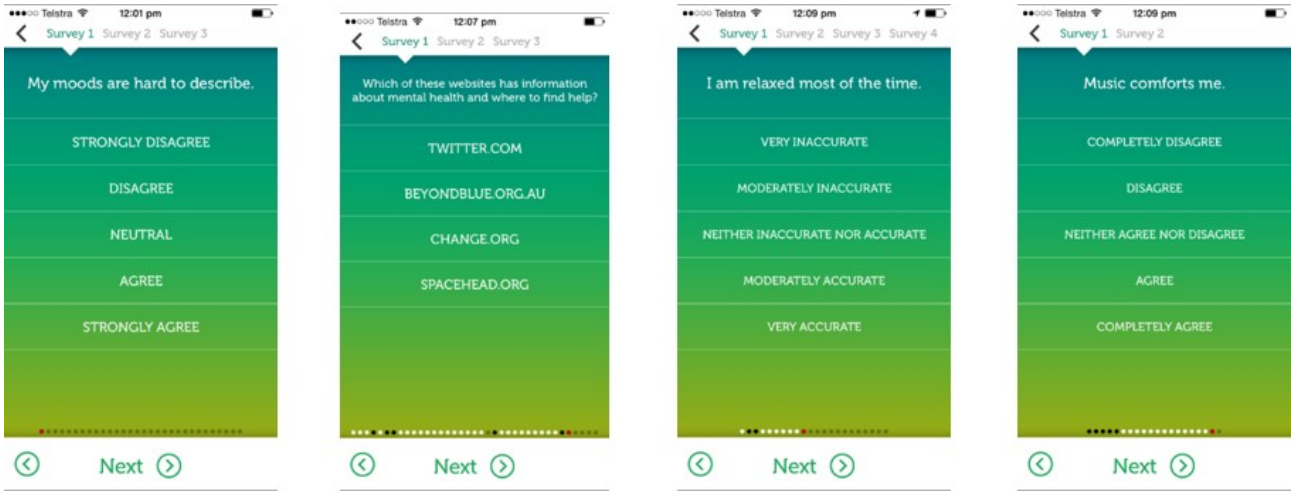


Table 1. Qualitative feedback: questions guiding qualitative feedback forums.

Broad question	Prompts
Was the app easy to use?	**Privacy issues (eg, social networking sites)**
	Was it clear to you why you were providing the information that you did?
	Why did you opt-in or opt-out of connecting your social media accounts? What things would be an incentive to opt-in?
	Can you imagine anyone using the app without incentives?
	Who do you think would benefit from using it?
	Was it clear to you that you were earning entries into a draw to win an iPad? Was it clear how the prize entries were being awarded? Did this consciously motivate you to use the app?
	Were the colors or emoticons used in the mood feedback helpful?
How did you find the daily prompts?	**Did they get in the way at all?**
	Were significant events captured?
	What kind of event did you feel was appropriate to report (major, minor, or both)?
How did you find the feedback?	**Mood feedback**
	Did you notice yourself paying more attention to the way you feel than usual?
	When you started using the app, was it made clear that reporting your mood could improve your mental health and well-being?
	Surveys
	Mental health info or contacts – did you explore any of these? Were they useful?
	Did you ever find the overview upsetting or negative?

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Table 2. Sample feedback provided by beta-testers.

Theme	Sample responses
Positive feedback	
Aesthetically pleasant	It looks nice!
Easy to use	Seamless and smooth to use
Daily reports quick to complete	Simple set of responses takes only a few minutes daily – easy to use daily
Feedback useful and specific	Targeted questions give specific feedback about links between mood and daily activities
	Colored display of mood was useful representation [sic]
	Liked unlocking of content - motivated to keep using
	Feedback was not upsetting
Good to be able to get feedback about how feelings change daily	The ease of the app and being able to check in how exactly I'm feeling at a certain time
Negative feedback	
Wording of some questions confusing	Many questions in the introductory questionnaires are confusing double-negative repeats of previous questions, combined with putting negative responses near the top (where you expect positive ones) is confusing.
	I've never been irked when people expressed ideas very different from my own: "Yes or No". Is it possible to put Agree or Disagree instead?
Some content can make you feel negative	Quite morbid things in the list of "most negative thing to happen to you today" -- makes me imagine some pretty terrible rare events like "death of a loved one", etc. -- not a great thing to remind someone with depression to think about on a daily basis. / Many questions are quite negative like this -- you think about how stressed, worried, out of control, etc. you are -- creates a major disincentive to participating -- they're not things you want to dwell on when you're depressed.
Feedback clarity	The summary information for tracking well-being across times seems simplistic. For example, if I was in a good but deactivated mood, it said I was "on my way to thriving" - but of course it's not healthy to be highly activated ALL the time.
	The other thing I thought could be made clearer is what the numbers on the main screen mean - they're all different colors for the different days of the month but not sure what those numbers or colors mean
ESM functionality	There are a couple of categories I felt were missing when logging the things that happened today. On the "who are you with" screen, the option of "partner" would be useful. The "won something" category in the positive events screen was less useful.
	No positive event option for work
Privacy or information issues	Need trust in the app to give permission for social media sharing. So should give permission later on, perhaps after surveys, after built trust in app after some use
	Location information should be clarified to be postcode, not specific GPS point
Installation issues	Hard to download

Feedback

The final design feature of *MoodPrism* was the provision of a range of feedback to the user on their emotional well-being and mental health. This feedback was organized in consultation with the Australian mental health organizations *beyondblue* [66] and headspace [67], research literature on mental health and well-being, and expert advice on currently available mental health apps.

The feedback was available at several stages (see Multimedia Appendix 2):

- On the completion of a survey block, users were provided a summary of their general score on one of the surveys within that block.
- On completion of each daily report, users were provided with a color-coded brief description and custom emoticon representing their emotional state on that day. Weekly and monthly overviews were also available when multiple ESMs were completed.
- On completion of 1 week's worth of ESMs, "positive mental health" data provided individualized feedback (based on their positive health responses), which included links to positive health websites and apps.
- On completion of 2 weeks' worth of ESMs, depression and anxiety data were collated to provide individualized feedback on mental illness risk (based on their PHQ-4 responses). Recommendations and supporting links to mental health websites or contacts were also provided, as well as advice suitable to the user's emotional functioning over the past 2 weeks.

Database Security and Storage

With such extensive and potentially identifiable information being collected by *MoodPrism*, data storage and data security became a major priority. The following considerations were

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made regarding data storage in adherence with industry and University [68] standards, the *Privacy and Data Protection Act 2014*, and the *Guidelines for Ethical Practice in Psychological Research Online* as outlined by the British Psychological Society [69].

Immediately following the survey collection, data were stored on the user's mobile phone prior to being uploaded encrypted into a secure database every 24 h. All data uploaded from the user's phone was stored on an Amazon Web Services server. This database was protected by a firewall and regularly updated security protocols. The data stored were anonymized at the point of upload. All potentially identifiable information was removed from the data and only the device ID was retained (functioning as a randomly generated participant code). Data were only accessible online by authorized users via Secure Shell (SSH), which authenticates server access with digital certificates and encrypted passwords. All communication between authorized users and the server also occurred through HTTPS. This ensured that all information passed between the server and the researchers was encrypted and cannot be accessed or manipulated by a third party.

With regard to social media data, explicit consent to access Facebook or Twitter accounts ("opt-in") was provided by the user. Their social media credentials were stored locally on the phone but were never uploaded to the server. All Facebook and Twitter posts' content were processed locally in the mobile phone's memory and aggregated word counts were generated. Only the aggregate word count was uploaded to the storage server.

Results

The app was initially tested by both the researchers and the app developers for minor issues and bugs. A small convenience sample of independent, nonclinical users (N=11; age range=16-52 years; 4 males, 7 females) was then recruited to test the app to generate feedback on the functionality and usability of the app to the researchers and app developers. They used *MoodPrism* daily over a 30-day period and kept notes of their user experience. Information about the study was provided to the participants and electronic consent was required before the app could be used.

The test sample was invited to provide more intensive qualitative feedback by either Web-based questionnaire (n=5) or via attendance at a focus group session (n=6). Focus group participants also provided quantitative feedback by completing the Mobile Application Rating Scale (MARS) [70]. The MARS is a multidimensional measure for trialing and rating the quality of mobile phone apps, and has demonstrated interrater reliability and internal consistency. All beta-testers were also invited to discuss or provide emailed notes on their user experience. Broad questions were posed, and prompts were provided where necessary (see Table 1). (No attempt was made to analyze the emotional well-being data from the beta-testers, as the sample was small, and this aim was beyond the scope of the current paper, the primary aim of which was to provide information on the development of the app.)

Themes extracted from the comments provided via the focus group or Web-based feedback are presented in Table 2.

The testing of the app with this sample was approved by the Monash University Human Research Ethics Committee (Approval # CF14/968 – 2014000398). App development was completed in 2015 and tested over June-July 2015. The app was then revised in response to feedback received and the final version of the app prepared. The app was then released on the Google Play (Android) and Apple (iOS) stores. Future publications will report empirical data from this app, with the scope of the current publication limited to the development process only.

Feedback about the functionality and usability of the app was obtained from 11 beta-testers, who completed a standard survey of app usability, the MARS. The results are presented in Figure 3.

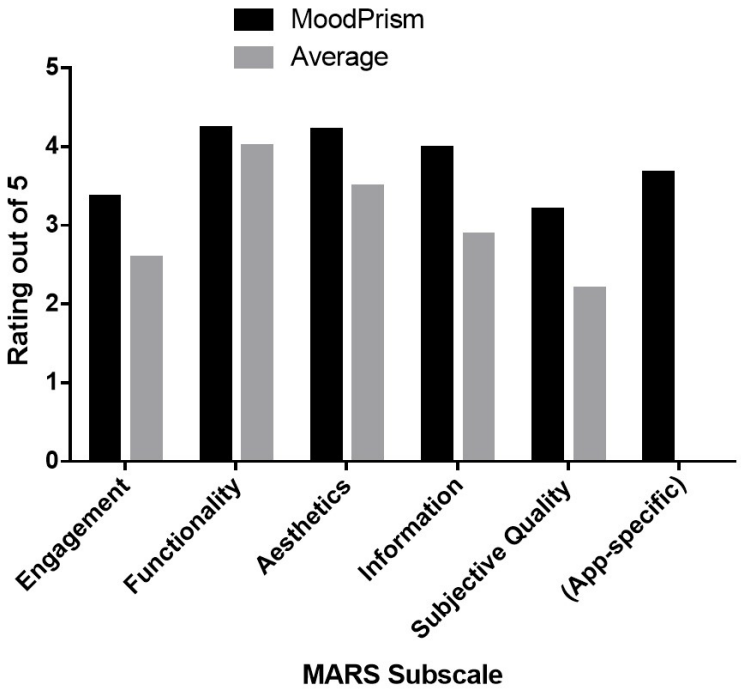
MARS ratings for the *MoodPrism* app exceeded the average rating for 50 apps reviewed by Stoyanov et al [70] for each MARS subscale. Highest satisfaction ratings were obtained for items relating to the app's graphics quality (eg, buttons, icons), gestural design (eg, swipes, scrolls), ease of use (eg, clear menus), credibility of the information sources, the layout aesthetics, and increased awareness of mood. Lowest ratings were obtained for entertainment value (eg, fun to use), customization options, likelihood to change behavior, motivations to address mood and interest, and likelihood to recommend to others.

The results from the focus group sessions and emailed responses from all 11 beta-testers are also summarized in Table 2.

The majority of issues identified by the beta-testers were addressed in the final version of the app. For instance, the order of positively or negatively worded options was made consistent across all questionnaires, additional information on how location and social networking data will be used was provided, with reassurance that information collected was deidentified was added, and an explanatory key was provided for interpreting colors and emoticons. The only issues that were not able to be addressed related to the integrity of psychometrically validated questionnaires (and therefore wording could not be altered), inclusion of negative content (which was important to the primary purpose of the app), or installation difficulties (as they related to the trial version only, and would not be present in the Apple and Android Web-based stores).

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Figure 3. Quantitative feedback: beta-tester ratings on the Mobile Application Rating Scale (MARS) subscales (N=11).



Discussion

Principal Findings

In this paper, we demonstrated how mobile phone technology could be harnessed to overcome several challenges in current mental health research and practices. Key needs we aimed to meet by developing this tool included the following: real-time monitoring of emotional functioning, assessing the full spectrum of emotional well-being, confidential access to mental health support and information when required, and to reduce obtrusiveness of regular monitoring.

MoodPrism was developed on both iOS and Android mobile phone platforms as an app to monitor emotional well-being in real time. It achieved this using ESM and collection of behavioral data via mobile phone apps (addressing challenge 1). It included assessment of daily positive psychological functioning (or "flourishing" [55]) in addition to more traditional assessment of negative psychological functioning (depression and anxiety) (addressing challenge 2). *MoodPrism* offered users a range of resources and links to enhance mental health literacy and access to professional mental health support, which vary depending on their current emotional functioning (addressing challenge 3). *MoodPrism* also incorporated voice monitoring, social networking site, and music playlist data collection as the first steps toward less obtrusive monitoring of emotional well-being for extended periods (addressing challenge 4)—although extensive algorithmic modeling will be necessary to achieve this goal. In sum, *MoodPrism* successfully responded to 4 key challenges in the emotional mental health domain. A number of important learnings were also achieved during this project, which may be helpful to outline for future researchers considering developing a mental health app [36].

Considerations When Developing a Research-Based Mental Health App

Development of mental health apps is a relatively young field, and the guidelines to support researchers and app developers are not yet widespread. During the development of *MoodPrism*, a number of key issues were identified that could be helpful to researchers developing apps for mental health research and practice. These issues are briefly outlined in the following and then recommendations for consideration in future research are summarized in Figure 1.

First, it is important to recognize the different priorities of app developers and researchers (and mental health practitioners). For example, the *MoodPrism* researchers' main goals were database integrity, psychometrically sound questionnaires, and ethical administration of sensitive content. The app developers' main goals were an enjoyable user experience, good design, simple user interface, brief page content, and anonymous data storage. Identifying these goals and coming to an agreement on how they should be prioritized could help design an app that optimizes functionality (and therefore will be used by the participants) with integrity (so that the data are suitable for analysis). With *MoodPrism*, the researchers' priority to maintain psychometric properties of questionnaires was in conflict with the app developers' priority for good user interface and design. Administration of long questionnaires was overcome by creating brief checkpoints or "blocks" of surveys to complete, each with a portion of feedback provided as a reward to incentivize completion of long surveys. Similarly, the developers' database priorities were guided by industry standards for data collection and storage. At times, this conflicted with the researchers' need to obtain sufficient details; for example, anonymity of social media posts initially prevented the integrity of coding processes from being verified. Coding solutions were eventually achieved,

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but considerable delays could have been avoided if the database requirements were thoroughly discussed at the project's outset. When these conflicting priorities were identified, a solution was often achieved that produced the unexpected benefit of optimizing outcomes for both stakeholders. For example, the chunking of questionnaires not only improved the user experience, but also was likely to improve the validity of data as participants were less likely to fatigue, or resort to nonserious responding.

Second, sufficient time should be quarantined at the outset for planning, and at the completion for beta testing and revision. App developers' schedules can overlook the details involved in translating research requirements into the app space, and as a result underestimate the time involved. Database APIs for commercial apps also tend to have simpler output requirements than is often essential for advanced statistical analyses. A failure to identify the more complex necessities of the app's function at the outset can result in over simplistic transition of features into the app, and subsequent delays in revision to meet research needs. Time spent presenting the entire app's contents clearly up front to app developers will help avoid significant delays during development. Time should also be sufficient at the outset for complete storyboarding and wireframing of the app to ensure both parties agree on the app's format and presentation. Aesthetics that work well in commercial apps do not always translate well for research content, which may out of a necessity include lengthier content or inflexible formatting or labeling of items (eg, traditional Likert-type scales in psychological questionnaires). Samples of similar app presentations that are known to work effectively with this type of content should if possible be reviewed and the best features identified. Allowing sufficient time for planning should also ensure that clear milestone dates are set, post which no further changes or additional content can be made by researchers or practitioners until trialing. Ongoing modifications can magnify delays for app developers and confuse versions being delivered. Sufficient time when the app is being finalized is also critical. Users should be allowed a sufficient trial period to allow testing of the app in various contexts, and the schedule should also ensure that they are able to report back both individually, and where possible as a part of group discussion. Focus groups are invaluable for identifying common themes across users, as well as allowing more singular experiences to emerge.

Third, communication among app developers and researchers or practitioners should be managed centrally. A flexible Web-based platform (such as "Basecamp") provides project management tools such as discussion threads, allocation of tasks, a central file repository, and reminders. Progress of tasks should be monitored regularly and updates provided when item check off is delayed. Clear assignment of tasks avoids tasks being overlooked, and ensures accountability.

Fourth, methods to evaluate the app should be included within the app itself. Commercial apps can contain simple "thumbs up" or star ratings, but this is unlikely to be sufficiently informative for research or practitioner needs. Importantly, it is helpful to obtain assessments of the various aspects of the app, including commercial considerations such as aesthetics and functionality as well as those of central interest to researchers, such as ethics or trust and integrity. Published app assessment measures such as the MARS for health apps should be considered if possible. This will allow standardization and comparability across apps in the mental health space, and to build integrity and an evidence base for improvement of mental health apps over time.

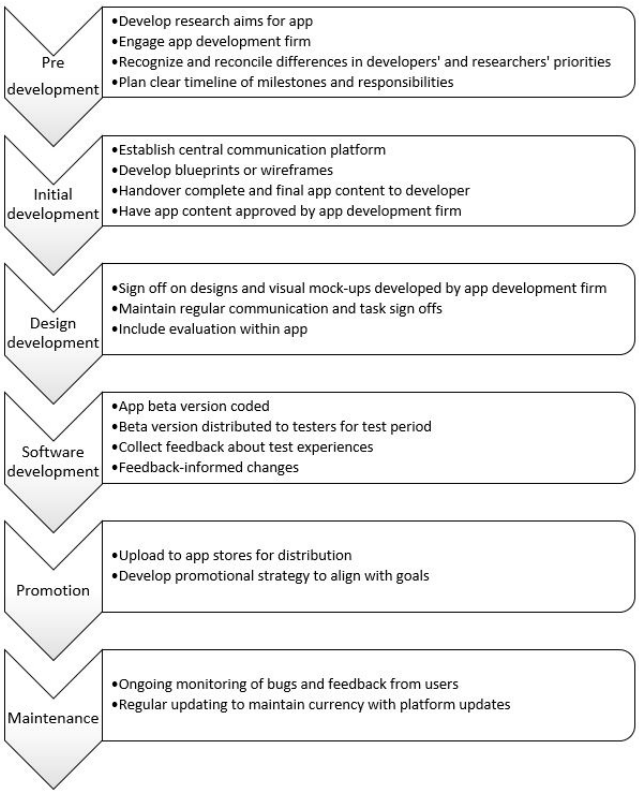
Our experiences researching and developing mental health apps have yielded a number of important practical insights of value to researchers in this field. The issues highlighted during the development of *MoodPrism*, taken together with our recommendations documented elsewhere [36], are summarized in Figure 4.

Potential Applications of *MoodPrism* in Psychological Research

The development of a research mobile phone tool such as *MoodPrism* has enormous potential within the mental health field. Several applications of *MoodPrism* currently in progress are summarized in the following to illustrate the power of flexible, real-time monitoring using this platform.

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Figure 4. Recommended steps for researchers engaging in the app development process.



Automated Prediction of Mental Health Risk

One of the most exciting promises for data-rich apps like *MoodPrism* is the development of algorithms which allow automated prediction of emotional health. This modeling could determine the minimum number of constructs required to reliably predict significant changes in emotional well-being, which could be used to inform a more streamlined and userfriendly app. Importantly, it is unlikely that any 1 or 2 variables will provide reliable prediction of such changes; a strength of *MoodPrism* is that it provides a breadth of variables that can be used to answer diverse and important research questions. Various algorithms may be identified, for instance, which discriminate between periods of stability and decline, and *MoodPrism* could then unobtrusively monitor for this change, and provide targeted mental health support to the user. This extends previous research that demonstrates feasibility of such modeling [40,41,71] by utilizing predictors already established in previous research to be associated with mental health (such as online social networking) rather than only those mobile phone sensors that are convenient to record (such as app use and activity).

Improving Emotional Self-Awareness, Mental Health Literacy, and Mental Health and Well-Being Outcomes

Bakker et al [36] detail how mental health apps can be categorized as reflection-, education-, or problem-focused. *MoodPrism* is largely a reflection-focused app aimed at improving a user's emotional self-awareness by encouraging the user to report their thoughts, feelings, or behaviors and then reflect upon them. There is also an education component in *MoodPrism* that provides access to mental health information and resources. Use of this type of mental health app may therefore result in improvements in mental health and well-being. Kauer et al [72] found evidence that using a mobile phone app that promotes self-reflection through mood tracking can increase ESA and decrease depressive symptoms. Furthermore, rigorous study is needed to explore the mental health benefits of *MoodPrism* and other similar reflection-focused or education-focused apps, as very few randomized controlled trials have been conducted to investigate the efficacy of mental health apps [37]. Importantly, mobile phone technology complements traditional emotion monitoring techniques such as CBT-based recording worksheets [73,74], by increasing recording of subtle changes in behavior in real time. The innovative pairing of changes in emotional well-being with rapid delivery of mental health information has the potential to improve a user's access to relevant resources such as Web-based health portals (eg, eheadspace, eHub), or local GPs when it is needed [75-77].

Leveraging Behavioral Data on Social Media to Gain Insight Into Mental Health and Social Context

Users of social networking sites leave rich digital traces of their social behavior, which includes the structure of their friendship networks and the written interactions between connections [78-80]. The quality of interactions on social network service (SNS) has been shown to hold important relationships with mental health. Positive interactions are associated with better mental health outcomes, and negative interactions may exacerbate mental illness [81-83]. However, how certain individual characteristics might lead a user to gain benefit or detriment from their SNS use is yet to be clearly described [84]. This requires access to both SNS data and the administration

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of psychometrically sound surveys to profile the users of SNSs. By profiling SNS users and better tapping into the interindividual variation in SNS use, the accuracy of SNS language models for mental health prediction could be improved [85] and some of the conflicting findings around the use of SNS and its mental health impact could be disentangled [85]. Furthermore, apps like *MoodPrism* enable SNS data to be associated in real time with ESM assessments of mood and psychological surveys. Time-sensitive linking of self-reported mood change and emotional expression in SNS posts may also provide evidence to support the use of SNS data and language analysis as a tool for mood and mental health tracking overtime.

Predicting Resilience Patterns to Everyday Significant Events

Event-based resilience research explores individual capacities to maintain healthy psychological functioning in response to naturally occurring stressor events [86,87]. Previous research methodologies use cross-sectionally designed studies and typically rely on retrospective reports [88-90]. These provide only partial snapshots of an individual's capacity for resilient responding and can be subject to recall biases. The collection of *MoodPrism's* daily reports of psychological well-being, as well as the presence or absence of stressor events, is therefore pertinent to advancing event-based resilient research methodologies. Such methodological approaches allow for multiple snapshots in mood responding that, when compiled, create more representative, real-time observation of dynamic fluctuations that occur in an individual's mood responses to stressor events. Such data will permit a more accurate exploration and identification of the heterogeneous mood trajectories that individuals display following stressor experiences [85,87,91-93]. Favorable patterns of responding, reflecting the maintenance of psychological functioning, can be identified and profiled to explore important factors that discriminate resilient individuals from other groups that reflect less-resilient patterns of responding.

Conclusions

Development of mental health apps such as *MoodPrism* maximize health impact by harnessing the opportunities offered by mobile phone technology. Approximately, three quarters of the US and Australian populations own a mobile phone, and around 3 in 4 of those never leave home without their mobile device [31,94]. People check their mobile phones up to 150 times a day [30], demonstrating that mobile devices offer unprecedented access to everyday behavior. Incorporating evidence-based monitoring of emotional health into routine mobile phone apps can provide a powerful and flexible methodology for increasing personal control over one's own emotional health. Capitalizing on inbuilt tools within mobile phones—such as music players, voice recorders, and social network media—to contribute data further enhances the potential of such apps to sensitively monitor emotional health over extended periods of time, while remaining unobtrusive. People (particularly young people) often find mobile phone technologies more engaging, anonymous, and less stigmatizing than other means of accessing help, and therefore are much more likely to use this methodology [16]. The new technologies described in this paper not only complement traditional approaches or educational tools supporting mental health but also have the potential to enhance their reach by overcoming many of the barriers currently challenging the reliable surveillance of emotional well-being.

Acknowledgments

This research was funded by *beyondblue.*

Conflicts of Interest

None declared.

Multimedia Appendix 1

Details on 3 forms of data (automatic, experience sampling, and psychological surveys) collected from *MoodPrism*.

[PDF File (Adobe PDF File), 55KB - mental_v3i4e49_app1.pdf]

Multimedia Appendix 2

Feedback generated by the subjects while using *MoodPrism*.

[PDF File (Adobe PDF File), 594KB - mental_v3i4e49_app2.pdf]

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Abbreviations

APIs: application programming interfaces
CBT: cognitive behavioral therapy
ESM: experience sampling methodology
LIWC: Linguistic Inquiry and Word Count
SSH: Secure shell
SNS: social network service

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Review

Social Networking Sites, Depression, and Anxiety: A Systematic Review

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Abstract

Background: Social networking sites (SNSs) have become a pervasive part of modern culture, which may also affect mental health.

Objective: The aim of this systematic review was to identify and summarize research examining depression and anxiety in the context of SNSs. It also aimed to identify studies that complement the assessment of mental illness with measures of well-being and examine moderators and mediators that add to the complexity of this environment.

Methods: A multidatabase search was performed. Papers published between January 2005 and June 2016 relevant to mental illness (depression and anxiety only) were extracted and reviewed.

Results: Positive interactions, social support, and social connectedness on SNSs were consistently related to lower levels of depression and anxiety, whereas negative interaction and social comparisons on SNSs were related to higher levels of depression and anxiety. SNS use related to less loneliness and greater self-esteem and life satisfaction. Findings were mixed for frequency of SNS use and number of SNS friends. Different patterns in the way individuals with depression and individuals with social anxiety engage with SNSs are beginning to emerge.

Conclusions: The systematic review revealed many mixed findings between depression, anxiety, and SNS use. Methodology has predominantly focused on self-report cross-sectional approaches; future research will benefit from leveraging real-time SNS data over time. The evidence suggests that SNS use correlates with mental illness and well-being; however, whether this effect is beneficial or detrimental depends at least partly on the quality of social factors in the SNS environment. Understanding these relationships will lead to better utilization of SNSs in their potential to positively influence mental health.

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KEYWORDS

depression; anxiety; social media; social networking; review, systematic; mental health; well-being

Introduction

Background

Social networking sites (SNSs) are Web-based platforms on which individuals connect with other users to generate and maintain social connections [1]. Considerable disagreement exists as to associations that SNS use may have with depression and anxiety [2,3]. On the one hand, SNSs may protect from mental illness, as they support and enable social interaction and connection [1,4], and allow users to reflect aspects of their identity and express emotion that may be relevant to their lived experience [5]. On the other hand, there are many opportunities

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for miscommunications and mismanaged expectations, and maladaptive tendencies can be exaggerated, leaving individuals feeling a greater sense of isolation [2,6]. As a whole, the SNS environment may be just as complex as face-to-face interactions. As SNS membership continues to rise [7], it is becoming increasingly important to address the possible benefits and detriments the use of SNSs may have on mental health.

Affective disorders such as depression and anxiety have been shown to have bidirectional interactions with the social environment that influence the path of illness onset and maintenance [8]. Depression and anxiety have an approximate prevalence of 4.7% and 7.3%, respectively, in the global population [9,10]. These disorders have high levels of comorbidity [11] and impact the quality of social relationships [12,13]. Depression and anxiety may be implicated in determining the size and structure of an individual's social network [12], the quality of interactions within these networks, and how effectively social capital may be leveraged or developed to provide an individual with social support [8,14].

The social characteristics (both qualitative and structural) affected by depression or anxiety are also relevant to one's sense of well-being. Current mental health theories suggest that the presence of well-being is not the same as the absence of mental illness; a complete model of mental health requires not just the absence of psychopathology, but also a focus on positive indices of functioning such as subjective well-being [15]. This is particularly pertinent when exploring how the social environment may affect an individual, as such environments may simultaneously confer a number of benefits to the individual and exaggerate deficits [16-18].

Social aspects of the Internet have been argued to augment social relationships and support mental health. SNSs in particular connect us to friends, family, colleagues, strangers, and celebrities and can help users to maintain and make new friendships, express thoughts and feelings, and express identity [1,4,19]. The primary social functions that SNSs perform may augment the benefits of engaging in face-to-face interaction by extending the reach and accessibility of our social networks [20]. Indeed, SNS use is associated with lower levels of loneliness and greater feelings of belonging (social connectedness), social capital, and actual and perceived access to social support and is generally associated with higher levels of life satisfaction and self-esteem [6,21-26].

As a whole, the positive social components of SNS use suggest a protective role against depression and anxiety. For instance, higher levels of self-esteem and life satisfaction may aid in attenuating depressive symptoms [27]. Kraut et al [28] found that frequent general Internet use did not increase depression over time, and, in a second study, communication activities on the Internet were shown to be associated with lower levels of depressive symptoms [29]. Computer-mediated communication (CMC; eg, email, instant messaging) allows users to express and interpret emotion in a similar way to face-to-face interaction [17]. CMC may therefore be beneficial for emotion regulation as has been demonstrated for offline forms of written emotional expression [30,31].

However, for individuals with depression or anxiety, the interpretation and frequent exposure to this emotion may have a negative impact [13]. SNS use may increase an individual's exposure to negative social interactions (eg, cyberbullying), which may negatively impact mood and mental health [2]. For example, negative interaction quality was associated with decreases in self-esteem and life satisfaction [32]. Even passive exposure to the language used in SNS posts has been shown to influence the emotive language subsequently expressed by the receiving SNS user, where positive or negative emotions are argued to transfer via contagion [33-35]. As SNSs explicitly support a number of social features, the relationships and interactions between the user, their emotional experience, and Web-based technology are likely to be complex and may even accentuate differences between those who are doing well in life and those who are struggling.

Cognitive and social factors frequently emerge as both moderators and mediators of the relationships between offline social interactions or events and depression [36-38] and might also occur in Web-based environments. For instance, self-esteem mediates the pathway between relationship interactions and depressive symptoms [39], but it might also moderate how a person uses and is affected by the SNS. Rumination, a response style where an individual maintains a passive and repetitive focus on their distress [40], is one mechanism linking stressful life events and the development or maintenance of depression [41], and the SNS environment provides opportunity for a person to both internally ruminate on bad events and have an entire social network further accentuate shortcomings. Social support has additionally been shown to moderate relationships between stress and depression, with greater levels of social support acting as a buffer to depressive symptoms [42]. This is pertinent to SNSs as they present a potential intervention opportunity for developing and strengthening supportive social networks for vulnerable individuals.

Objective

Since the advent of SNSs, a number of articles have been published examining the relationship between SNS use and depression and anxiety. The interaction between SNSs and our mental health and well-being is clearly varied and complex. The objective of this paper was to provide a systematic review of literature examining SNSs and their relationship with depression and anxiety. It also considers links with well-being, as well as potential mediators and moderators to these relationships.

Methods

Search Strategy

Figure 1 summarizes the search strategy and article selection. A multidatabase search identified studies conducted between January 2005 and June 2016. The databases included were PsycINFO, MEDLINE (Ovid), Scopus, IEEE Xplore, CINAHL (Cumulative Index to Nursing and Allied Health Literature), Education Resources Information Center, Social Sciences Citation Index, and Communication and Mass Media Complete. The inclusion of conference papers accessed through IEEE Xplore was intended to capture the research within the computer

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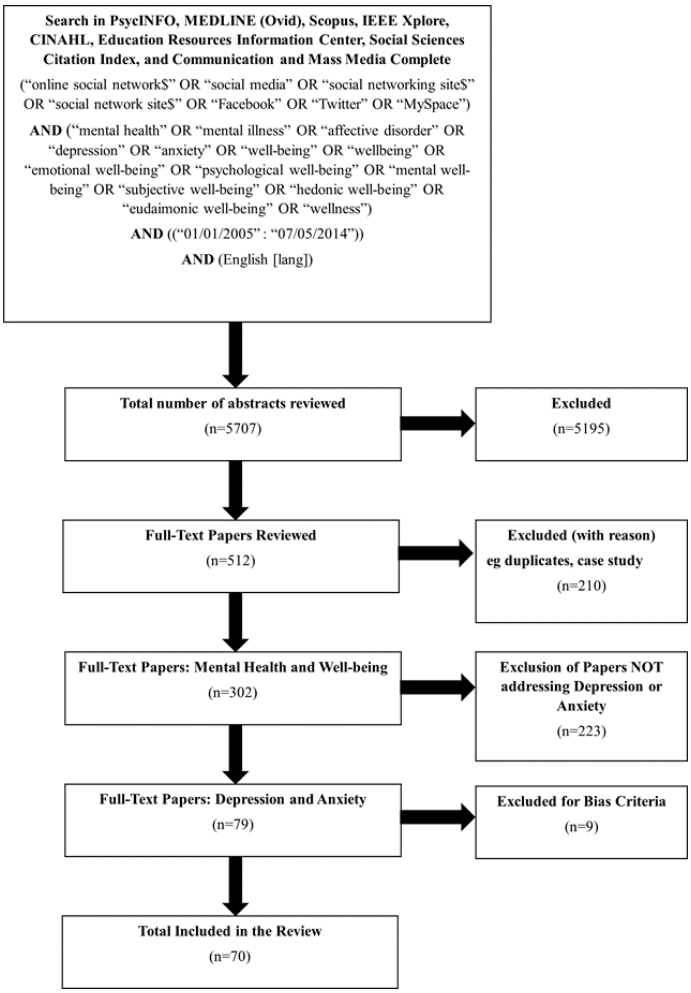
sciences and engineering fields that may have been relevant to the psychological literature.

Search terms were selected in order to comprehensively capture the various ways mental health, mental illness, subjective well-being, and SNSs have been defined and explored in the existing literature.

SNSs were defined as conceptualized by Ellison and Boyd [1] as sites that are a Web-based communication platform with 3 distinct characteristics: (1) user profiles are unique and created through user-provided content and content provided by other users, (2) the network connections between individuals are visible and can be navigated through by other users, and (3) individuals can broadcast content and consume and interact with content contributed by others in a continuous stream of information. Prototypical examples of SNSs include Facebook, Twitter, Myspace, and Instagram.

For mental health, search terms specifically focused on depression and anxiety, as well as overall well-being (eg, subjective well-being, psychological well-being, wellness; see Figure 1 for full list of search terms).

Figure 1. Overview of search strategy and selection process for the systematic review.



Inclusion and Exclusion Criteria

Studies were included if they had a primary focus on SNS use as a behavior. As such, studies that referred to SNSs as a recruitment method only or used SNSs as a means for intervention delivery were excluded.

Articles were included if they provided results addressing anxiety or depression directly and were excluded if they were only referred to in the context of general psychological distress (or similar). As the primary focus of the review was on depression and anxiety, not the broader well-being construct, articles addressing well-being were only included if they also included specific reference to anxiety or depression.

The search was limited to articles published after 2005 to capture research on the prototypical examples of SNSs that include the basic features of modern networks. Studies that had a primary focus on the Internet, chat rooms, or online support forums were also excluded; although they may contain some of the features of SNSs, differences in the function they perform for users may exist [19].

Additionally, articles were restricted to English language, peer-reviewed journal or conference proceedings, and quantitative or mixed methodologies. Gray literature, commentary and editorial, qualitative research, literature reviews, and descriptive case studies were excluded.

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Data Extraction and Data Synthesis

Two raters (the first author and a trained research assistant) reviewed all abstracts returned from the literature search and selected abstracts for full-text reading based on the inclusion and exclusion criteria. All articles that included measurement of depression, anxiety, or well-being were retained. The selected full-text articles were downloaded and reviewed by the first and third authors.

To provide some preliminary evaluation of the strength of the research, three risk of bias indicators were adapted from the Cochrane bias tool (*Cochrane Handbook for Systematic Reviews of Interventions* [43]), which classifies methodology that may limit replicability or generalizability. Studies were rated to indicate whether the study (1) included psychometrically reliable and valid measures, (2) used an external measurement criterion for mental health, and (3) provided description of the sample demographics including some SNS activity statistics (eg, number of friends and/or use frequency). These were rated by the first and third authors from "0=No bias," "1=Unclear risk of bias," and "2=High risk of bias" and were summed to create a final score between 0 and 6. A linear weighted kappa statistic for interrater reliability (.78, SE=.06) indicated that there was very good agreement in applying the bias criteria. Consensus was reached on all ratings. Articles with a rating of 3 or above were excluded [44-52], resulting in the final set of 70 studies, as presented in Multimedia Appendix 1.

From each article, the year of study, population of interest, type of SNS, and variables used (anxiety, depression, well-being) were noted, along with whether or not any formal mediators or moderators of these relationships were indicated. Information was then qualitatively synthesized to identify common themes.

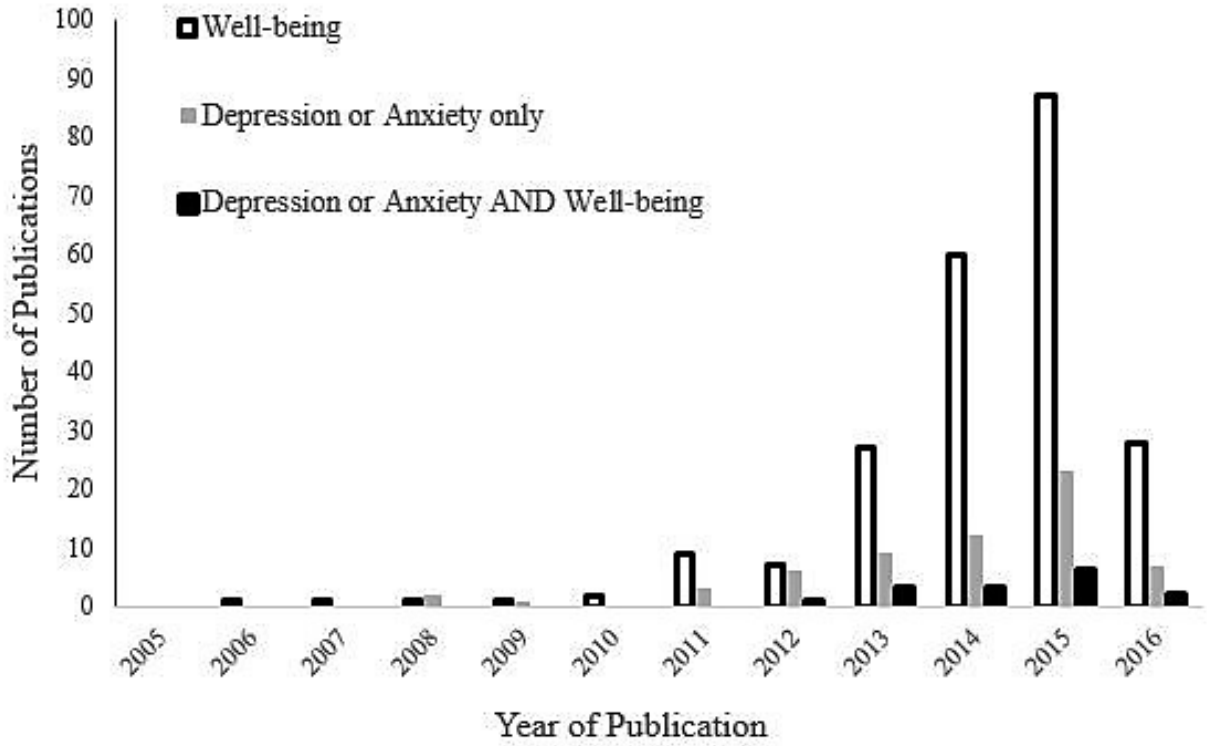
Results

Description of Studies

Figure 2 indicates the number of articles addressing SNSs, depression and anxiety, and well-being from 2005 through 2016, based on the 302 full-text articles initially reviewed. There were considerably more articles addressing well-being alone than articles only addressing depression and anxiety. Only 15 articles included both positive and negative aspects of mental health. This review includes the 70 articles that include depression or anxiety only or depression or anxiety and well-being.

A total of 22 studies addressed potential moderators or mediators in SNSs' relationship with depression or anxiety (see Multimedia Appendix 1). Most articles obtained a bias rating of 0 to 1. Ratings of 1 or above were primarily due to the limited focus on reporting SNS activity statistics, such as the number of friends or average frequency of use, which help characterize the average SNS user in each sample. Facebook was the most commonly explored SNS followed by the measurement of SNS use as a general category (ie, no specific platform explored). The majority of studies examined young adults (late teens or early 20s).

Figure 2. Publication frequency of research into well-being, depression or anxiety only, and depression or anxiety with well-being from 2005 to June 2016, based on the initial 302 full text articles reviewed, which included quantitative findings. Case studies, editorials, literature reviews, and gray literature were excluded.



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Depression, Anxiety, and Social Networking Sites: Summary of Findings

Across the 70 articles, several general themes were apparent: frequency of use, size and structure of the SNS, language features and observable SNS activities, self-disclosure and expression, quality of interactions, social support, social connectivity, social comparison, addictive and problematic behaviors, and physiological associations. Findings are summarized in Multimedia Appendix 2 and are described below, with particular attention to moderators and possible mechanisms involved in the associations. As some articles were relevant to multiple themes, these articles appear in multiple sections. Studies that included well-being are also highlighted.

Frequency of Social Networking Site Use

Overall, total frequency or time spent on SNSs had mixed associations with depression and anxiety. Of the 30 studies examining these variables (see Multimedia Appendix 2) [53-81], 8 studies found a direct positive association with depression and 16 found a nonsignificant association. For anxiety (and social anxiety), 3 studies found direct positive associations and 7 found nonsignificant associations. With the exception of 1 study showing a significant negative association between Facebook-specific social anxiety and the frequency of SNS use [80], no studies supported an association between the frequent use of SNSs and a lower level of anxiety or depressive symptoms.

Several moderators appeared. In one study, the number of strangers followed moderated frequent Instagram use and greater depressive symptoms, where a significant relationship only occurred for those with high proportions of strangers in their social networks [68]. Similarly, time spent on Facebook was only a predictor of depression and anxiety for those individuals who have higher motives to use the site for social connection [73].

Associations may be affected by the study design. Studies utilizing an experience sampling method (ESM) to collect SNS use frequency over 1 to 2 weeks found no significant associations between SNS use frequency and depressive symptoms over time [61,63,77]. Indeed, across 2 studies, while Steers et al [77] found a positive association between the time spent on Facebook and depression when using a retrospective survey, this effect was nonsignificant when participants completed daily ESM diaries. In addition, 2 studies [54,56] conducted a 3-week follow-up and demonstrated no change in depressive or anxiety symptoms over time as a function of SNS use frequency.

Tendencies toward depressive rumination and corumination did not moderate associations, suggesting that the frequency of SNS use may not be a significant risk factor for depression even across varying cognitive styles [54]. Kross et al [63] additionally included depression as a moderator of the relationship between the frequency of daily SNS use and affective well-being (ratings of negative affect) and cognitive well-being (life satisfaction). Although more frequent SNS use was associated with more negative affect and lower life satisfaction across a 2-week period, depression did not moderate these associations.

A number of studies have made a more nuanced consideration of SNS use frequency by looking at the different functions of use of SNSs [54,56,69,74-76,78]. Table 1 presents how these broad functions have been defined in the literature and presents some example behaviors. It also provides the Cronbach alphas that have been reported for the measures of each function. The table shows a distinction between passive and active use (broad-level functions). Active use may further be divided into content production and interactive communication functions. The table also shows where behaviors may be enacted in public (entire SNS friend network audience) or in private (dyads or small selected audience).

Table 1. Broad functions of social networking site use and example behaviors.

	Passive use (alpha=.77-.88)[a] [75,78]	Active social use (alpha=.83-.86)[a] [69,76]	
		Content production (public) (alpha=.52)[a] [75]	Interactive communication (alpha=.80)[a] [75]
Example behaviors	Checking or reading friends' profiles or posts Browsing the newsfeed	Status updates Updating profile pictures Image management (maintaining profile information)	Chatting in messages (private) Posting on friends' walls (public) Posting comments on statuses (public)

[a]Cronbach alphas indicating the internal consistency of measures defining functions of social networking site use as defined in the reviewed literature.

In general, passive uses of SNSs was not directly related to depression and anxiety, but there may be differential behavioral patterns for individuals high in depression or social anxiety [75,78]. Higher levels of social anxiety were significantly related to passive uses of Facebook but not to content production uses of Facebook [75]. Brooding, or anxious rumination, emerged as a mediator of the relationship between passive Facebook use and social anxiety and may be a cognitive risk factor for increasing social anxiety symptoms where passive Facebook use is frequent. Tandoc et al [78] found that Facebook envy mediated frequent passive Facebook use and depression, where lower levels of Facebook envy resulted in a direct effect of passive Facebook use reducing depressive symptoms and higher levels of envy led to greater depressive symptoms.

Active uses of SNSs demonstrate a more complex relationship. Shaw et al [75] found that depressive symptoms positively correlated with more frequent content production and interactive communications. McCord et al [69] showed that the frequency of social Facebook use did not predict social anxiety in the entire

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sample but was positively correlated with anxiety for a high anxiety group only.

Simoncic et al [76] suggested that personality and gender moderate the association of frequent active uses of Facebook (content production and interactive communication) and depression and may be protective. The study found a three-way interaction between gender, Facebook active uses, and neuroticism, such that lower depressive symptoms occurred in females who were high in neuroticism and actively used Facebook.

Size and Structure of Social Network on Social Networking Sites

The size of the SNS friendship network and its association with depression and anxiety has similarly yielded mixed findings. Fernandez et al [57] and Weidmann and Levinson [82] found significant negative relationships between social anxiety and the number of friends, and Park et al [83], Park et al [84], Rae and Lonborg [73], and Rosen et al [74] found this same relationship direction when examining depression. Rae and Lonborg [73] found that a greater number of friends on Facebook was associated with higher general positive affect and life satisfaction, when use of the site was motivated by maintaining friendships. The remaining studies demonstrated no significant relationship between the number of SNS friends, depression, or anxiety [53,57,64,67,71,73,78,79,85,86].

Specific friend categories have also been examined. Tsai et al [87] found that users accepting the friend request of an ex-partner tend to have higher levels of trait anxiety and depression severity than those who reject the request. Mota-Pereira [88] demonstrated that for individuals with treatment-resistant major depressive disorder (MDD) also currently taking antidepressants, the use of Facebook over a 3-month period significantly reduced depressive symptoms, compared with a no-Facebook control, and the addition of a "psychiatrist as a friend" showed significantly faster improvement in depressive symptoms. Such findings suggest a broad beneficial impact of SNS use when treatment is augmented by friends from a user's network.

The structure of the network itself may make a difference. For instance, Homan et al [89] revealed significant differences in the network structures of individuals with depression and those without on an LGBTQ (lesbian, gay, bisexual, transgender, and queer) support SNS, TrevorSpace. Individuals without depression had significantly more integrated friendship networks on the SNS compared with depressed individuals, with their friends being more likely to know each other and also having a higher proportion of friends who do not know each other. For the depressed group this could indicate they have less diverse social networks. Peer-selected groups have the potential to offer social support to depressed individuals, whereas groups over which the user had less control may contribute further exposure to psychological distress [90].

Language Features and Observable Social Networking Site Activity

A number of articles have examined the language features in SNS posts, with the potential for identifying individuals with depression. SNS users with depression differ from users without depression in that they express negative affect more frequently, use more personal pronouns, and generally have lower frequencies of interaction with others in their SNS network [91,92]. Park et al [93] have shown that individuals with a diagnosis of MDD more frequently post negative sentiment than those who are not depressed, and Moreno and colleagues [85,94] demonstrated that depression could be identified in the language used in the Facebook posts of college students based on the *Diagnostic and Statistical Manual of Mental Disorders* (Fourth Edition) criteria for MDD.

Settani and Marengo [95] directly examined the expressed emotion in participant status updates and generated an automated word count from the emotion dictionaries of the Italian version of *Linguistic Inquiry and Word Count* (*LIWC*), which was also supplemented with emoticons. Providing face validity, the frequency of word use from the negative emotion and sadness *LIWC* subscales positively correlated with depression, while the anger subscale positively correlated with anxiety. Positive emotion was unrelated to depression or anxiety scores. Interestingly, only the relationship between the sadness subscale and anxiety remained statistically significant when examining individuals older than 25 years.

In addition to language features, the time of posting, relative volume of posts, and reciprocity (likes and comments, tweets and retweets) may also aid in describing individuals with and without depression, with depression correlating with more night activity and less volume and reciprocity than nondepressed peers [84,91,96]. Over multiple weeks, there may also be subtle variation across time [96]. Park et al [84] provided evidence indicating that, for individuals experiencing acute depression (or a relative increase in their symptom severity), there is an increase in their posting frequency over a 6-month period. This is consistent with Shaw and colleagues' [75] findings indicating those with higher depressive symptoms engage in content production features on Facebook frequently.

The number of identity items on SNS users' profile page have also been associated with both depression and social anxiety scores [57,82,97]. For example, listing a "Single" relationship status relates to higher levels of social anxiety [82]. This related to the quantity of information provided in specific areas of a user's profile information (eg, TV, Books, Quotes, Music; [57]). Although some of the specific findings are mixed [57,82,98], studies generally suggest that social anxiety may be visible on SNSs through compensatory behaviors (increases in information disclosure) or through relative inactivity or social withdrawal [57,82].

Social Networking Sites for Self-Disclosure and Expression

At a broad level, it has been suggested that users of Facebook have lower levels of social anxiety than nonusers, suggesting that there might be a selection effect, such that SNS activities are unattractive to individuals high in social anxiety [99]. However, this depends on the social media platform. Baker and Moore [100] showed that, for new Myspace users, those who intended to use the site for blogging had higher mean depression and anxiety ratings than those who did not intend to blog. These

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individuals were also more likely than nonbloggers to feel dissatisfaction with their social networks and had a greater likelihood to use self-blame and venting coping strategies. Average levels of depression and anxiety among the bloggers were maintained across a 2-month period, although there was a trend in some symptoms being reduced and a significant increase in feelings of social integration and satisfaction with online and offline friendships [101]. Similarly, große Deters and Mehl [102] found that depressive symptoms remained stable through an intervention, although loneliness decreased via feelings of social connectedness.

Social anxiety is associated with an increased preference for SNS-mediated communication [103] and relates to differences in the depth of self-disclosure via public (status updates) or private (eg, messages) communication on SNSs. For individuals with higher levels of social anxiety, greater importance is placed on the need for reduced social cues and increased controllability of communication [59,104]. This leads to greater disinhibition and Facebook self-disclosure for private SNS communication only and not for public SNS communication [59]. Green et al [59] suggest that this may be related to the trust, audience size, and privacy differences between private and public communication on SNSs, which may position private SNS communication as more attractive and accessible for individuals high in social anxiety. Similarly, Baker and Jeske [80] suggested that assertiveness on Facebook (the ease with which an individual offers opinion or interacts with others) is lower for individuals high in social anxiety compared with those low in social anxiety.

A potential explanation for the self-disclosure activities of individuals with high social anxiety on SNSs may be related to motivations or perceived pressure to present an idealized self-image or to avoid presenting a negative image on SNSs [86,105,106]. Motivations to avoid presenting a negative self-image have been found to be a greater concern for individuals who had experienced high social anxiety the previous day and does not vary according to levels of perceived social competence [105]. Similarly, frequent impression management (including updating profile information) on SNSs is positively related with depression [74].

Frequently expressing positive or negative affect (emotional valence) in SNS status updates has also been shown to relate to depression and may be mediated by rumination [67]. In contrast, positive and negative expression appears to be unrelated to social anxiety [98]. Positive and negative self-disclosures may, instead, impact the quantity of social reciprocity an individual with social anxiety receives [98]. For example, when individuals higher in social anxiety post positive status updates, this generates more pronounced increase in social feedback (likes) than when positive posts are made by those low in social anxiety or when posts have low positive content [98].

Quality of Interactions

Considerable evidence suggests a link between the quality of interactions on SNSs and mental health. Studies have operationalized SNS interaction quality as either the perceived (when self-rated) or observed (when coded by experimenters) valence of interactions between friends and the user on SNSs. Items often refer to a global estimate of "How positive [or negative] are your interactions with people on Facebook" [54] or, where coded, the frequency of positive or negative sentiment expressed in comments on posts [103]. This differs from the frequency of social or interactive communication on SNSs, discussed above, which refers to the estimated frequency or total time spent engaging in these activities.

Depression is generally associated with fewer positive interactions and more negative interactions on SNSs [54,56,103,107,108]. Social and global anxiety similarly relate to the perception of negative quality interactions on SNSs [56,107]. Depressed individuals may use SNSs in a more problematic manner than do anxious individuals [56], thus creating negative interactions. For instance, symptoms recorded at the age of 13 years significantly predicted a reduced likelihood of receiving comments that contained deviancy talk from SNS peers at the age of 20 years; however, symptoms at the age of 20 years predicted a greater instance of verbally abusive comments from peers [103]. The findings of Frison et al [81] also suggest that depressive symptoms are a risk factor for peer victimization on Facebook. Moberg and Anestis [108] have additionally shown that, when controlling for the influence of depressive symptoms on perceived negative interactions on SNSs, greater ratings of negative interactions predict feelings of thwarted belongingness (disconnection), a potential risk factor for suicidal desire.

Depressive rumination and corumination may moderate associations between the perception of SNS interaction quality and depression. In 2 studies, Davila et al [54] showed that those with higher levels of depressive rumination exhibited a stronger relationship between the frequency of perceived negative interactions on SNSs and greater depressive symptoms. Although corumination (ie, "excessive discussion of problems within friendships"; [54] p73) did not emerge as a significant moderator, it did yield a number of relationships with other variables, notably, feeling down or depressed after interactions on SNSs and a greater frequency of SNS use. The quality of use also relates to intentions for continued SNS use. Belief that online communities are dangerous, including concerns about privacy and the potential to encounter hostile or negative interactions, has been shown to be a potential antecedent of online and general social anxiety and their link to reduced continuance intention of using Facebook for social communication [109].

Associations may depend in part on the methodologies used. When researchers have directly observed and coded the language of comments made to an SNS user by their friends, it has been shown that a greater level of social anxiety at age 20 years was a significant predictor of more positive supportive comments from SNS friends and fewer negative peer interactions [103]. This is in contrast with the research utilizing self-report survey methods that show more frequent reporting of negative interactions for those with high levels of depression and anxiety symptoms [54,56,107]. This discrepancy suggests there may be a role for perceptual bias in a participant's interpretation of the quality of interactions to which they are exposed on SNSs. In this light, individuals with higher levels of depression and

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anxiety may be more inclined to interpret or perceive SNS interaction as more negative regardless of the communication content exchanged between users. The potential for such a perceptual bias in interpreting SNS interactions has also been suggested in reference to social support perceptions and is further discussed below (see Park et al [93]).

Social Support

Social support plays a mixed and varied role within the SNS environment. Studies suggest that individuals with higher depressive symptoms perceive their SNS friend networks as providing them with less social support than they actually receive [93] and that SNS social support seeking may exacerbate depressed mood for some individuals [110]. Perception of support appears to be more important than actual support. Across 2 studies, Park et al [93] showed that in the general population greater depressive symptoms were associated with more *actual* social support on status updates that contained negative emotion. In contrast, *perceived* support was negatively associated with depression, and higher depressive symptoms were associated with a greater discrepancy between actual and perceived social support. Frison and Eggermont [110] similarly found that depressed mood increased in adolescents when social support was sought on Facebook but perceived to not occur. Other research has also demonstrated the protective role of perceived social support in ameliorating the impact of SNS peer victimization on depression [81].

For anxiety, social support provided on SNSs may play a protective role. Indian and Grieve [111] found that perceptions of Facebook social support were only predictive of subjective well-being for individuals with high levels of social anxiety and not for those reporting low levels of social anxiety. Furthermore, in the high social anxiety group, perceived Facebook social support was the only significant predictor of subjective well-being, suggesting that SNS social support may provide unique benefits to individuals with high levels of social anxiety.

The nature of seeking social support on SNSs may differ from traditional face-to-face approaches [110,112]. Some evidence suggests that emotional support provided by Facebook can increase depressive symptoms and decrease quality of life [112]. It may depend in part on the characteristics of the user. For example, SNS users' perceived communication competence—an overall evaluation of communication skills and behaviors—plays a role in determining the level of satisfaction they feel is generated from their SNS social support. Wright et al [79] demonstrated that better perceived communication competence predicted higher ratings of both face-to-face social support and Facebook social support satisfaction, which in turn were significantly negatively related to depression.

Social Connectedness

Facebook social connectedness encompasses subjective feelings of belonging and closeness to an individual's social network [113]. Grieve et al [113] demonstrated that higher levels of Facebook social connectedness were related to lower levels of depression and anxiety and higher levels of subjective well-being (life satisfaction). Feelings of social connectedness may mediate the impact an increase in posting behavior has on decreasing loneliness [102].

Social Comparison

Social comparison on SNSs, where individuals compare themselves as having more positive (downward comparison) or negative (upward comparison) qualities than others, is a significant risk factor for depression and anxiety [68,77,114,115]. Several studies found that Facebook envy, a hostile evaluation of others from their social information on SNSs, is associated with higher ratings of depressive symptoms [78,116]. Lee [114] found that depression and anxiety were positively related to the frequency of social comparison on Facebook. Feinstein et al [115] extended these findings by revealing rumination as a mediator in the relationship between negative (upward) social comparison on Facebook and depressive symptoms. This relationship changed over time; at a 3-week follow up, more frequent negative social comparison on Facebook was associated with increases in rumination and a subsequent increase of depressive symptoms.

Appel et al [116] examined how depression may influence an SNS user's interpretation of the profile information of other users. Individuals with depression were more likely to rate themselves as being unhappier (or inferior) in comparison with profiles of any type (attractive or unattractive) than those without depression. Individuals with depression also experienced greater envy than those without depression in response to viewing the unattractive profile, with this difference being greater after viewing the attractive profile.

Social comparison of any direction (upward, nondirectional, or downward) may also indirectly mediate the association between the time spent on Facebook and depression. Across 2 studies, as individuals spend more time on Facebook they engage in more frequent negative (upward) and nondirectional social comparison and less positive (downward) social comparison, which in turn relates to more depressive symptoms [77].

Envy potentially plays a destructive role in passive Facebook use (eg, viewing or browsing profiles; see Table 1). Where Facebook envy is high, greater frequency of passive Facebook use is associated with greater depressive symptoms, and where Facebook envy is low (or not present), passive Facebook use is associated with reduced depressive symptoms [78]. Indeed, research into Instagram (a photo-sharing SNS) [68] has shown that more positive (downward) social comparisons are associated with decreased depressive symptoms. Social network composition, additionally, may moderate the relationship between frequent Instagram use and increases in depressive symptoms via social comparison [68].

Addictive or Problematic Social Networking Site Use

"SNS addiction" and "problematic SNS use" are linked with depression and anxiety [58,60,62,65,104,106,117-121], although associations most likely are bidirectional in nature. It has been suggested that such maladaptive SNS use is only present for a small subset of users [62,106], although one study suggested that 41.9% of adolescents had a Facebook addiction [119]. While depression and social anxiety explain much of the variance in problematic SNS use or SNS addiction, other

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variables (younger age, male, and more frequent SNS or general Internet use) have also emerged as significant predictors [58,62,118]. Through cluster analysis, Moreau et al [120] showed that problematic Facebook use is most prevalent in individuals high in borderline personality traits and depressive and social anxiety symptoms compared with groups low in those symptoms or high in sensation seeking (but low in psychopathology). Their findings may indicate considerable comorbidity between psychopathological symptoms and SNS addiction.

Wegmann et al [121] suggested that depressive symptoms and social anxiety have both a significant direct relationship with SNS-specific addiction and a partially mediated pathway to SNS-specific addiction via 2 cognitive styles: self-regulation and Internet use expectancies. In these pathways, higher levels of depression and anxiety are related to lower levels of self-regulation, which are in turn related to higher SNS-specific addiction scores. Internet use expectancies, the perception that the Internet can aid in increasing pleasure and decreasing negativity, were greater for those with higher depression or anxiety symptoms, which again lead to greater vulnerability for SNS-specific addiction. They suggest that depression and social anxiety may predispose SNS users to these cognitive styles.

In contrast, Andreassen et al [117] found that while social anxiety was positively related to addictive SNS use, depression was negatively related to addictive SNS use. This was interpreted as reflecting social withdrawal characteristics of depression and CMC's social compensation for individuals with social anxiety [117]. Indeed, addiction and the compensatory uses of SNSs have been demonstrated to be related to higher levels of social anxiety [106]. Some evidence suggests that the addictive use of SNSs arises from the need to compensate for the social functions affected by social anxiety symptoms. Casale and Fioravanti [104], for example, show that addressing unmet face-to-face social needs, such as the need to belong, to be perceived as socially competent, and to be assertive in communication, may drive problematic SNS use. However, associations may depend on gender. For males and females, a direct association between social anxiety and problematic SNS use has been demonstrated; however, a significant mediator (motivations for competent self-presentation) in this relationship only emerged for males [104]. Lee-Won et al [65] suggested that when the need for social reassurance (ie, motivations to seek social interactions and feelings of belonging) is high or moderate, the relationship between social anxiety and problematic SNS use is strengthened. Thus, social anxiety may only be a risk factor for problematic use of SNSs where the need for social connection is also high.

Physiology and Facebook

Finally, one study examined the impact of Facebook or face-to-face exposure as a primer for physiological arousal [122]. Arousal was greater for individuals when observing someone face-to-face after browsing their Facebook profile than for individuals exposed to a face-to-face encounter followed by the Facebook condition. Social anxiety was a significant moderator, with a more pronounced increase in arousal for those high in social anxiety, particularly in the Facebook than face-to-face exposure. The authors suggested that for the high social anxiety group, the initial exposure to Facebook may prime social comparison and self-presentation concerns for the subsequent face-to-face meeting. However, as emotional valence was not measured, it is unclear if the arousal experienced by participants was perceived as a positive or negative event.

Discussion

Principal Findings

This systematic review examined associations between SNS use and anxiety and depression. Across 70 studies reviewed, a number of positive and negative correlates have been suggested, as well as moderators and mechanisms of these associations. On the basis of this review, it is likely that there are differing engagement and interactional styles on SNSs for users high in social anxiety and depression. These may be driven or defined by both symptoms and motives to compensate for needs that are not met face-to-face. Negative interactions, frequent social comparison, and SNS addiction or problematic use are related to higher levels of depression and anxiety. Furthermore, cognitive response styles such as rumination or brooding may exacerbate the negative interactions between SNS use, depression, or anxiety for some individuals.

While these potential risks exist for mental health, it is also clear that SNSs can provide considerable benefits to their users. Positive quality interactions, social support, and social connectedness most consistently related to lower levels of depression and anxiety. Social support and connectedness derived from SNS use may be uniquely beneficial to individuals with social anxiety who are unable to access these resources face-to-face. However, especially for those with depression, some evidence suggests that there is a discrepancy between the perceptions of interaction quality and social support and the actual content of their SNS communications, which may attenuate the potential positive impacts of SNS use.

Across a number of studies, observable SNS features such as language use and expressions of identity on user profiles have been demonstrated to provide insight into the depression and anxiety status of the SNS user. With continuing research these characteristics may be a useful tool for monitoring mental health. The content and quality of interactions on SNSs may provide the clearest candidates for monitoring depression and anxiety and may be potential intervention targets for improving mental health and well-being through engaging with SNSs.

Social Aspects of Social Networking Sites

Across studies, social aspects, including feelings of social support, social connectedness, and positive interaction quality, emerged as protective factors for SNS users. The SNS network structure itself may play an important role in supporting mental health, in that some platforms may better provide social resources to individuals with depression. Indeed, more integrated social networks on SNSs were associated with lower levels of depression [89]. Studies suggest that social support and social connectedness derived from SNSs are constructs distinct from general social support or connectedness [111,113]. SNSs may therefore be contributing additional benefit to their users by

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creating another domain in which individuals can access, or have greater perceived access to, social support, especially with individuals for whom face-to-face interaction is difficult [123-125]. The broad and visibly articulated social context on SNSs may contribute to the feeling of social connectedness derived from SNSs and its association with better mental health outcomes [126]. As such, SNSs may provide an environment where those already high in social skills and resources are benefiting from their cumulative sources of social support ("rich-get-richer"; see [28]) as well as augmenting social support access for those who have difficulties engaging face-to-face [111,123-125].

Consistent with offline research, the perception of social support appears to be more important than actual support [126-128]. Findings demonstrated that perceived social support was greater in those with lower depression scores and that perceived communication competence may contribute to this relationship [79,93]. Greater perceived positive interaction quality and greater reciprocity in interactions are also indicative of lower depression and anxiety. Similarly, Valkenburg et al [32] demonstrated higher levels of life satisfaction and self-esteem for those who frequently reported positive peer experiences on SNSs. However, aspects of the individual that drive depressive feelings and social anxiety, greater use of negative language, and cognitive aspects such as social comparison and rumination, can prevent the user from perceiving support that is actually there [93], further contributing to depressive or anxious symptoms.

Emotional Aspects of Social Networking Sites

The valence of posts on SNSs may both reflect and impact depression and anxiety. Individuals scoring higher on depression scales in the reviewed studies generally expressed more negative affect on SNSs and were more likely to perceive negative interactions. The way individuals interpret emotional and social content on SNSs may place depression as antecedent to maladaptive SNS use, which may, in turn, maintain depressive symptoms. For individuals who are already depressed, ambiguous interactions are often interpreted as negative [13,129], which may attenuate the potential benefits available through SNS use.

Evidence suggests that frequent positive expressions are associated with better mental health, and frequent negative expressions are associated with depression and poorer life satisfaction [67,91,96]. While therapeutic writing can provide some benefits in reducing distress and improving well-being [30,31], online writing may serve a different function, with Web-based expressions reflecting the lived experience of the individual (eg, [91,130-132]), rather than providing a therapeutic outlet. Indeed, relative increases in posting frequency were shown to be associated with greater depressive symptoms [84]. For others, the presence of social anxiety may hinder the use of posting functions for emotional disclosure on SNSs [59], which may decrease access to potential social interaction [98]. As emotional content can be effectively communicated on the Web [133], SNSs represent another space in which positive and negative interactions can be enacted and may provide key behavioral insights into the mental health and well-being of a SNS user. Alternatively, increases in self-expression on SNSs may be more beneficial to well-being domains (such as connectedness, social support, and life satisfaction) but may not have an impact on depression or anxiety. A direct comparison of these relationships has not been conducted, and might be an area to investigate in the future.

Cognitive Aspects as Mechanisms and Moderators

The prominent risk factors for depression and anxiety that emerged from this review included frequent SNS social comparison, negative perceived interaction quality, addictive or problematic SNS use, and rumination (or brooding). These factors represent cognitive and interactional styles that have well-established associations with depression and anxiety but may be enhanced by the enduring nature of social content on SNSs. Although the total frequency of SNS use does not appear to be directly related to either depression or anxiety, there are different moderating and mediating factors [68,73,77,78] and patterns in the functions of SNS use by individuals with higher depression or anxiety that may contribute to or exacerbate symptoms [69,74-76,78].

One of the risk factors for depression and an individual's interaction with SNSs was rumination. Greater rumination is frequently associated with higher ratings of depression and also impacts well-being by maintaining a focus on negative affect [134,135]. Rumination is a likely mechanism for the relationship between negative interactions with SNSs and depression based on its role in SNS negative emotional expression [67] and social comparison [115]. There is considerable potential for SNSs to amplify and assist ruminative processes by exposing SNS users to a constant stream of rich social information that can be selectively reflected on as permanent content on a user's profile [54,115].

Similar to depression, the cognitive risk factors for social anxiety include social comparison (via brooding) and the perception of frequent negative interactions. However, the pathway to and importance of these risk factors may differ from depression. In contrast to those with depression, those high in social anxiety mainly use SNSs for passive browsing and private communication, not for content production [75]. The passive uses of SNSs may place individuals at greater risk of more frequent social comparison, which may have negative mental health effects [114]. This differs from the relative benefit of content production on SNSs for an individual with social anxiety, as posts are often rated as being more appreciated by friends in the network [98], which may have a flow-on effect to the perception of SNS-derived social support [111] and may even reflect more positive interactions with peers [103].

The reduced social cues on SNSs may be attractive to individuals with social anxiety, as has previously been suggested in the general Internet literature [124]. However, the need to compensate for a lack of belonging and social reassurance in face-to-face interactions, in conjunction with lower self-regulation, may drive problematic SNS use for individuals with social anxiety [65,104,106,117]. Similarly, these motives may also contribute to individuals with social anxiety generating more content on their profile pages than others [57], and for those highest in social anxiety it may contribute to a higher

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frequency of SNS use [69]. On the whole, there appear to be a number of well-being benefits to using SNSs for individuals high in social anxiety that cannot be gained in face-to-face interactions; however, the pattern of SNS use may negatively affect other domains.

Mixed Results and Nonpredictors

The frequency of SNS use as a whole suggested no clear association with depression and anxiety. Longitudinal research suggests that depression and anxiety remain stable in the context of how frequently a user engages with SNSs [54,56,61,63,77] and the function of use holds clearer associations with depression and anxiety [75]. This is consistent with the literature examining general Internet use where total frequency of use is often not a predictor of depression, particularly when examining the social features of the Internet [28,125]. For example, when examining different functions on the Internet, Morgan and Cotten [29] showed that more hours spent using the Internet for social activities (IM'ing, chat rooms) are associated with decreased levels of depression and that informational uses and gaming are associated with increases in depression.

While total SNS use may not affect psychopathology, it may be related to subjective well-being. This was illustrated in the study by Kross et al [63], in which more frequent SNS use was related to experiencing more negative affect and reducing life satisfaction. As frequent experience of negative affect may contribute to the onset and maintenance of depression, it is likely that a pathway to poorer mental health outcomes exists via the impact SNS use has on the frequency of experiencing positive and negative emotions [54,63,67]. Additionally, other SNS features and cognitive processes (eg, network size, structure, and composition, tendency to ruminate, frequent social comparison) may be more informative in describing the impact frequent SNS use has on mental health.

In contrast with the literature examining social network size and structure offline [12,136], SNS friendship network size, on the whole, was not associated with depression or anxiety. However, some evidence has shown distinct network structure differences between individuals with depression and those without in terms of the interconnection between friends within a network [84]. Individuals with depression or anxiety have previously been shown to have more impoverished social networks, and changes in mental health are often associated with changes in an individual's social network [12,137]. Impoverished social networks are often a risk factor for depression and anxiety by reducing access to "buffering" social support and increasing feelings of isolation [138-140]. They may also result from poor-quality social interactions, often typical of depression and anxiety [137].

The absence of a clear association between depression or anxiety and the number of friends on SNSs may be explained by one of the major differences between the offline and online social networks; that is, the way friendships are maintained over time. As SNSs do not necessitate direct social interaction to maintain the status of "friendship," many users may not actively redefine their networks [141]. It is likely that the social pruning and the dissolution of social ties associated with mental illnesses such as depression and anxiety may not be visible on SNSs. Social pruning does occur for many SNS users (eg, 63% of American SNS users endorsed that they had removed friends from the "friends" list; [141]), but how comprehensively this behavior is performed remains unknown. Therefore, change in mental health status for SNS users may not be as accurately detected by a decreased social network size online as it may be when observing offline networks. Other metrics, such as communication output and reciprocity, may be more informative in describing the social network changes associated with depression and anxiety. For instance, De Choudhury et al [91] demonstrated that the volume of tweets and the associated replies were reduced in Twitter users with depression compared with those without.

Strengths and Limitations

As with any study, there are both strengths and limitations of this review. We included a basic criterion for bias that focused on evaluating the methodology of studies, which considered whether papers included (1) the use of psychometrically reliable and valid measures; (2) an external measurement criterion for mental health; and (3) description of sample demographics that included basic SNS user activity statistics. Only 9 studies were excluded for bias, suggesting that there is relative strength in defining the variables of interest in this field. However, a greater focus on defining the SNS characteristics of the sample is required.

The review attempted to characterize the research in terms of the populations and specific SNSs that have been studied. Studies have focused rather narrowly on the young adult population. While these individuals tend to represent the highest membership category of SNSs, recent estimates have suggested that SNS use is becoming more evenly represented across the life span, with more than 50% of older Internet users (65+ years) now also using SNSs [7]. This is an important consideration for future research as the social connection that may be gained through SNSs may provide more benefit for older users as quality of the interactions, particularly through language use, may vary significantly over the life span [142].

Despite the systematic approach to this review, the identified themes are not exhaustive. Other themes such as the differences between SNS users and nonusers and SNS use motives may have been extracted and more explicitly discussed. The discussion of results was limited to the depression or anxiety context and did not discuss findings outside this scope. Well-being, which clearly is becoming a growing area of interest (Figure 1), was only included if there was also a focus on depression or anxiety. Future studies might extend to other aspects of mental illness and wellness.

Finally, although we identified some moderating characteristics, few studies have considered individual differences such as gender and personality and their interaction with SNS variables. Future studies might give greater attention to how characteristics of users impact the identified factors.

Implications and Future Directions

The results of this systematic review have revealed considerable support for the importance of examining the content and quality of the interactions a user has with SNSs. As such, the language

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used in interactions on SNSs could become a target of interest, particularly as it has been shown to be sensitive in identifying individuals with depression [91,92,94,143]. Further research should also focus on the interplay between the network structure components and dynamic interactions observable on SNSs. The SNS friend structure could be instrumental in defining the type and efficiency with which social resources may be accessed on SNSs. Examining network structure in concert with the quality of interactions, characteristics such as perceived social support, and mental health could provide rich explanations for why some people benefit from SNS use and others are placed at risk, echoing the detailed social network research that has occurred offline (eg, [12]).

Only a few studies in this review utilized SNS-derived data to answer their research questions. The majority focused on the use of self-report survey and relied on participant estimates of their SNS behaviors, which may have introduced considerable retrospective bias. This bias was addressed to some extent by including ESMs that more accurately sample a participant's lived experience [144]. The studies directly observing SNS behaviors indicate that the mental health status of SNS users may be at least partly derived from their patterns of use, language expression, and profile information. These findings provide more weight to the potential of using computational science techniques within psychological research, particularly in characterizing well-being in large community samples [33-35,145,146], as well as predicting personality [147]; see also [148]. In reference to depression and anxiety, SNS data hold huge potential for early identification and time-sensitive monitoring of symptoms [143]. SNS data should be leveraged in future research as a part of ESMs to provide real-time, unobtrusive accounts of social behavior in a natural setting.

Conclusions

This systematic review examined the recent research on associations between SNSs and depression and anxiety. It examined findings in association with the suggested mediators and moderators and the links made with well-being. With more than 50% of adults using multiple SNSs [7], they permeate many aspects of daily life. For many, SNSs represent a way to socially connect with others. However, for others, SNSs may encourage and perpetuate maladaptive tendencies. SNSs maintain and reflect the complexities of the offline social environment and the risks and benefits it may pose to mental health. SNSs represent a novel, unobtrusive, real-time way to observe and leverage mental health and well-being information in a natural setting, with the ultimate potential to positively influence mental health.

Conflicts of Interest

None declared.

Multimedia Appendix 1

Summary of studies included in the systematic review.

[PDF File (Adobe PDF File), 321KB - mental_v3i4e50_app1.pdf]

Multimedia Appendix 2

Main results table: associations between depression, anxiety, and social networking site outcomes across the 70 reviewed studies.

[PDF File (Adobe PDF File), 106KB - mental_v3i4e50_app2.pdf]

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Abbreviations

CMC: computer-mediated communication
ESM: experience sampling method
LIWC: Linguistic Inquiry and Word Count
MDD: major depressive disorder
SNS: social networking site

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Original Paper

Developing an Unguided Internet-Delivered Intervention for Emotional Distress in Primary Care Patients: Applying Common Factor and Person-Based Approaches

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Abstract

Background: Developing effective, unguided Internet interventions for mental health represents a challenge. Without structured human guidance, engagement with these interventions is often limited and the effectiveness reduced. If their effectiveness can be increased, they have great potential for broad, low-cost dissemination. Improving unguided Internet interventions for mental health requires a renewed focus on the proposed underlying mechanisms of symptom improvement and the involvement of target users from the outset.

Objective: The aim of our study was to develop an unguided e-mental health intervention for distress in primary care patients, drawing on meta-theory of psychotherapeutic change and utilizing the person-based approach (PBA) to guide iterative qualitative piloting with patients.

Methods: Common factors meta-theory informed the selection and structure of therapeutic content, enabling flexibility whilst retaining the proposed necessary ingredients for effectiveness. A logic model was designed outlining intervention components and proposed mechanisms underlying improvement. The PBA provided a framework for systematically incorporating target-user perspective into the intervention development. Primary care patients (N=20) who had consulted with emotional distress in the last 12 months took part in exploratory qualitative interviews, and a subsample (n=13) undertook think-aloud interviews with a prototype of the intervention.

Results: A flexible intervention was developed, to be used as and when patients need, diverting from a more traditional, linear approach. Based on the in-depth qualitative findings, disorder terms such as “depression” were avoided, and discussions of psychological symptoms were placed in the context of stressful life events. Think-aloud interviews showed that patients were positive about the design and structure of the intervention. On the basis of patient feedback, modifications were made to increase immediate access to all therapeutic techniques.

Conclusions: Detailing theoretical assumptions underlying Internet interventions for mental health, and integrating this approach with systematic in-depth qualitative research with target patients is important. These strategies may provide novel ways for addressing the challenges of unguided delivery. The resulting intervention, Healthy Paths, will be evaluated in primary care-based randomized controlled trials, and deployed as a massive open online intervention (MOOI).

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KEYWORDS

Internet; unguided; distress; person-based approach

Introduction

Background

Research on Internet interventions for common mental health problems is maturing. Numerous systematic reviews have demonstrated the effectiveness of guided Internet interventions for reducing depression and anxiety [1-3], with meta-analyses showing that effect sizes can be equivalent to face-to-face psychotherapy [4]. In contrast, unguided Internet interventions for mental health have been more problematic. Removing structured human guidance frequently results in low use, high attrition, and reduced effectiveness [5-7], leading some to call for unguided formats to be avoided [8]. However, if the challenges of unguided interventions can be addressed, they have the potential to be a low-cost, minimally disruptive, self-directed therapeutic resource [9], with a high chance of successful implementation in health care systems, particularly where resources are limited. This format also has the greatest potential to enable mental health interventions to be delivered globally [10-12]. Addressing the challenges of unguided delivery may require bespoke interventions. The development of such interventions provides opportunities to explore theories underlying therapeutic content and novel development approaches.

The majority of Internet interventions for depression and anxiety emulate face-to-face psychotherapy protocols, predominantly based on cognitive behavior therapy (CBT) [13]. Internet CBT interventions often consist of multiple sessions forming a linear "e-course." Importantly, the therapeutic content in unguided CBT interventions is usually very similar to their guided counterparts [14]. In an unguided context, without the support and guidance of a therapeutic relationship, critical elements of CBT [15], standard CBT rationales and specific techniques, may be difficult to adhere to [16,17]. This is also likely to be true of other forms of therapy where central ideas are complex (eg, brief psychodynamic therapy) [18]. In order to design effective unguided interventions, the unguided context may need to be considered throughout the development process, with the resulting interventions structured differently and featuring different and/or amended content to guided interventions.

Ideally, when looking to develop a novel unguided Internet intervention, we would turn to the literature on how psychotherapy-derived interventions work; ensuring critical elements are included where possible, and nothing is lost that would have been beneficial. In reality, although there are many evidence-based psychotherapies (EBPs) for depression, [19] there is little evidence regarding which elements of these complex interventions are necessary for effectiveness [20]. Theory may serve as a useful guide. At the level of specific psychotherapeutic approach, however, most EBPs are based on a diverse range of corresponding theories, from Beck's cognitive theory [21] to Weismann's interpersonal theory of depression [22], with varying levels of supporting evidence. Consequently, we propose that meta-theory and, in particular, "common factors" models may be helpful [23]. Common factors models arose from psychological, sociological, and anthropological theories around how humans manage disease and reduce distress [24,25]. They comprise sets of key factors and/or ingredients necessary for beneficial change, and have been developed to explain the consistently robust finding that different "active" or bona fide psychotherapeutic interventions lead to equivalent effectiveness [26]. These models represent theories about how psychotherapies in general produce effect; so operate at a higher level of abstraction than the individual theories associated with each therapeutic approach. They may provide a useful overarching guide for amending existing intervention manuals for suitability in an unguided context, whilst retaining their effectiveness.

Although the therapeutic relationship is a key common factor there are a number of remaining factors that transfer well onto unguided Internet interventions including (1) a functional explanation for a person's symptoms; (2) an aligning coherent therapeutic rationale for the reduction of symptoms; (3) techniques for ameliorating symptoms or training in skills to be utilized to feel more effective in handling daily life; (4) use of techniques and/or skills in the person's daily life; and (5) attribution of improvement to the person's increased skillfulness and understanding [24,27,28]. All factors are likely to be important; however, particular emphasis is often placed on the role of explanation and therapeutic rationale in generating positive response expectancies [29-32] and novel insight [33].

Effective interventions such as CBT contain all of the above, although specific theories (eg, cognitive mediation) and practices (eg, correcting automatic thoughts) will be emphasized in treatment protocols. Applying a common factor model enables us to modify, restructure, and potentially remove elements that could be difficult without guidance (automatic thought challenging for instance), whilst ensuring the modified intervention remains within the bounds of a robust meta-theory of effectiveness.

The flexibility inherent in common factor models provides a great deal of scope for the integration of user experience and perspectives when developing unguided Internet interventions. Understanding users' perceptions of the target symptom as well as the intervention content is likely to be critical for engagement, which is often poor when guidance is removed. The person-based approach (PBA) is a systematic method for integrating in-depth qualitative research into intervention development [34,35]. Emerging from the development of Internet interventions for physical health within health psychology, it aims to ensure interventions are grounded in "a profound understanding of the perspective and psychosocial context of the people who will use them" [35]. The PBA is highly compatible with, and sympathetic to, similar methodologies such as participatory and user-centered design [36,37] in the field of human-computer interaction (HCI).

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However, the PBA also has significant differences from participatory design methods. The PBA was developed to allow integration of the user perspective into theory- and evidence-based approaches to intervention design. In addition, developing from health psychology, the PBA has an explicit focus on the behavior change and symptom management aspects of user experiences. As such, the PBA can be used in the development of digital and non-digital intervention alike, drawing on users' perspectives to guide the application of evidence and theory, with a focus on ensuring engagement. In addition to guiding qualitative investigations, the PBA promotes an approach that respects autonomy and attempts to ensure an empathic understanding of the user is clear throughout intervention content.

In-depth qualitative research conducted in the development of Internet interventions for mental health remains relatively novel. The qualitative research that has been conducted has primarily been nested within randomized controlled trials (RCTs) of Internet interventions for depression (for a review see [38]). Whilst this research is valuable for developing broad principles to explore more generally, conducting in-depth qualitative research as part of development processes enables users' views and experiences to be rapidly incorporated directly into the resulting interventions.

The Current Study

In this paper we aim to describe the development of the unguided Internet intervention "Healthy Paths Through Stress" (Short name: Healthy Paths), designed to support primary care patients in reducing emotional distress. Sub-threshold depressive symptoms are prevalent in primary care patients, with estimates as high as 45% [39]. Despite not meeting criteria for major depression, these symptoms lead to substantial functional disability, and can lead to the onset of major depressive disorder [39,40]. Patients experiencing this level of symptom burden may be suitable for unguided interventions. However, the content of full Internet CBT might seem less relevant to these patients if their symptoms are not being driven by established cognitive and behavioral patterns characteristic of diagnosed depressive disorder [21]. Our objectives were to (1) draw on a common factor model to select and modify established theory and evidence-based approaches; and (2) use the PBA to ensure the resulting unguided intervention has the greatest potential for both engagement and effectiveness.

Methods

Applying a Common Factor Model

The five common factors we aimed to ensure our intervention, Healthy Paths, included and/or promoted are as follows: (1) a functional explanation for a person's symptoms, (2) an aligning coherent therapeutic rationale for improvement, (3) therapeutic techniques for ameliorating symptoms that align with the rationale, (4) use of techniques and skills in the person's daily life, and (5) attribution of improvement to the person's increased skillfulness and understanding.

Factors 1 and 2: Selecting a Functional Explanation for Symptoms and Coherent Rationale for Improvement

It is common for general practitioners (GPs) to point to difficulties in diagnosing psychological disorders in patients, as many present with social and/or environmental issues and what seem to be "problems of living" [41]. As such we wanted to draw on an overarching approach to the content of the intervention that incorporated social and environmental stressors into the explanations provided. Ricardo F Muñoz has developed an approach to preventing and treating depression that may be particularly relevant for distress in primary care. For 39 years Muñoz has practiced and taught at San Francisco General Hospital (SFGH), a public hospital that primarily serves a low-income, ethnically diverse, multilingual population. This led to the development of an approach with explicit focus on the formidable stressors faced daily by the populations SFGH serves [11]. Therapeutic manuals were written with an emphasis on what Muñoz has termed "The Healthy Management of Reality" [42], an approach that incorporates social learning theory [43], particularly reciprocal determinism and elements of CBT. The central tenet is that it is possible for individuals to use their thoughts and behaviors to manage their reality in a "healthy" way, that is, a way likely to lead to good outcomes for the individual and those around them [42]. There is an overt focus on individuals' external reality (stressors), and internal reality (thoughts, feelings, and moods), ensuring rationales apply to those whose psychological symptoms may primarily be a response to crisis, acute or chronic environmental stressors such as illness, unemployment or familial issues, all of which are prominent in primary care practice presentations.

Factor 3: Therapeutic Techniques Aligning With Explanation and Rationale

Muñoz's depression prevention manuals formed a basis for selecting techniques that we considered most suitable for unguided use. Suitability was based primarily on (1) the simplicity of the technique; (2) the likelihood of reinforcement during or soon after the practice; and (3) inclusion in evidence-based interventions. The first two factors are paramount, as patients are likely to be attempting to engage with material when their moods are low or they are experiencing emotional upset, often in the presence of enduring life stressors. Without the support and guidance of a therapist, techniques that are difficult and/or likely to be beneficial only after days or weeks of consistent use, may lead to disengagement and reduce effectiveness [5]. Based on these parameters cognitive restructuring techniques were excluded and self-monitoring techniques were included as potentially helpful, but made optional. Simple behavioral activation techniques were included as key strategies. Behavioral activation is an important part of Muñoz's manuals [44], and is noted for both its simplicity and effectiveness in the treatment and prevention of depression [45]. A number of techniques from mindfulness-based approaches were also incorporated including body scanning, 3-minute breathing spaces, walking with awareness, and simple self-compassion exercises, all of which met our above criteria.

With the overarching rationale focusing on the healthy management of reality, we wanted to ensure the individual

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techniques were contextualized in a systematic framework, to strengthen coherence and avoid the tools provided appearing like a collection of disparate techniques. We proposed that helpful thoughts and behaviors fall into two groups: increasing awareness and making changes. Increasing awareness includes strategies such as self-monitoring (increasing awareness of thoughts and behaviors in the past), and mindfulness-based approaches (increasing present moment awareness of thoughts and behaviors). Making changes includes behavioral activation strategies (increasing the frequency of pleasant activities), simple cognitive tasks (increasing the frequency of helpful thoughts), and self-kindness practices. We suggested that both approaches worked well together, but that people may be drawn to one over the other. Emphasis was placed on encouraging the use of approaches individuals found engaging and useful.

The evidence to date suggests that in linear unguided programs, most individuals tend to use the first session, and then not go further [6,14]. This is an issue if the main therapeutic techniques in the program are introduced in later sessions. In addition, Donkin et al [46] found that there does not appear to be a simple linear relationship between total use or suggested techniques and the measurable benefit. This relationship is complex and still not sufficiently understood. To acknowledge this, we suggested our intervention should be used when it was needed, and all therapeutic techniques could be accessed immediately. The only requirement we made was that individuals should be tunneled through the introduction and rationale sections of the intervention on their first login, a requirement based on the importance placed on the therapeutic rationale by common factors models [25,28]. The introduction and rationale sections could be skipped at subsequent logins. Linear ways of using the techniques were suggested for those who might value this approach, but primarily the emphasis was on using the intervention in a way that worked best for the individual. This is consistent with an autonomy-supportive approach [47], which is likely to be critical for promoting engagement with unguided programs. In addition, there is evidence that Internet intervention users are able to pick the elements (kernels) within a participant preference trial that are relevant to their needs, and that when they do so, they are more likely to reach their goal [48].

In order to have some variance in a system that is non-linear, following the tunneling through the rationales, 3 routes or "paths" were provided to a range of specific techniques grouped under increasing awareness or making changes. Path 1 enables users to explore all the techniques and choose for themselves. Path 2 provides examples of different ways of dealing with difficulties, and recommends increasing awareness or making changes, depending on which way of dealing users feel applies most to them, whereas path 3 provides an emotion-specific recommendation option; users select their dominant feeling at the time (eg, sadness, anger or worry), and the intervention makes a recommendation based on that selection.

Healthy Paths could be described as having a modular structure, as it fulfills many of the criteria Chorpita et al [49] require for modularity. Healthy Paths consists of 12 "content modules" containing a therapeutic technique that could be used alone, or in combination with others, and 4 coordination modules (the introductory module and 3 paths modules) that provide overarching ways of thinking about the Healthy Paths approach, and guidance on which content module to select. A key difference with the examples of modular protocols described by Chorpita et al [49] is that in Healthy Paths the user self-guides regarding the choice of modules, rather than a therapist who assesses patients' needs. There is also overlap with our focus on techniques and Embry and Biglan's [50] concept of selecting evidence-based "kernels"; irreducible components that may affect symptoms or behavior change.

We aimed to make going through the intervention a visually reinforcing and appealing experience to enhance intrinsic motivation to use the material. Beyond text and audio content, we included hi-resolution nature images on the majority of the pages. As well as adding to the general positive feel of the intervention, there is a body of evidence to suggest that viewing nature images facilitates cognitive restoration [51], and can also improve mood [52]. The rationale for the images was explained in the intervention.

Factors 4 and 5: Use of Techniques and Skills in the Person's Daily Life, and Attribution of Improvement to the Person's Increased Skillfulness and Understanding

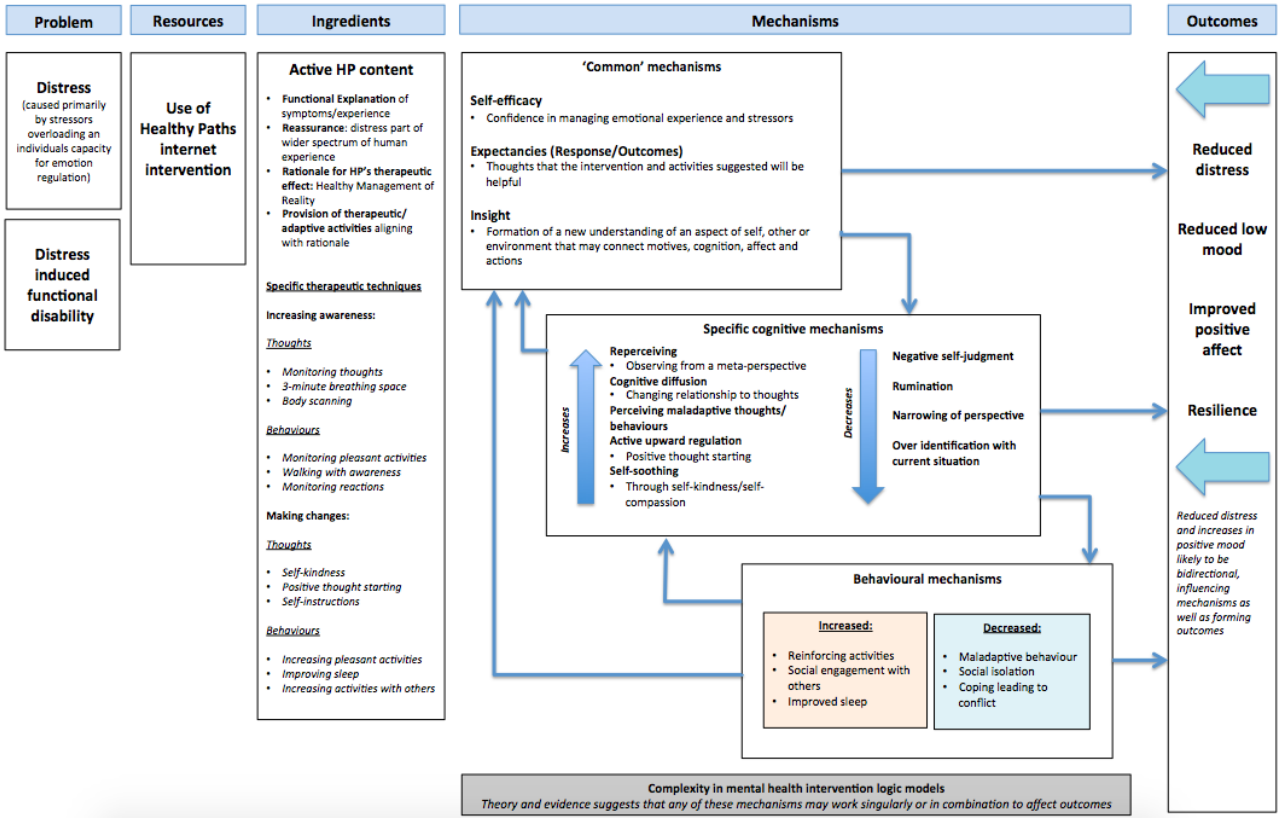
These important common factors are inherent in unguided Internet interventions. In face-to-face psychotherapy, improvement may be attributed to the therapist, whereas in antidepressant treatment, improvement is often attributed to the medication. When the primary delivery mechanism is text and audio, there is great potential for users to attribute improvements to their own development and new techniques learned.

Intervention Logic Model

Creating logic models as part of the development process highlight assumptions' researchers make about their interventions and how they produce change in symptoms. Logic models developed in public health interventions are now explicitly recommended in UK guidance on process studies [53]. Essentially, they are a visual representation of how interventions and their components may affect change (ie, the proposed mechanisms). We suggest that explicitly outlining logic models early in the intervention development cycle may facilitate discussion and debate regarding critical ingredients, and how interventions might be amended to become more suitable for different contexts, based on proposed mechanisms. A logic model for Healthy Paths can be found in Figure 1.

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Figure 1. A logic model for Healthy Paths.



Using the Person-Based Approach

The PBA has a number of elements that can be applied to intervention development, systematizing the involvement of target user groups. The three that will be discussed here are (1) exploratory qualitative interviews; (2) guiding principles; and (3) think-aloud interviews with early intervention prototypes. All elements are iterative, often occurring in parallel. Guiding principles are developed and amended throughout the process. Importantly, our aim is to use the PBA to inform the application of theory and evidence-based techniques in our unguided Internet intervention. This emphasis differs from how some may use participatory or co-design methods, with users themselves recommending and generating content.

Exploratory Qualitative Interviews

We conducted in-depth qualitative interviews to explore primary care patients' experience of distress and to ensure our theory and evidence-based material was contextualized appropriately. Full methodological details have been described elsewhere [54]. Briefly, 20 patients were recruited from 10 UK primary care practices. Practices were asked to identify patients who had consulted in the last 12 months and the GP had placed a "distress" code in their notes, but did not diagnose with major depressive disorder or treated with antidepressants. Patients with a Patient Health Questionnaire-9 (PHQ-9) score of greater than 14 were excluded on the basis of likelihood of major depressive disorder. Interested patients consented to participate and were interviewed at their home or at their primary care practice. The first part of the interview was exploratory and focused on their experience of distress more generally (for full details see [54]), as well as their perceptions of Internet interventions. Interviews were conducted iteratively, in blocks of 3 or 4 over 2 weeks across a 9-month period. The interviews ranged in length from approximately 1 to 1.5 hours. A semi-structured interview guide was used and amended as the interviews went on to focus on points of interest. Patients provided informed consent, and the study was approved by the National Health Service (NHS) Research Ethics Committee (REC reference: 12/SC/0352). All interviews were fully transcribed, and a thematic analysis [55] was conducted with the resulting interview data.

Think-Aloud Qualitative Interviews

From the above sample, 13 patients undertook qualitative think-aloud interview [56]. In this interview participants went through early prototype versions of Healthy Paths on a laptop, with a researcher (JMS) who prompted them to "think-aloud" as they went through each page. In addition to assessing the usability of the intervention, participants were encouraged to describe their perceptions' of the rationales, therapeutic techniques, and how these related to their experience of distress. All think-aloud interviews were transcribed verbatim.

For the current paper, the primary analyses included data from the open-ended interviews regarding participants' views on Internet interventions in general and all think-aloud data. A thematic analytic approach was taken [55], drawing on methods of constant comparison [57]. AG read and reread all transcripts, and proceeded with open coding. A coding manual was developed by AG and reviewed by JMS. All potential amendments to the coding manual and themes were discussed between AG and JMS and added where there was agreement.

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Results

For a description of the participants' baseline characteristics, see Table 1.

Table 1. Demographic characteristics (N=20).

Demographic characteristic	Participants, n (%)
Age in years, mean (SD)	51 (16.5)
Gender, female	15 (75%)
Marital status	
Single	4 (20%)
Married	10 (50%)
Cohabiting	1 (5%)
Divorced	4 (20%)
Widowed	1 (5%)
Ethnicity	
White	18 (90%)
Indian	1 (5%)
Other	1 (5%)
Age since left education, mean (SD)	18 (2.9)
Qualifications	
No formal educational qualifications	3 (15%)
GCSE[a]/O levels or similar	3 (15%)
A levels or similar, ONC[b]/OND[c]	2 (10%)
Diploma (non degree) HNC[d]/HND[e]	3 (15%)
Degree	5 (25%)
Postgraduate degree	1 (5%)
Other	3 (15%)
Employment	
Full-time employment	7 (35%)
Not in employment due to long-term sickness	2 (10%)
Part-time employment	4 (20%)
Retired	4 (20%)
Self-employed (full-time or part-time)	2 (10%)
Unemployed	1 (5%)
Income, £	
<10,000	3 (15%)
10,000-20,000	3 (15%)
20,001-40,000	8 (40%)
>40,000	5 (25%)
Not provided	1 (5%)

[a]GCSE: General Certificate of Secondary Education.
[b]ONC: Ordinary National Certificate.
[c]OND: Ordinary National Diploma.
[d]HNC: Higher National Certificate.
[e]HND: Higher National Diploma.

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Exploratory Interviews

The exploratory interview findings on participants' experiences of distress are described in full elsewhere [54]. In summary, participants reported severe affective experiences, despite not being diagnosed with depression. The majority of patients' disruptive affective experience was tied to complex life difficulties including chronic illness, caring roles following family or spouse serious mental and/or physical illness, unemployment, bereavement, bullying at work or relationship breakdown. Often multiple stressors coincided leading to the consultation with the GP. These stressors were described as overwhelming participants' ability to cope. Terms like "depression" were used with different meanings (mood vs mental illness); however, a number of participants were cautious and sought to distance themselves from notions of "depression."

Based on the exploratory interview data on patients' experience of distress, the tone of the material was adjusted to ensure it was positive but acknowledged the difficulty and/or seriousness of stressful life events likely to lead to use of the interventions. The use of cartoons was avoided throughout, on the basis that they could be perceived as making light of users' circumstances. Descriptions of difficulty were grounded in life experiences, and we avoided the use of words like depression and mentions of mental disorder or illness.

Analysis of patients' perceptions of Internet interventions in the exploratory interviews resulted in 4 primary themes, which are discussed in turn below.

Positive Perceptions

The majority of participants were positive about the idea of using Internet interventions to manage distress, suggesting that Internet interventions could be used as a source of guidance and coping strategies in times of difficulty.

> *So it is having that sort of guidance as well and I mean even now I write stuff down so that I can go back to that. So if you have got it on the Internet you can go to it and, you know, give yourself...get yourself back.* [Female, 26]

> *I think a lot of problems is just having a lack of knowledge or information.....or it could be like having coping strategies and things like that. Um, so if those could be fulfilled then yeah, I can't see there being a problem.* [Male, 40]

Managing Flare-Ups

Some participants suggested that they would use an Internet intervention as a resource to manage "flare-ups" in their affective experiences. This supported the idea of proposing Healthy Paths be used as and when patients feel is necessary. It also provides a possible indication of why linear, unguided multisession interventions may be used infrequently by those with sub-threshold symptoms.

> *I mean at the moment, yeah, I would look at it um and if I did have another flare up, yeah, I probably most certainly would have another good look at it but um, I don't think it will be something that I would continually... because I tend to when it's gone, that's it forget it and just carry on with things.* [Female, 61]

> *It's there to sort of when, you know, when the alarm is going off I should go ok, just to get some perspective on what's happening and just to quiet the alarm down for a minute... what would be key is to have in people's minds is this trigger, stress um, go to that Internet site and then the sooner that can happen the sooner they can work through whatever is stressing them out.* [Male, 39]

Concerns

There were a small number participants who had concerns about Internet interventions. These concerns centered on self-help websites replacing time with a GP, and the necessity for face-to-face contact when dealing with emotional problems. When recommending Healthy Paths, it would be important for GPs to ensure patients understand that the intervention is in addition to, rather than in place of their usual primary care.

> *I think it's possibly just a way of um taking away face-to-face contact with people.* [Female, 50]

Trust and Credible Source

Some participants talked about the importance of trusting the source of the information, when considering whether they would use an Internet intervention to manage distress.

> *That is something that I would… because I've spoken to you, yes, I would go on there because I know it is genuine… and it has come from the doctor as well, so it does make it totally different.* [Female, 63]

As Healthy Paths has been developed initially for primary care patients, although delivered as unguided, it is likely to be recommended by a GP. This link to a trusted health care practitioner via a trusted health care pathway may increase uptake and engagement.

Development of Guiding Principles

On the basis of our exploratory qualitative interviews, theory, and evidence a set of guiding principles were developed for Healthy Paths (Textbox 1). Guiding principles, features of the PBA, are short statements of intervention design objectives and key features of the intervention design that can meet these objectives. The aim of guiding principles is to succinctly capture what is unique or distinctive about the intervention. As such, they are useful when working on development in large multidisciplinary teams, particularly where development will occur in iterations over a number of years; ensuring members stay on track and work toward the same goals.

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Textbox 1. Guiding principles for the Healthy Paths intervention.

Intervention design objectives and the key features that may achieve these objectives

- To design material for an unguided context, focusing on simplicity and maximizing intrinsic motivation to engage.
  - Ensure material is simple, informative, and as original as possible.
  - Selected techniques should have potential for reinforcement or to be rewarding with little behavioral commitment.
  - Navigation should be straightforward, whilst providing different ways of engaging with the material.
  - Autonomous motivation will be fostered by:
    - Providing choice;
    - Giving explanations for why suggestions might be helpful;
    - Using non-directive language throughout such as a tone that invites rather than instructs [35].
- To offer material suitable for broad range of primary care patients experiencing emotional distress.
  - Include content with a primary focus on core feelings, thoughts, and behaviors common to many distress experiences, with an acknowledgment of environmental and social causes.
  - Included content will seek to demedicalize experiences, through avoidance of "terms such as “mental illness” and “psychological disorder.”

Think-Aloud Interviews

Analysis of think-aloud data resulted in 6 positive themes relating to aspects of the intervention and 4 negative themes relating to difficulties. The negative themes guided intervention amendments. Primary themes with examples are summarized below.

Look and Feel

Throughout the think-aloud interviews, participants were generally positive about the look and feel of the intervention. In particular participants often suggested the look and layout was calming.

> *I like the whole look of it actually because it feels calm. It sounds stupid but the colors are right.* [Female, 61]
>
> *Given that it's to do with stress it seems quite nice and calming; yes, nice layout, easy to read so the layout is nice.* [Female, 39]

Specific Intervention Explanations and Rationales

The majority of participants suggested that the therapeutic rationales were clear, and the ideas made sense. Participants talked about the importance of having different options to support them through their experiences. They also mentioned the importance of simplicity and messages being to the point.

> *I think that's a good idea because it is different for different people and it is a path and it takes a long time and, yes, I think that's a good way of putting it, actually. It's not an immediate thing and a path, it's a way to go; it might be a short time, it might be a long time and that is the best way of describing it, really.* [Female, 26]
>
> *It's nice and quite to the point, there's not too many hidden meanings or anything behind what the message is, so that's good.* [Female, 24]

Content in General

Participants reported feeling that they could relate to the content. They valued the direction the intervention provided and emphasized the positive aspects of having the information broken into small sections.

> *Right, you see that’s quite good, I think, isn’t it really, because it’s saying what are you like, right ok, this is the path for you. You know, that’s directing you. I think that’s quite good.* [Male, 68]
>
> *If I came in and said, “Well, I don’t know what to do”, supposing it happened to me, I’d think well, what should I do? And then I’ve had a positive feedback to tell me to do such and such a thing...* [Female, 88]
>
> *I think that the information is interesting. It's broken into chunks, easily absorbed, especially I'm just thinking if I'm feeling more stressed than I am now then it is nice and calming to read it and it's inviting to read it.* [Female, 39]

Usability Difficulties

On early versions of the intervention, some participants suggested that rationales were too extensive, and they were looking for a way to get directly to techniques to help them. Subsequently, the intervention was amended to signpost how the intervention would work, and inform users that following the first login, they could skip all rationales and go directly to the therapeutic techniques.

> *I think really people who are anxious or worried they’re not thinking straight at that time are they, their thoughts are irrational, so are they going to sit down and plot through something like this when all they want is relief from the way they are feeling? So I think a straight line to the techniques—yeah, I agree you have got to put all of the background in and the understanding and why it is happening and all that, and that’s going to be beneficial to a lot of*

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> *people—um, but I think, you know, cutting to the techniques...* [Male, 66]

Concerns With Images

Initially, a small number of nature images were used to illustrate feelings that were being discussed in the content, for instance dark clouds for low mood. Some participants did not like these images, leading to their removal. We then ensured all nature images depicted uplifting scenes.

> *Dark and dismal. I don't like it. [what about] a nice blue sky, it's sky isn't it, and clouds? A bluer sky, nicer, I'd rather see. Maybe I'm wrong, maybe when you're – no that would make you even lower.* [Female, 69]

Complexity of Text

In the increasing awareness section (based on mindfulness approaches), some participants suggested that rationales were too complex. Following this being noted, all sections were broken down to ensure the material as was straightforward as possible.

> *[P reading material] "The difference with walking with awareness is that we deliberately chose to notice more of the actual experience of walking" Yeah. I just think that that could be said in a more simplistic way. And some people may appreciate that.* [Male, 66]

Issues With Explanations

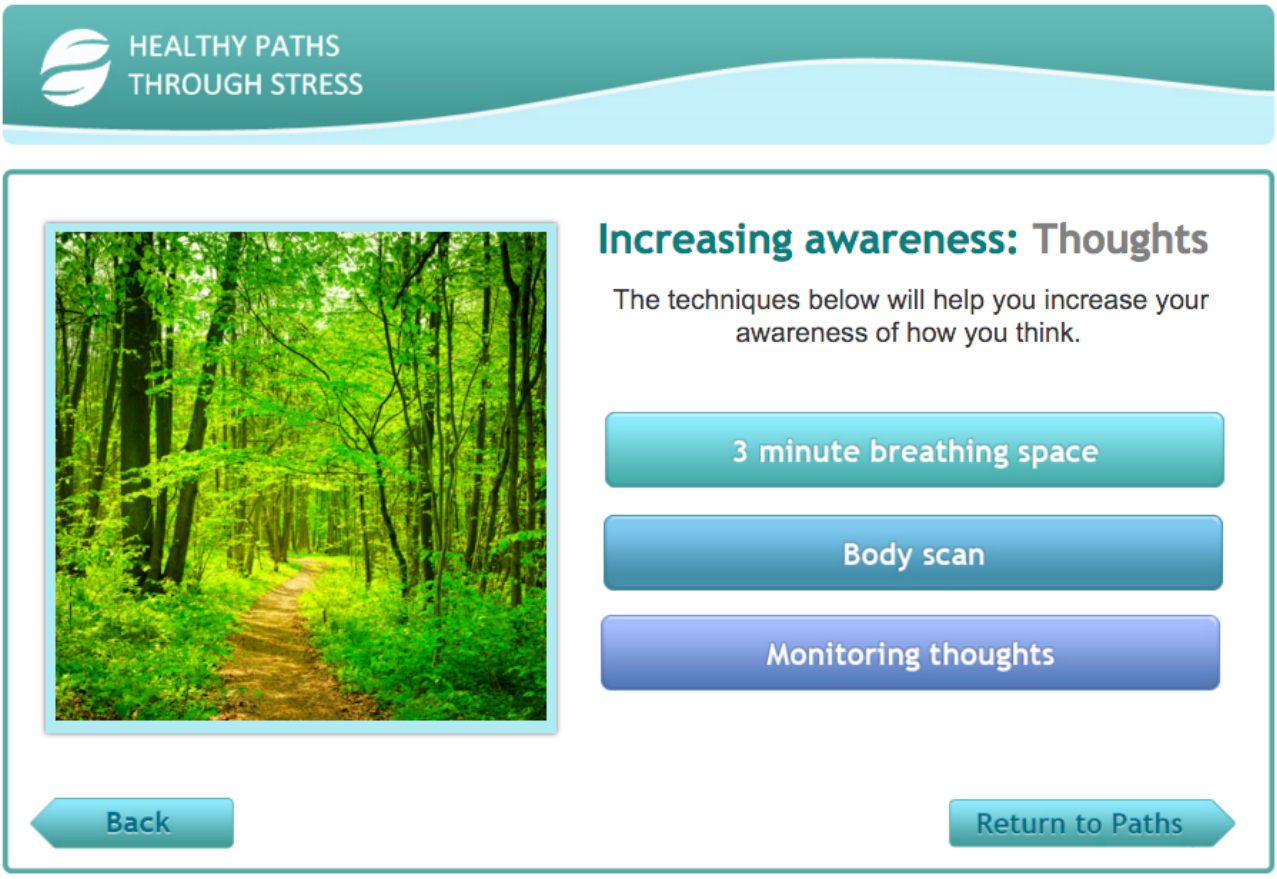
Although all efforts were made to ensure simplicity in the description of ideas, if the idea itself was very straightforward or not novel, it was picked up as being "obvious."

> *It's stating the obvious ain't it, 'Helpful thoughts help you achieve a positive mood, harmful thoughts produce a more negative mood'.* [Male, 66]

As such, efforts were made to reduce or remove these obvious statements throughout the intervention. Where the team felt it was important to keep them, we ensured this was acknowledged, for instance, by prefixing a section with "this may seem obvious…" and going on to explain why it was still important to mention.

Overall, both the open-ended and think-aloud interviews were used to ensure the theory and evidence informed intervention was thoroughly grounded in the lived experiences of the target users. A screenshot from the intervention is shown in Figure 2.

Figure 2. Screenshot of Healthy Paths.



Discussion

Principal Findings

This paper describes our approach to developing an unguided Internet intervention. Common factor meta-theory guided the selection of and amendments to the evidence-based content, with the aim of retaining effectiveness in an unguided context. The PBA was used to guide the integration of users' perspectives into the development process, as well as ensure material fostered autonomy. Both exploratory and think-aloud elements led to

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amendments and adaptations to the theory- and evidence-based content aimed at improving engagement. Subsequently, the majority of participants found our intervention to be informative, able to relate to their experiences, and to be acceptable.

In Healthy Paths, users are encouraged to engage with the intervention in a way that suits them, particularly in times of need. This deviates from approaches employed by previous researchers, where Internet interventions for mental health are structured so that sessions or modules recap and build on each other in a progression over time [58,59]. Our aim is to foster intrinsic and autonomous motivation to use the intervention as far as possible. Avoiding the learning course structure may be important to reach and retain those with lower levels of educational attainment, where elements reflective of a more extrinsic approach (eg, completing sessions within set time intervals, homework worksheets etc) may be particularly off-putting. If initial interest is driven by a user's autonomous motivation to reduce their symptoms, and then when using the intervention they find it to be a positive, reinforcing experience, this may lead to sustained motivation for use in the future. This approach acknowledges that symptoms are often a primary driver of adherence and engagement across a number of areas; the presence of pain is related to greater adherence to physiotherapy exercises [60], and increase in symptoms is linked to greater adherence to antidepressant medication [61].

We believe this is the first application of the PBA to the development of an Internet intervention targeting mental health. Our approach to development differs substantially from other development examples. For example, Landback et al [62] used a product design methodology without qualitative user input when developing an Internet intervention for preventing adolescent depression in primary care; Sheeber et al [58] developed and modified their intervention for preventing post-partum depression primarily on theoretical grounds; and Tiburcio et al [63] developed an intervention for substance abuse and depressive symptoms including 20 users, although their input did not go beyond usability aspects of the intervention. The PBA ensures sound usability testing principles are enriched with users' experience of their symptoms, and their perceptions regarding the suitability of approaches in relation to those symptoms.

The development of a logic model [53,64] for our intervention represents a novel application of this approach to the mental health field. With developer's assumptions clear from the outset, it becomes easier to observe and address challenges, and subsequently adapt theory collaboratively. In combination with in-depth user perspective, this theory and person-based approach may take us closer to understanding why Internet interventions produce change, and how they can be improved on this basis.

The initial development of Healthy Paths represents the first step in a continuing, iterative research program. Future projects include a longitudinal qualitative study of primary care patients experiencing distress using Healthy Paths over a 4-week period. Patients will be interviewed over this month regarding how they are using the Internet intervention and the suggested techniques. After this there will be another round of optimization, in preparation for large-scale primary care trials. If successful, Healthy Paths may be suitable for the first step of stepped care programs [65], and will also be openly disseminated free of charge as an example of a massive open online intervention (MOOI) [12]. With a primary focus on managing difficult emotions, Healthy Paths may also be easily adapted for specific stressful circumstances (for instance, managing illness-related distress).

Limitations

Our work has some limitations. The sample used in the qualitative work was predominately female. In future work we will focus on sampling equal numbers of males. In addition, we are likely to have recruited patients who are disposed to this form of intervention and delivery. In the next phase of this project we aim to develop recruitment materials such that we reach beyond this group, in order to include a more diverse range of perspectives. There were a smaller number of participants who took part in think-aloud interviews, potentially limiting the perspectives provided. As common factors models operate at a meta-theoretical level they are necessarily broad, increasing difficulty in application. This puts the onus on researchers to provide and extrapolate their therapeutic rationales for others to evaluate and judge whether they are to be considered "coherent," for instance.

Conclusion

Unguided Internet interventions have great potential for improving mental health if they can be developed to be engaging and effective. The development of Healthy Paths represents the application of novel approaches, encouraging debate around intervention development and mechanisms of effectiveness. Ultimately, we hope our work will lead to new a wave of effective unguided self-directed therapeutic resources for highly prevalent psychological distress.

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Authors' Contributions

AG, PL, LY, RM, and MM conceived the idea for the study and secured funding. AG, RM, JMS, MM, PL, and LY developed the intervention. JMS conducted the interviews, and AG led the qualitative analysis with support from JMS. AG drafted the manuscript with substantial input from all authors. All authors read and approved the final manuscript.

Conflicts of Interest

None declared.

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Abbreviations

CBT: cognitive behavior therapy
EBP: evidence-based psychotherapy
e-mental health: electronic mental health
GP: general practitioner
NIHR: National Institute of Health Research
PBA: person-based approach
SFGH: San Francisco General Hospital

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Original Paper

Evaluation of a Digital Game-Based Learning Program for Enhancing Youth Mental Health: A Structural Equation Modeling of the Program Effectiveness

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Abstract

Background: Digital game-based learning (DGBL) makes use of the entertaining power of digital games for educational purposes. Effectiveness assessment of DGBL programs has been underexplored and no attempt has been made to simultaneously model both important components of DGBL: learning attainment (ie, educational purposes of DGBL) and engagement of users (ie, entertaining power of DGBL) in evaluating program effectiveness.

Objective: This study aimed to describe and evaluate an Internet-based DGBL program, *Professor Gooley and the Flame of Mind*, which promotes mental health to adolescents in a positive youth development approach. In particular, we investigated whether user engagement in the DGBL program could enhance their attainment on each of the learning constructs per DGBL module and subsequently enhance their mental health as measured by psychological well-being.

Methods: Users were assessed on their attainment on each learning construct, psychological well-being, and engagement in each of the modules. One structural equation model was constructed for each DGBL module to model the effect of users' engagement and attainment on the learning construct on their psychological well-being.

Results: Of the 498 secondary school students that registered and participated from the first module of the DGBL program, 192 completed all 8 modules of the program. Results from structural equation modeling suggested that a higher extent of engagement in the program activities facilitated users' attainment on the learning constructs on most of the modules and in turn enhanced their psychological well-being after controlling for users' initial psychological well-being and initial attainment on the constructs.

Conclusions: This study provided evidence that Internet intervention for mental health, implemented with the technologies and digital innovations of DGBL, could enhance youth mental health. Structural equation modeling is a promising approach in evaluating the effectiveness of DGBL programs.

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KEYWORDS

digital game-based learning; mental health; program evaluation; Internet

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Introduction

Youth Mental Health

Problems with mental health are common in adolescents. Review studies have consistently shown that the prevalence of youth mental illnesses has been increasing and the onset age of developing mental illnesses has been decreasing [1]. For instance, it has been found that the lifetime prevalence rate for major depressive disorder in adolescents is between 15% and 20% [2]. Mental illness of young people is associated with poor academic performance, social dysfunction, high-risk sexual behavior, teen pregnancy, substance abuse, and self-mutilating behavior [3-5]. While genetic and biological factors may contribute to a person's experience of mental illness or mental health, there are risk and protective factors involved that people can modify. Risk factors are factors that are present before the onset of a mental illness and that increase the risk of developing a mental illness [6-8]. Protective factors decrease the risk of developing a mental illness by moderating the effects of the risk factors [7-8]. The field of mental health prevention and promotion has identified many strategies to maximize the mental health and well-being of individuals by weakening the impact of the risk factors and strengthening the impact of the protective factors [8-9]. According to the World Health Organization [10], enhancing the knowledge of the mental health of adolescents and helping them develop the coping skills and strategies that enhance and promote positive mental health are two of the most effective ways to combat youth mental health problems.

Psychological Intervention for Mental Health

Effective psychotherapies for treating mental illnesses exist [11-12], with cognitive behavioral therapy (CBT) being the most widely used [11,13]. CBT has its roots in the biopsychosocial model of mental illness [14] and has been repeatedly shown effective in treating both adolescents and adults with mental illnesses such as depression, anxiety disorders, schizophrenia, and eating disorders [15]. It encompasses cognitive restructuring strategies (such as identifying and challenging automatic negative thoughts) and social problem-solving skills (such as perspective taking, goal-setting, and decision making) [16]. Apart from clinical settings, CBT programs were also implemented as educational interventions in school settings [2,17-19].

Whereas CBT works toward risk prevention for mental health, positive psychology takes a more positive development orientation to mental health. Positive psychology is an approach which encompasses psychological theories that focus on individual traits or character strengths [20]. As pointed out by Seligman [20], pathological issues had been emphasized in the psychological field for the past 50 years. Human strengths for well-being such as hope, happiness, and self-esteem are seldom addressed. Therefore, Seligman and colleagues have begun advocating for positive psychology to complement deficit-based and risk prevention approaches [21-22]. From this, CBT and positive psychology have their unique roles as the theoretical basis for risk prevention and positive development respectively, and intervention programs in mental health could be designed based on both.

Intervention Programs for Youth Mental Health

Over the past two decades, major advances have been made in intervention programs designed to promote or enhance youth mental health [23]. Traditional pathways of information dissemination have been mostly limited to school settings because of the easy accessibility to adolescents at school [13]. However, the number of beneficiaries of school-based intervention programs is highly limited. The school-based intervention program involves labor-intensive engagement; additional human resources are needed to implement the program to more users in more schools, and as a result, the program itself cannot be sustained upon project completion and funding withdrawal. Besides, a review study on school-based interventions for preventing child and adolescent depression showed that it might not be justified to widely disseminate school-based intervention because there was limited evidence for its efficacy and effectiveness [24]. The study also suggested that if the intervention programs were relatively brief and focused on enhancing individual skills without changing the social environment of the individuals, they were less likely to produce long-lasting effects. The fidelity and quality of program delivery were also important when considering whether to disseminate a school-based mental health program. Even if the school principal is supportive to sustain an effective mental health program in school and teachers are willing to deliver the program, the teachers must accept the program wholeheartedly, have the self-efficacy to carry out such a program, and receive adequate training and feedback or the program will have limited effect [25]. Therefore, there are limitations to the implementation and sustainability of a school-based mental health program.

With the evolution and advancement of the Internet in the past decade, intervention programs could be delivered through that medium to more beneficiaries with nearly no marginal cost for each additional participant [26]. The ease of adoption of the Internet for adolescents is dramatic; they can self-learn through the Internet and the learning can take place anytime and anywhere without restriction to time and space. This may enable Internet intervention programs to reach and benefit more adolescents than traditional classroom settings. Moreover, Internet intervention programs can be sustained and maintained at the server, meaning that the intervention program developed for a project could be used continuously with minimal server maintenance cost upon project completion.

Despite few studies on Internet interventions for mental health being identified from recent reviews [23,26-27], there is evidence to show that Internet-based prevention and treatment programs for anxiety and depression can be as efficacious as classroom-based programs, if not better. If an Internet intervention program can be at least as effective as a classroom-based intervention program in attaining the program outcomes, it would be worth developing because of its multimedia capabilities, far-reaching ability, and timeless accessibility. There are a few structured Internet intervention programs focused on educating and enhancing adolescents on mental health both locally and internationally; among those are *beyondblue* [28], *Ching Ching Story* [29], *MoodGYM* [30], *SPARX* [31], *WalkAlong* [32], and *MyHealth Interactive*

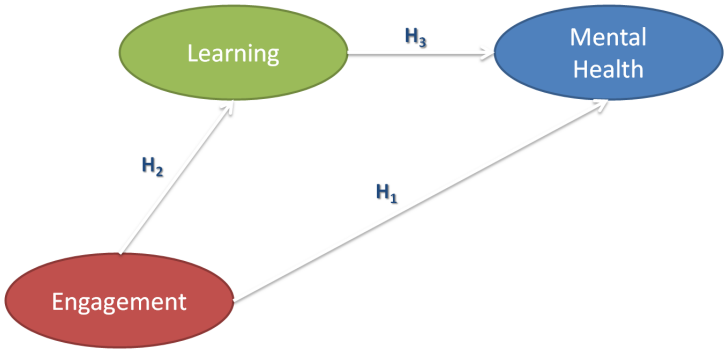
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Magazine [33]. Most of the existing programs function like educational websites containing informative contents on mental health, although effort has been made to present the contents in an interactive way with some multimedia elements. These programs may not have been evaluated using rigorous research methodology (ie, testing the intervention empirically to draw conclusions about program outcomes), and the efficacy or effectiveness of these programs is largely unknown. It is important to evaluate whether undergoing Internet interventions can enhance the mental health of participants as intended.

In Hong Kong, some school-based mental health intervention programs were developed and launched. *The Little Prince is Depressed* [34-35] was a school-based project developed and launched by our research team with an aim to reduce depressive symptoms of students and enhance protective factors of depression. Like many other mental health intervention programs locally and internationally, this project took a risk prevention approach, which has its limitations in school-based mental health promotions because a large number of students being targeted, as in our *The Little Prince is Depressed* project, had very low depressive symptoms to start with (ie, a floor effect). Thus, mental health promotion could move from a risk prevention orientation in reducing symptoms of mental illness to a more positive development orientation in enhancing psychological well-being. The challenges of the mental health promotion being limited to risk prevention and the opportunities that could be brought by incorporating positive youth development have been discussed in our prior work [36].

Cairns et al [8] conducted a systematic review and meta-analysis of 113 longitudinal studies recently to identify risk and protective factors for depression among youngsters. Intervention programs in youth mental health could focus on the major predictors or protective factors for mental health which were identified in this study, especially those factors which Cairns et al concluded to be modifiable factors with a sound evidence base (eg, substance use, dieting, coping strategies, weight), when developing evidence-based intervention programs.

Figure 1. Basic digital game-based learning effectiveness model testing three hypotheses (H_{1-3}).



Digital Game-Based Learning

In this era of unprecedented innovation in technology, a number of multimedia and highly interactive elements can be embedded in Internet-based programs to foster engagement, education, and intervention of the adolescents. In particular, adding digital game elements to learning and instruction can appeal to today's adolescents and facilitate their engagement [37]. Digital game-based learning (DGBL) is becoming increasingly popular in this direction. DGBL can be defined as making use of the entertaining power of digital games for the purpose of engaging or motivating learners to attain certain educational outcomes [38]. A number of game attributes have been identified in the literature to constitute the entertaining power of digital games [39-41]. These include setting the game in a fantasy environment, designing scenarios that induce curiosity, assigning tasks which pose a reasonable level of challenge for players to complete, and allowing players to control their actions, which may potentially influence the game progress. Taken together, Internet intervention programs may take the form of DGBL by incorporating certain game attributes to appeal to youngsters and motivate their learning.

Recent reviews conducted on the effectiveness studies of DGBL found that many studies have reported the benefits and learning effectiveness of DGBL, but they pointed out that some evaluation studies under review were of low quality and therefore rigorous assessment was needed to evaluate the effectiveness of DGBL properly in future studies [42-44]. Since education and entertainment are the two important components in DGBL, both learning and engagement/motivation of users must be simultaneously modeled and evaluated in the effectiveness assessment of a DGBL intervention program [45]. Structural equation modeling (SEM), a statistical modeling technique commonly used in psychological research but not in DGBL effectiveness assessment, can be used for rigorous evaluation of DGBL program in this direction.

Putting a DGBL program for enhancing mental health into context, a basic DGBL effectiveness model (Figure 1) can be built and tested using SEM. Based on the rationale of DGBL discussed earlier, the basic DGBL effectiveness model hypothesizes that both user engagement and learning of the educational contents in the program will impact the program outcome (ie, enhancement of mental health). Basically, three hypotheses were simultaneously tested in this model. First, the extent of engagement and learning of users in the program will impact the program outcome, mental health (see H_1 & H_3 in Figure 1). Furthermore, the extent of engagement of users will also facilitate their learning of the module contents in the program (see H_2 in Figure 1). From these, the effect of user engagement in the program on their subsequent mental health can be examined as an indirect effect and direct effect. Indirect effect refers the effect of user engagement on mental health

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through learning attainment on individual modules. The direct effect of user engagement on mental health is evident if engagement in the module activities alone had an impact on mental health, regardless of the learning attainment on individual modules.

Our DGBL Program, Professor Gooley and the Flame of Mind

In this study, we designed an Internet-based DGBL program, *Professor Gooley and the Flame of Mind*, for enhancing youth mental health. It is a 12-week Internet intervention program (about 45 minutes per week) developed based on the theoretical bases of CBT and positive psychology aforementioned to reduce negative outcomes and enhance positive outcomes, respectively, in mental health in an integrated framework. It consisted of 8 modules aimed at enhancing the mental health of adolescents through DGBL. Textbox 1 shows the outline of content and psychological constructs covered in each of the 8 DGBL modules, which are to be completed sequentially. They are learning constructs pertaining to positive psychology (such as hope and gratitude), cognitive behavioral modification (such as automatic thoughts and procrastination), and interpersonal skill training (such as communication and problem-solving skills).

We incorporated a role-playing game component to make the educational content appealing and entertaining to the users. Users played the role of space intern in a fictional setting of the prevalence of cognitive distortions on earth. Under the instruction of Professor Gooley, they undertook a space journey to 8 planets (modules 1 through 8, see Textbox 1 for details) to search for the Flame of Mind to solve the world health crisis. During the space journey, the users undertook quests that prompted them to learn the psychological constructs and apply the knowledge and skills learned in order to complete the quests to obtain various components to activate the *Flame of Mind*. Each DGBL module has a structured framework including an adventure trailer, preassessment, learning goals and objectives, logbook, minigame, homework, and postassessment (see Multimedia Appendix 1-10). It should be noted that the medium of instruction of *Professor Gooley and the Flame of Mind* was in Chinese because the program was first implemented in the local community of the authors.

To assess the effectiveness of *Professor Gooley and the Flame of Mind*, we adopted a rigorous outcome measurement methodology to test the following research questions simultaneously in a controlled DGBL effectiveness model, which differs from the basic DGBL effectiveness model (Figure 1) in that the controlled DGBL effectiveness model has included controlled variables in its SEM. In this study, users' initial psychological well-being and initial attainment on the psychological constructs at the preassessment could be controlled or accounted for their effect on subsequent psychological well-being and attainment on the psychological constructs at the postassessment. Taken together, we examined in each of the DGBL modules, controlling for users' initial psychological well-being and initial attainment on the psychological construct:

Does users' extent of engagement in the DGBL module positively predict their psychological well-being?

Does users' extent of engagement in the DGBL module positively predict attainment on the psychological construct? (Note: an opposite direction is expected for modules using negative constructs as measures.)

Does users' attainment on the psychological construct positively predict their psychological well-being? (Note: an opposite direction is expected for modules using negative constructs as measures.)

It should be noted that "learning" in our DGBL effectiveness model refers to participants' learning attainment on the psychological construct of each DGBL module—automatic thoughts (Module 1), self-esteem (Module 2), goal setting and attainment (Module 3), hope (Module 4), communication skills (Module 5), gratitude (Module 6), and problem-solving skills (Module 7)—in our program. There is no new construct in Module 8.

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Textbox 1. Outline of content and psychological constructs covered in each digital game-based learning module of Professor Gooley and the Flame of Mind.

Module 1—Planet of perception: automatic thoughts

- Knowledge: Learn the relationship between activating event, belief, and consequences (ABC model)
- Skills: Identify one's thoughts about a situation and to refute thinking errors (if any)
- Attitude: Realize the importance of realistic thinking

Module 2—Planet of awareness: self-esteem

- Knowledge: Learn about the basis of self-esteem and the association between self-esteem and a number of psychosocial variables
- Skills: Make use of effective ways to improve one's self-esteem
- Attitude: Have a positive attitude and appreciation of oneself

Module 3—Planet of wanderers: procrastination

- Knowledge: Understand goal-setting and procrastination on goal attainment
- Skills: Set practical, realistic, and measurable goals according to the 6-step model for goal attainment
- Attitude: Have a healthy lifestyle through setting and achieving goals

Module 4—Planet of positivism: hope

- Knowledge: Learn the hope theory (consisting of goal, pathways thinking, and agency thinking)
- Skills: Set goals, develop pathways thinking, and enhance agency thinking
- Attitude: Be hopeful toward life

Module 5—Planet of solitude: communication skills

- Knowledge: Understand the basis of interpersonal communication, common communication barriers, empathy, and effective communication skills
- Skills: Apply effective communication skills to communicate with different people in different situations
- Attitude: Be respectful, patient, and empathetic when communicating with others

Module 6—Planet of thankfulness: gratitude

- Knowledge: Understand what gratitude is
- Skills: Learn the skills and components that cultivate gratitude
- Attitude: Be grateful regardless of one's life circumstances

Module 7—Planet of uncertainty: problem-solving skills

- Knowledge: Learn the 6-step problem-solving model
- Skills: Identify effective and adaptive solutions for specific problems encountered in everyday life according to the 6-step problem-solving model
- Attitude: Build up a positive and optimistic attitude toward problems

Module 8—Home planet Earth: review of the past 7 modules (note: no new psychological construct in this module)

- Knowledge: Recap key concepts of mental health and common mental health problems in adolescents
- Skills: Apply the skills learned in different life situations to enhance one's mental health
- Attitude: Hold a positive attitude toward mental health and people with mental health problems

Methods

Recruitment

Invitation letters for the purpose of recruiting schools to participate in the project were sent to all secondary schools in Hong Kong in June and December 2012. Each of the interested schools completed an enrollment form, and a list of activation codes was delivered to the school. A school talk about mental health with a demonstration of the program was provided to the school upon request. Students of Secondary One, Secondary Two, or both (depending on the enrollment details of their respective schools) would be given activation codes to activate their user accounts on the program website [46]. After the account activation and registration of a valid email address,

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users could log in to the program at any time from any computer connected to the Internet.

All users were guided step-by-step through the DGBL program *Professor Gooley and the Flame of Mind*. They were required to fill in a questionnaire measuring their attainment on the psychological construct and psychological well-being before and after each DGBL module. In other words, measurements were taken prior to and after undergoing each DGBL module (pre- and postassessment). The system prompted the users to complete the preassessment before starting a new DGBL module and the postassessment immediately after finishing that specific module. The time elapsed between the preassessment and postassessment is the average time taken by users to complete each of the modules, about one week's time. In addition, they were asked to self-report their extent of engagement in the module activities at the end of each completed module. The system would prompt respondents who missed certain items to answer all questionnaire items before submission.

In order to encourage participation, users who completed the whole DGBL program (ie, all 8 DGBL modules) would be eligible to enter a lucky draw.

Technology

Professor Gooley and the Flame of Mind was hosted on a computer server on the network of the home institution of the authors and was accessible by participants who activated their user accounts and logged in to their accounts via the log-in page [46]. This online interactive game was produced in Adobe Flash. Adobe Systems Incorporated and composed of digital elements including animations, graphics, and background music. The logical flow of this role-playing game was controlled by Adobe ActionScript version 3.0. Questionnaire data and user responses were stored in a MySQL (Oracle Corporation) database.

Measures

Mental Health (All Modules)

Mental health was measured by the Scales of Psychological Well-being developed by Ryff and Keyes [47] measuring 6 facets of wellness of an individual: purpose in life, personal growth, positive relations with others, self-acceptance, environmental mastery, and autonomy. A Chinese version of the scale was used in this study [48]. It consists of 24 items in total, and each facet is measured by 4 items. Respondents are asked to rate on a 6-point Likert scale their extent of agreement to each item (from 1 = strongly disagree to 6 = strongly agree). A higher score means a higher level of psychological well-being in each facet. The internal consistency alphas of the 6 facets in this Chinese version of the scale ranged from .52 to .68.

Automatic Thoughts (Module 1—Planet of Perception)

Automatic thoughts were measured by the Children's Automatic Thought Scale developed by Schniering and Rapee [49] assessing a range of negative self-statements of children and adolescents. The original scale consists of 4 subscales, and each subscale has 10 items. Our study adopted 2 subscales (social threat and personal failure) to make a 20-item scale. Respondents are asked to rate the frequency of having those negative self-statements in the last week on a 5-point Likert scale (from 1=not at all to 4 = all the time). A higher score indicates higher frequency of having negative thoughts. The internal consistency for both subscales was .92 and the test-retest reliability was acceptable at 1 month (alpha=.78 for social threat and .80 for personal failure) and 3 months (alpha of .73 for social threat and .74 for personal failure) measurement. A Chinese version of the scale was used in this study.

Self-Esteem (Module 2—Planet of Awareness)

Self-esteem was measured by the Rosenberg Self-Esteem Scale, a 10-item scale [50]. Respondents are asked to rate their extent of agreement to each of the statements on a 4-point Likert scale (from 1 = strongly disagree to 4 = strongly agree). A higher score indicates a higher level of self-esteem. This scale has good reliability and validity. For instance, previous studies showed that the 2-week test-retest reliability was high (r_s>.80) and the scale correlated significantly with other measures of self-esteem and depression and anxiety in predicted directions [51]. A Chinese version of the scale was used.

Procrastination (Module 3—Planet of Wanderers)

Procrastination was measured by the Procrastination Scale developed by Tuckman [52]. Our study adopted the 16-item short form to measure the tendency of procrastination of respondents. They were asked to indicate how well the description of each statement match them on a 4-point scale (eg, from 1 = "That's not me for sure" to 4 = "That's me for sure"). A higher score shows a greater tendency of procrastination. This scale had good internal consistency (alpha of .86) and good concurrent validity which it negatively correlated with a scale for self-efficacy and a behavioral measure of self-regulated performance [51]. A Chinese version of the scale was used.

Hope (Module 4—Planet of Positivism)

Hope was measured by the Children's Hope Scale, a 6-item scale measuring the goal-directed thinking of children, namely, agency thinking and pathway thinking, which are the two components in the hope theory [53]. Respondents are asked to rate on a 6-point Likert scale on how well each statement described how they are in most situations (from 1 = "None of the time" to 6 = "All of the time"). A higher score indicates a higher level of hope. The internal consistency alphas ranged from .72 to .86 in 6 samples and the scale had good test-retest reliability for 1-week and 1-month intervals in a study conducted by Snyder et al [53]. The study also showed good convergent validity, that the Children's Hope Scale predicted that children's hope level was positively correlated with their self-perceived competence, control, and self-esteem and negatively correlated with depression. A Chinese version of the scale was used.

Communication Skills (Module 5—Planet of Solitude)

Communication skills were measured by the Interpersonal Communication Competence Scale, a 10-item scale measuring 10 dimensions of interpersonal communication skills such as self-disclosure, empathy, and assertiveness [54]. Respondents are asked to rate how each statement reflects their communication with others on a 5-point Likert scale (from 1 = "Almost never behave in this way" to 5 = "Almost always

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interact in this way"). A higher score shows a higher level of competence. This scale was reliable (alpha of .63) with good concurrent validity because it significantly correlated with cognitive and communication flexibility in interpersonal interactions [54]. Also, it correlated significantly with communication satisfaction, pleasure, affection, and relaxation, which were the motives for initiating conversation [54]. A Chinese version of the scale was used.

Gratitude (Module 6—Planet of Thankfulness)

Gratitude was measured by the Gratitude Questionnaire-6, a 6-item scale measuring the gratitude disposition of an individual. Respondents are asked to rate on a 7-point Likert scale to indicate their extent of agreement with each statement (from 1 = strongly disagree to 7 = strongly agree). A higher score indicates a higher disposition of gratitude. The scale had high internal consistency (alpha of .82) and good discriminant validity; for instance, grateful disposition was distinct from life satisfaction, happiness, optimism, and hope [55]. A Chinese version of the scale was used.

Problem-Solving Skills (Module 7—Planet of Uncertainty)

The Chinese version of the Social Problem-Solving Inventory [56] was used to measure the problem-solving ability of the respondents. It is a 25-item scale with 5 subscales: negative problem orientation, rational problem solving, positive problem orientation, avoidance, and impulsiveness/carelessness. Respondents are asked to indicate how well the statements describe their reaction to everyday problems on a 5-point Likert scale (from 0 = "Not at all true of me" to 4 = "Extremely true of me"). A higher score indicates a higher level of problem-solving ability. This scale had good internal consistency (alphas of .65 to .88) and showed good temporal stability over a 2-week interval [56].

Engagement (All Modules)

The engagement of the users in the DGBL program was measured by self-constructed items on the extent to which one was committed to (1) devote full effort, (2) read thoroughly, (3) act seriously, (4) learn fruitfully, and (5) enjoy learning in each of the DGBL modules. A higher score indicates a higher extent of engagement in the module activities. The scale had high internal consistency (alphas of .96 to .98 across modules). The item-total correlations were also strong (all r_s>.88).

Statistical Analysis

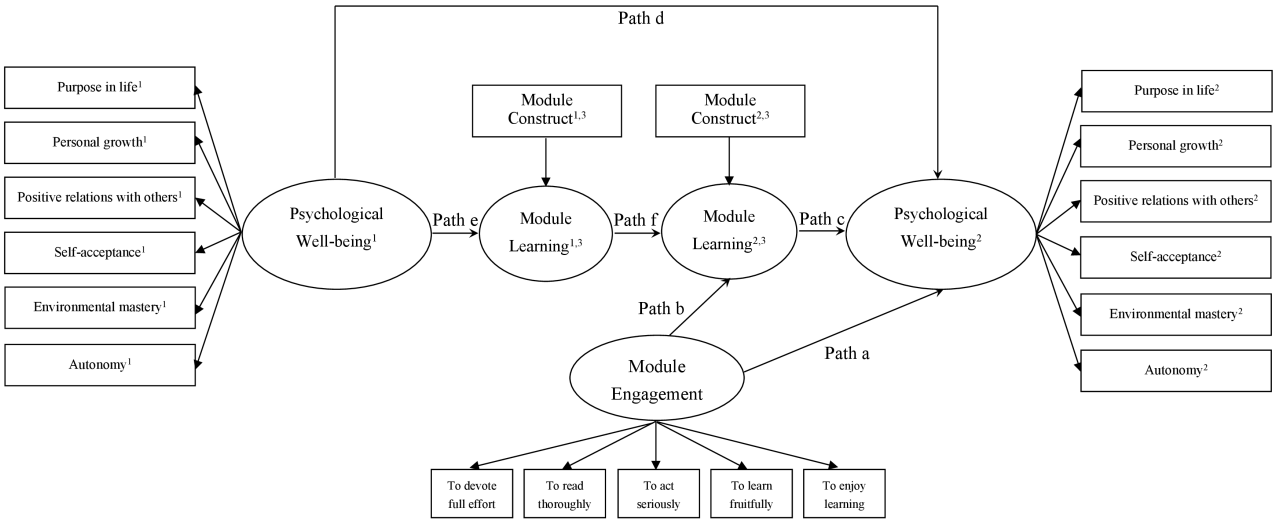
The statistical analysis was conducted using IBM SPSS version 20 (IBM Corp) and LISREL 8 (Scientific Software International Inc). Confirmatory factor analysis (CFA) was used to test the unidimensionality of psychological well-being, whether its 6 underlying facets (purpose in life, personal growth, positive relations with others, self-acceptance, environmental mastery, and autonomy) are loading highly on one factor. Similarly, CFA was used to examine the underlying factor structure of the items designed to measure each of the module constructs (ie, automatic thoughts, self-esteem, procrastination, hope, communication skills, gratitude, and problem-solving skills) and user engagement. A 1-factor CFA model was specified for each of the above constructs to determine whether the specified model could be identified. Categorical CFA was applied given that all the above variables were measured in Likert scale.

The research questions were tested using SEM, a statistical modeling technique that enables researchers to model and test the structural relationships of multiple independent and dependent variables simultaneously in a single analysis [57]. It is particularly useful when the study variables involve latent constructs that cannot be directly measured and thus are approximated through measurement items. Moreover, it can estimate the measurement errors (ie, inaccuracies in users' responses and their measurement) as well as the strength of the measurement items in loading on their posited latent construct or variable.

One SEM was constructed for each of the DGBL modules to test the direct effect of engagement in the module activities on psychological well-being and the indirect effect through attainment on the psychological constructs covered in the modules. Users' initial psychological well-being and initial attainment on the construct (ie, preassessment) were also included in the model to study the above effects on the postassessment after accounting for users' initial performance before the DGBL took place. Figure 2 shows the path diagram of the DGBL effectiveness model used in the study. The fit of the each model was evaluated on the basis of two goodness-of-fit indices: comparative fit index (CFI) and root mean square error of approximation (RMSEA). According to the literature [58-60], a good fit is generally indicated by CFI above .90 and RMSEA below .08.

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Figure 2. Path diagram of the DGBL effectiveness model used in this study.



Note:

[1]Preassessment.

[2]Postassessment.

[3]The module constructs to be learnt from module 1 to 7 are automatic thoughts, self-esteem, procrastination, hope, communication skills, gratitude, and problem-solving skills respectively.

Results

User Statistics

A total of 33 local secondary schools enrolled in our DGBL program involving 1605 Secondary One and Secondary Two students. A total of 498 students (246 males) from 31 schools activated their user accounts and completed the first module of the program. Hence, the response rates are 31% for individual students and 93% for individual schools. The mean age of these students was 12.6 (standard deviation [SD] 1.2) years. There were attritions after the first module at a cumulative rate of 37% (Module 2), 47% (Module 3), 50% (Module 4), 53% (Module 5), 56% (Module 6), 59% (Module 7), and 61% (Module 8). Specifically, the number of completers across modules is 498 (Module 1), 312 (Module 2), 265 (Module 3), 249 (Module 4), 235 (Module 5), 221 (Module 6), 202 (Module 7), and 192 (Module 8). The user data of completers was included in the statistical analysis on evaluation outcomes.

Evaluation Outcomes

Confirmatory factor analyses suggested that the outcome variable (ie, psychological well-being), module constructs (ie, automatic thoughts, self-esteem, goal-setting and goal attainment, hope, communication skills, gratitude, and problem-solving skills), and predictor variable (ie, engagement) followed the 1-factor model with good fit: all CFIs above .90 and RMSEAs below .08. Thus, the 1-factor model could be identified for each of the constructs of interest and this also supported the reliability of all the scales adapted in the study.

One SEM was used for each module to test the extent to which users' psychological well-being could be predicted by their engagement and whether this relationship was mediated by their learning on the module construct. Based on the criteria of good fit previously mentioned, the model fit was regarded as good (Module 1: CFI = .98, RMSEA = .05; Module 2: CFI = .98, RMSEA = .06; Module 3: CFI = .98, RMSEA = .06; Module 4: CFI = .99, RMSEA = .06; Module 5: CFI = .98, RMSEA = .07; Module 6: CFI = .98, RMSEA = .08; Module 7: CFI = .98, RMSEA = .07). Table 1 shows the path coefficients estimated by SEM, and Figure 2 presents graphically each of the paths in the DGBL effectiveness model. Though there was variation in strength of each of the paths across modules, most of the path coefficients were statistically significant (P<.05).

The overall pattern of results showed that the extent of engagement in the module activities positively predicted user attainment on the psychological constructs and that higher attainment on the psychological constructs would predict higher psychological well-being after controlling for users' initial psychological well-being and initial attainment on the psychological constructs. As expected, an opposite direction was found in modules using negative constructs as measures. In other words, there is an indirect effect of user engagement on psychological well-being through learning on the psychological constructs. Apart from the indirect effect, the direct effect of user engagement on psychological well-being was also present in some of the modules, meaning that engagement in the module activities alone had an impact on psychological well-being regardless of the learning attainment on psychological constructs.

Specifically, a significant indirect effect was found in five modules (2, 3, 4, 5, and 7) and a significant direct effect was found in three modules (2, 4, and 6). For modules not having a significant indirect effect (ie, modules 1 and 6), there is a need to review the role of the corresponding psychological constructs in enhancing psychological well-being and/or review the design of the module activities in facilitating attainment on the psychological constructs.

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Table 1. Path coefficients estimated by SEM for the DGBL effectiveness model.

Module construct	Path coefficients											
	Path a[a]	*P* value	Path b[b]	*P* value	Path c[c]	*P* value	Path d[d]	*P* value	Path e[e]	*P* value	Path f[f]	*P* value
Automatic thoughts[g]	.09	.17	−.02	.73	−.03	.61	.23	.002	−.40	<.001	.67	<.001
Self-esteem	.15	.04	.56	<.001	.15	.03	.15	.03	.79	<.001	.28	<.001
Procrastination[g]	.10	.12	−.30	<.001	−.29	<.001	.17	.01	−.61	<.001	.28	<.001
Hope	.15	.01	.22	<.001	.17	.01	.42	<.001	.57	<.001	.54	<.001
Communication skills	.01	.09	.44	<.001	.23	.001	.43	<.001	.50	<.001	.41	<.001
Gratitude	.16	.03	.55	<.001	.05	.54	.45	<.001	.48	<.001	.31	<.001
Problem-solving skills	−.01	.87	.48	<.001	.41	<.001	.36	<.001	.56	<.001	.32	<.001

[a]Path from module engagement to psychological well-being (postassessment).

[b]Path from module engagement to module learning (postassessment).

[c]Path from module learning (postassessment) to psychological well-being (postassessment).

[d]Path from psychological well-being (preassessment) to psychological well-being (postassessment).

[e]Path from psychological well-being (preassessment) to module learning (preassessment).

[f]Path from module learning (preassessment) to module learning (postassessment).

[g]Negative construct in which an opposite direction of relationship is expected.

Discussion

Principal Findings

The Internet-based DGBL program, *Professor Gooley and the Flame of Mind*, was effective in enhancing the mental health of adolescents. The program was evaluated using SEM based on a DGBL effectiveness model. Specifically, the structural relationship between engagement in the program activities and psychological well-being was examined as well as the potential mediating effect of the attainment on each of the psychological constructs in each of the DGBL modules, controlling for users' initial psychological well-being and initial attainment on the psychological constructs. The results generally supported the program effectiveness by demonstrating that users' extent of engagement in the module activities positively predicted their psychological well-being, users' extent of engagement in the module activities positively predicted their attainment on the psychological constructs, and users' attainment on the psychological constructs positively predicted their psychological well-being.

The findings of this study added support to findings in previous research and theory. The learning constructs underlying the DGBL modules in this program pertain to positive psychology (self-esteem, hope, and gratitude), cognitive behavioral modification (automatic thoughts and procrastination), and interpersonal skill training (communication and problem-solving skills). Since no substantial difference was observed in the learning of these constructs and its effect on the program outcome on psychological well-being, this study provides theoretical support to the use of positive psychology, cognitive-behavioral modification, and interpersonal skill training for mental health promotion. Specifically, our findings advocated acting on human strengths (such as self-esteem, hope, and gratitude) for enhancement of well-being, which is in line with the movement for positive psychology called upon by Seligman and colleagues to complement the risk prevention approaches in mental health programs [21-22]. Second, our findings suggested that cognitive behavioral modification or CBT could be broadly used for mental health promotion to the general population. Indeed, in a systematic review of 42 school-based mental health intervention programs [13], CBT was found to form the basis of the majority of these programs and 55% of these programs included all students and promoted mental health to all regardless of symptom level (known as universal trials). Third, our findings showed that educating adolescents about skills to solve problems and effectively engage in interpersonal communication contribute to psychological well-being. This is consistent with the results of a recent meta-analysis of protective and risk factors for mental illness [8] in which coping strategies were identified to be factors to work on for mental health intervention.

Furthermore, the results of this study have been impressive when it is considered that all the users are undergoing self-learning on Internet-based learning modules. Evidence was observed from our study on the feasibility and effectiveness of Internet-based intervention programs as an alternative approach to traditional classroom-based intervention sessions. Taken together with the review findings of other studies concerning the potential feasibility and effectiveness of the Internet-based intervention [23,26], it is plausible that Internet interventions for mental health could be made widely available and more common in the future. The principle of choice between classroom-based and Internet-based programs is that if the latter is at least as effective as the former in attaining the program outcomes, it would be worth developing the latter because of

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its multimedia capabilities, far-reaching ability, and timeless accessibility.

Comparison With Prior Work

Professor Gooley and the Flame of Mind is a bridge between our prior work on *The Little Prince is Depressed*, a classroom-based program enhanced with audio-visual materials (eg, animations, short videos)[34,35]. DGBL in *Professor Gooley and the Flame of Mind* is an evolution of the delivery mode of our project along with the shift of focus from the risk prevention approach in *The Little Prince is Depressed* to the positive development approach in *Professor Gooley and the Flame of Mind*. A typical example is that while the former focused on reducing depressive symptoms, the latter focused on enhancing psychological well-being. From the evaluation outcomes, *Professor Gooley and the Flame of Mind* as a DGBL program has the potential to facilitate learning and engagement/motivation of adolescents in the program which in turn enhancing their psychological well-being as expected.

Most of the existing Internet interventions for mental health (eg, *beyondblue* [28], *MoodGYM* [30], *SPARX* [31]) were used for treatment support and thus were not intended to promote youth mental health in a general population. A few existing Internet-based programs such as *WalkAlong* [32] and *MyHealth Interactive Magazine* [33] were used for mental health promotion to the general population, but they were designed more for an information platform with little consideration to the pedagogy for educating users. Compared to the existing programs, *Professor Gooley and the Flame of Mind* was designed for enhancing the mental health of the youngsters in the general population with a more structured program in a series of learning modules tied with storyline and DGBL pedagogy. Furthermore, the use of SEM and the DGBL effectiveness model for understanding DGBL and evaluating DGBL program outcomes is a novel approach which can make a significant contribution to the field of Internet interventions.

Limitation

The present study has a major limitation of the attrition of users across modules. In particular, out of the 498 completers of Module 1, the cumulative numbers of attrition (cumulative attrition rate) from Module 2 to 8 were 186 (37%), 233 (47%), 249 (50%), 263 (53%), 277 (56%), 296 (59%), and 306 (61%), respectively. Despite the innovative design, interesting story, and incentive that had been introduced to motivate the students to complete the whole program, *Professor Gooley and the Flame of Mind* encountered about the same attrition rate as other Internet-based educational programs or Internet-based intervention programs (also known as eTherapy programs). In a systematic review and meta-analysis of 40 eTherapy programs [61], the overall attrition rate was 57%, although there were strong supports for the programs to be efficacious or effective. Among them, it was observed that some programs had experienced below average attrition rates, and they managed to achieve this lower end of attrition through providing therapist's support (28% attrition rate) and additional administrative support (38% attrition rate) [61]. From this, attrition rates may be reduced by incorporating human support to Internet-based programs.

One speculated reason for the high attrition rate in our program was that users could only proceed to the next module after they had completed all the module activities in the active module. If they were stuck at the certain point of a module activity or if the play time expired, respondents could not proceed further in the DGBL. Further, students could only complete one module every 7 days; therefore, they might need to wait for a few days in order to start the next module. The time lag or waiting time may have resulted in the low completion rate or, in other words, the high attrition rate. As improvement measures to manage or reduce the attrition rate, email reminders to attempt the next module were sent to users who completed the previous module. Also, users whose play time had expired were allowed to restart the program from the last checkpoint after the expiration date. The system also made changes to shorten the waiting time so that users who have completed all the module activities in an active module were allowed to go to the next module in 1 day. However, these improvement measures can only apply to new users, and therefore the impact can only be observed and studied in future implementation.

Learning from the experience of other Internet-based programs with below average attrition rates [61], a blended mode of program delivery may be considered for incorporating school-based support to students on top of the Internet-based program. For example, schools may be asked to allocate a 45-minute class period per week (for about 12 weeks) for students to engage in this DGBL program through the computer facilities in the school. Support could also be provided by schools to encourage and remind students to complete the program modules and offer assistance if they encounter any problems during the program.

Future Direction

Future research may address other psychological constructs not covered in this program that contribute to the enhancement of psychological well-being or mental health. Also, future research may study the generalizability of program outcomes to users of other age groups or sociodemographic groups. Although the educational content and learning platform developed in this DGBL program was tailor-made for adolescents, it may be adapted to promote the psychological well-being of various age groups (eg, children, adults) and sociodemographic groups (eg, socioeconomic status, family status) in the community. The DGBL effectiveness model developed in this study may guide similar evaluation studies of the DGBL in other contexts. Also, a blended approach of program delivery could be explored to reduce the attrition rate.

Conclusion

This study describes an Internet-based program, *Professor Gooley and the Flame of Mind*, which intervened on a range of key psychological constructs of mental health under a positive development approach, adopted a well-structured DGBL pedagogy, and evaluated the effectiveness of the program based on rigorous outcome measurement methodology. The findings of the study support the effectiveness of promoting youth mental health through DGBL which combines education and entertainment to equip youngsters with the knowledge and skills of the psychological constructs. The SEM approach and the

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DGBL effectiveness model used in this evaluation study could be applied to evaluate the effectiveness of other DGBL programs.

Acknowledgments

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Preliminary results of this project have been presented at the XXVII World Congress of the International Association for Suicide Prevention and the Hong Kong Psychological Society Annual Conference 2014.

Conflicts of Interest

None declared.

Multimedia Appendix 1

Digital video of *Professor Gooley and the Flame of Mind*: sample adventure trailer.

[MPG File, 79MB - mental_v3i4e46_app1.mpg]

Multimedia Appendix 2

Screenshot of *Professor Gooley and the Flame of Mind*: 8 modules (planets).

[PNG File, 1MB - mental_v3i4e46_app2.png]

Multimedia Appendix 3

Screenshot of *Professor Gooley and the Flame of Mind*: sample assessment.

[PNG File, 163KB - mental_v3i4e46_app3.png]

Multimedia Appendix 4

Screenshot of *Professor Gooley and the Flame of Mind*: sample learning goals and objectives.

[JPG File, 495KB - mental_v3i4e46_app4.JPG]

Multimedia Appendix 5

Screenshot of *Professor Gooley and the Flame of Mind*: index of logbook.

[PNG File, 256KB - mental_v3i4e46_app5.png]

Multimedia Appendix 6

Screenshot of *Professor Gooley and the Flame of Mind*: sample contents of logbook.

[JPG File, 341KB - mental_v3i4e46_app6.jpg]

Multimedia Appendix 7

Screenshot of *Professor Gooley and the Flame of Mind*: sample minigame.

[JPG File, 394KB - mental_v3i4e46_app7.jpg]

Multimedia Appendix 8

Screenshot of *Professor Gooley and the Flame of Mind*: sample homework.

[JPG File, 286KB - mental_v3i4e46_app8.JPG]

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Multimedia Appendix 9

Screenshot of *Professor Gooley and the Flame of Mind*: sample quest.

[PNG File, 1MB - mental_v3i4e46_app9.png]

Multimedia Appendix 10

Screenshot of *Professor Gooley and the Flame of Mind*: components to activate the Flame of Mind.

[PNG File, 299KB - mental_v3i4e46_app10.png]

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Abbreviations

CBT: cognitive behavioral therapy
CFA: confirmatory factor analysis
CFI: comparative fit index
DGBL: digital game-based learning
RMSEA: root mean square error of approximation
SD: standard deviation
SEM: structural equation modeling

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