ECOLOGICAL MOMENTARY INTERVENTIONS AND THEIR EFFECTIVENESS IN TREATING VARIOUS MENTAL HEALTH ISSUES: A LITERATURE REVIEW

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ABSTRACT

Technology is becoming a larger part of life for both the public as well as multiple medical treatments. Smartphones may offer an elegant intervention medium for individuals who may not be able to obtain face to face treatment on a regular basis as well as allowing for clinicians to observe and treat patients in daily life scenarios. Therefore, the aim of this review is to provide a scoping overview of the previous literature on the topic of ecological momentary interventions (EMI) in addition to addressing 3 sub questions. 1. Whether there is an emerging unified delivery system for EMIs. 2. Regarding effectiveness of EMIs are they more effective when used in conjunction with standard therapeutic techniques. 3. Whether there are certain EMI types that are better equipped to treat certain mental health issues. We searched PsychInfo, MEDLINE and Web of Science databases and extracted data into Rayyan. Data was analyzed with summary tables of EMI content and study characteristics created. There was a total of 17 studies included covering a range of mental health issues: the most common being mood disorders with 6 studies. Smartphone applications were used in 16 of the 17 studies to deliver the EMI and nine studies used EMIs alongside traditional techniques and found a larger effect size was yielded when compared to control groups against studies which used EMIs as a standalone treatment. Our third sub question could not be answered due to being unable to draw clear conclusions regarding types of EMI. Future research should aim to observe EMIs in terms of skill acquisition and skill practice as this appears to be a strength of the treatment method.

Keywords: Ecological Momentary Intervention, Smartphone Application, telehealth, Ecological Momentary Assessment

Introduction

There is only a finite amount of mental health workers, clinicians, therapists, and counsellors in the world. For example, in a large-scale study conducted by WHO in 2002 they found that there were on average 1.0 Psychiatrist, 2.0 mental health nurses, .4 Psychologists and .3 social workers per 100,000 individuals across a global scale. This number has increased significantly, more recently and can be seen in a study conducted by WHO from 2014 to 2020. With this study the number of mental health workers grew from 43.5 per 100,000 individuals in Europe in 2014 to 50 per 100,000 individuals in Europe in 2017. This number has decreased between 2017 and 2020 to 44.8 mental health workers per 100,000 individuals in Europe, however. This could be due to the global pandemic halting the training of new professionals. Although the rising number of mental health professionals growing is a step in the right direction, it has not been enough in order to keep up with the rising prevalence of mental health issues within the general population. This can be seen through the rising prevalence rates (8.1 in 2009 to 15.8 in 2019) found in a national survey study assessing the rates of depression measured in adolescents aged between 12 and 17. there should be a priority to allow these mental health professionals to be able to best effectively use their time in order to allow for the maximum number of patients to gain access to appropriate professional treatment.

Furthermore, a common complaint from therapists when administering therapies such as CBT is that they are unable to view and measure the patient's behaviour during an ecological setting when they're facing their day to day challenges. Because of this the therapist is unable to accurately always provide the correct care for the patient. For example, if a therapist sees a patient on a weekly basis, the patient may be progressing well on Monday at their appointment

but could experience some hardship on Wednesday and would have to wait until the following Monday before the therapist can sufficiently help them. Because of this issue it is important that we develop a way in which proven therapeutic techniques can be delivered across all times of day in all types of settings. An additional issue with regards to clinicians not being able to view their patient's behaviour in day to day activities is that the patient may give the clinician false information about what they're doing outside of their sessions. This is an issue because it affects the type of treatment that the clinician will give.

Individuals who need to access treatment face many obstacles before they can finally gain access to the treatments they need. These obstacles can have severe consequences as many who need the treatment the most, are unable to access it. In a study conducted by Wu et al in 2010 they reviewed a National community survey in the US and found that only 45% of suicide attempters reported receiving any sort of mental health treatment. One of the reasons why patients may not be able to receive care may be because it is too expensive. In a briefing from the Children's commissioner of the English Government in 2018 stated that the NHS Child and Adolescent Mental Health Services (CAMHS) was accessed by 324, 724 children in 2017. This equates to 2.85% of the population of children in England however, it was roughly estimated that 9.6% of the child population needed access to the mental health services provided by the NHS. Moreover, a study by Riberio et al 2022 argues that of the number of children that accessed the CAMHS 31% received treatment, 37% were denied treatment or were discharged after the first assessment whilst 32% remained on a waiting list at least until the end of the year. This study shows that cost of treatment is not the only factor that affects the accessibility of treatment and so it is important to consider what other factors influence how accessible good quality treatment is. Riberio et al (2022) investigated what other factors there could be in more detail and found that

if the caregiver possessed high intended stigma related behaviour then it would decrease the chance of young individuals accessing mental health services.

Whilst there is a large variety of mental health issues and disorders which require treatment of some kind. There are some which are more prevalent in the general population than others. For example, Baxter et al (2013) recorded the prevalence of anxiety symptoms from 1980 to 2009, in the general population. They found that the presence of anxiety symptoms was prevalent in 7.3% of the population. As well as the prevalence of anxiety symptoms in the general population there is also a high prevalence of depressive symptoms and mood disorders. Ell and colleagues (2006) drew their data from typical screenings of adults over 65 and found that 8.5% of the 9,178 patients screened met criteria for probable major depression. Ko and colleagues (2012) support those findings found by Ell et al (2006) with a study across 27 American states indicating a depressive symptoms prevalence rate of 11.5%. In a large scale interview study conducted by Stagnaro and their colleagues (2018) found that the most common disorder categories were anxiety disorders (9.4%), mood disorders (5.7%) and substance abuse disorders (2.4%) across their sample of 3927 individuals who were over 18. Further evidence for these prevalence rates can be found in a study conducted by Castaldelli-Maia et al (2019) who conducted surveys across university students and found that anxiety and depression were the most common mental health issues with a prevalence rate of 8.5% and 10.9% respectively. Additionally, they also found that over a quarter of their sample (27.9%) reported over the cut off for the CAGE questionnaire which assesses feelings regarding ones drink and drug use. One variable which has had a large effect on the prevalence rates seen in the general population has been the global pandemic of the Corona Virus. The World Health Organisation announced the global outbreak of the Coronavirus disease 2019 a public emergency in 2020. Musacchio

Schafer, et al (2022) conducted a meta-analysis comparing the prevalence rates of Depression and anxiety from pre coronavirus with post coronavirus periods. They found that the prevalence of anxiety and depression both increased significantly during the coronavirus period. Anxiety having a prevalence rate of 22.6% and depression 18.3% which is a significant increase to those prevalence rates which were reported before coronavirus.

Another large scale effect of the global pandemic is that during this period of time many companies and professionals were asked to cease face to face interaction in order to reduce the spread of the disease. In the case of Psychological treatment, this had a drastic effect on how treatment was now going to be administered as most treatments and clinicians operated in a physical face to face environment with the patient. This rapid shift in how treatments were administered to patients can be seen in an article by Moorman (2021). The article describes a mental health company's swift transition from face to face treatment to telehealth. Furthermore, the article describes some of the positive effects this change had on treatment, leading to greater engagement among adolescents as well as an increase in attendance from 76% to 90% in some cases. Further studies into the effect of telehealth during the pandemic found that telehealth was safe, efficient and accessible (Turner and Siegel, 2022) along with being more cost effective than face to face treatment (Mitzel, et al, 2021). This successful change from face to face treatments to more digital alternatives has given rise to new mental health modalities.

A case study which illustrates the difficulties and advantages of offering flexible modalities for patients during the global pandemic can be seen from the study by Saunders and Allen (2021). They followed the treatment path of a 56 year old woman who was asked to shield during the rise of the pandemic as she belonged to an at-risk group. Because of this her treatment

plan had to switch modality mid treatment course. The patient began to receive treatment for high anxiety and depressive symptoms via online methods and phone calls. Saunders and Allen found that regardless of the modality change, the patient still exhibited a decrease in her anxiety and depressive symptoms. This shows that it is possible to successfully treat these symptoms through alternative methods and not just with face to face therapy. Further evidence for the effect of the global pandemic on the changing of modalities for the treatment of anxiety and depressive symptoms can be found in a study by Kahlon and colleagues (2021). In this study they trained some young (17-23) adults in empathetic conversation strategies and were then assigned to individuals with high levels of anxiety and depression. These conversations were twice a week and were found to have a positive effect on symptom reduction across the 8 week period. On the other hand Webb (2014) discusses some of the limitations with the use of telephone cognitive behavioural therapy (t-CBT). They state that t-CBT can disempower the clinician as they must rely on the patient verbalising their feelings and thoughts as well as having to rely on the patient having access to the correct materials needed. Therefore, there is a need for more interactive modalities for the delivery of treatments. This can be seen through a smartphone application offering cognitive reappraisal treatment as well as allowing patients to gain a direct link to professionals to use when needed. The results from this were positive and resulted in a decrease of depressive symptoms (Parolin et al, 2021)

Following from these successful advances, mobile applications can be successfully incorporated with mental health treatment with the use of smartphones. Smartphones have been adopted as the most common device owned by the general public (Falaki, et al, 2010) with over 75% ownership in the US alone (Pew Research Centre, 2019) making them a good candidate for the delivery method of therapeutic techniques as they are easily accessible at all times of the day.

In addition, smartphones can offer the patient a lot of flexibility in terms of when and where they want to receive treatment (Beard, et al, 2021). Smartphone based intervention may be able to offer further advantages over the traditional intervention method by being cheaper, offering the patient anonymity, offering a large amount of accessibility as well as standardising content to allow for less clinician intervention (Wilhelmsen et al, 2013). A further advantage of smartphones is that it is also possible to develop applications that can be downloaded remotely onto the phone allowing them to be accessed at any point when the smartphone is in reach of the individual. Research has thus, directed resources to the development of health care applications that are used in conjunction with other tradition therapeutic techniques. An example is Beard and colleagues (2021) who developed an application HabitWorks which delivers cognitive bias modification intervention to individuals receiving and one month post treatment. The efficacy of these applications is not thought to be as effective when targeting severe disorders (Kerst et al, 2020). However, there is evidence to support the use of these applications in the delivery of therapeutic techniques in regards to treating mild to moderate conditions (Firth, et al, 2017).

Further use of smartphones ability to make treatment accessible and cheaper are EMIs (Ecological Momentary Interventions). EMIs are inherently high in ecological validity as they are used to apply treatment to patients in their everyday lives and settings (Heron and Smyth, 2010). They are often used in conjunction with other traditional therapeutic methods, but they can also be used as a standalone treatment (Heron and Smyth, 2010). These ecological interventions have been previously used in conjunction with PDAs, text messages and phone calls (Runyan and Steinke, 2015). More recently however, these interventions have been used with smartphones and more specifically through the form of applications accessible through the smartphones (Runyan and Steinke, 2015). EMIs are using the basis of computer and internet

based Cognitive Behavioural Therapy (CBT) (Moore et al, 2011). EMIs can be used in a wide

context and can be used to aide in a number of different areas. For example, EMIs can be used to

help promote self monitoring behaviour for the patient (Runyan et al, 2013). Further previous

uses of EMIs include aiding in the development of new skills (Bless et al, 2014), promoting

engagement with previously learned skills (Rizvi et al, 2011) and prompting individuals to

distract or notify them when they are at a time of high risk relapse (Bernstien et al, 2021).

There have been a small number of meta-analyses and systematic reviews for the

background of EMI. For example, Jiménez-Muñoz, et al 2022. In this meta analysis the

researchers identified a gap in research for the effectiveness of EMIs alone, on suicidal ideations

and behaviours. This study included 27 studies covering 19 EMIs. Jiménez-Muñoz and

colleagues concluded that there were indeed advantages for the use of mHealth treatments such

as increased availability and versatility. However, they also mentioned the need for a

patient-doctor relationship and how mHealth treatments can not replace it and so they advise that

these treatment methods are used in conjunction with other techniques. One limitation of this

study is that it looks specifically at suicidal ideation and behaviour and not at the wider

practicality of EMIs in general. This also results in a small sample size of studies which may

produce low Q statistics indicating a high homogeneity between the selected studies used in the

analysis. Bell (2017) is another review which investigated the use of EMIs in the treatment of

Psychotic disorders. The review included just nine studies with 5 meeting criteria for the use of

EMI and 4 meeting criteria for the use of ecological momentary assessment (EMAs). All 5

studies that included EMIs used them in the same way – to prompt the patient about behaviour.

Furthermore, only six of the nine studies had controlled samples for comparison. Bell and their

colleagues did conclude that the use of EMIs and EMAs had good accessibility and feasibility in

the treatment of psychotic disorders and called for more studies with controlled samples in the future. Therefore, there is a need in the research for a ground platform from which future research can be based around the use of EMIs as a whole. As well as their uses across a more general scope of psychological and neuropsychological symptoms. Because of this need, this systematic review will aim to provide an overview of the different forms of EMI and to discuss their potential and limitations in supporting individuals experiencing mental health issues. There are three additional sub questions to be addressed during this review. 1, Enquire about the potential for a unified delivery system. 2, Whether the use of EMIs in conjunction with traditional therapeutic techniques is advantageous in regard to the effectiveness of EMIs themselves. 3, To enquire about whether or not there is a specific form of EMI technique that holds a stronger effectiveness threshold when targeting specific stressors.

Methods

Protocol

This review was conducted in alignment with the preferred use of the PRISMA guidelines for reporting in Systematic Reviews and Meta-Analyses (Page, McKenzie, Bossuyt et al, 2020).

Search Strategy

The search strategy of this review is comprised of searching multiple search engines; namely: Web of Science, PsychInfo and MEDLINE. These search engines were searched from inception until the 25th of May 2022.

Search Strings

There were a total of two different search strings which were used across all three of the search engines to compile the database of studies used for this review. These were ("ecological momentary intervention" OR "EMI") AND ("smartphone" OR "smart phone" OR "mHealth" OR "m-health" OR "iphone" OR "mobile phone" OR "telehealth" OR "web based") AND mood disorders or depression or bipolar or anxiety OR Generalized anxiety disorder OR ("ecological momentary intervention" OR "EMI") AND ("smartphone" OR "smart phone" OR "mHealth" OR "m-health" OR "iphone" OR "mobile phone" OR "telehealth" OR "web based").

Eligibility Criteria

Studies were eligible for inclusion in this review if they met 3 criteria. Firstly, studies must be reported and published in the English language due to the translation errors which may occur using translation resources. Secondly, studies were able to be included if they provided empirical data through which the comparison of an intervention group and controlled group could be established. Thirdly, studies were eligible for inclusion if there was an EMI component to the intervention condition of the studies which would therefore allow for direct comparison between data. Duplicates in the data set were screened for in EndNote 20 and deleted before being imported to Rayyan where the screening of titles and abstracts would take place.
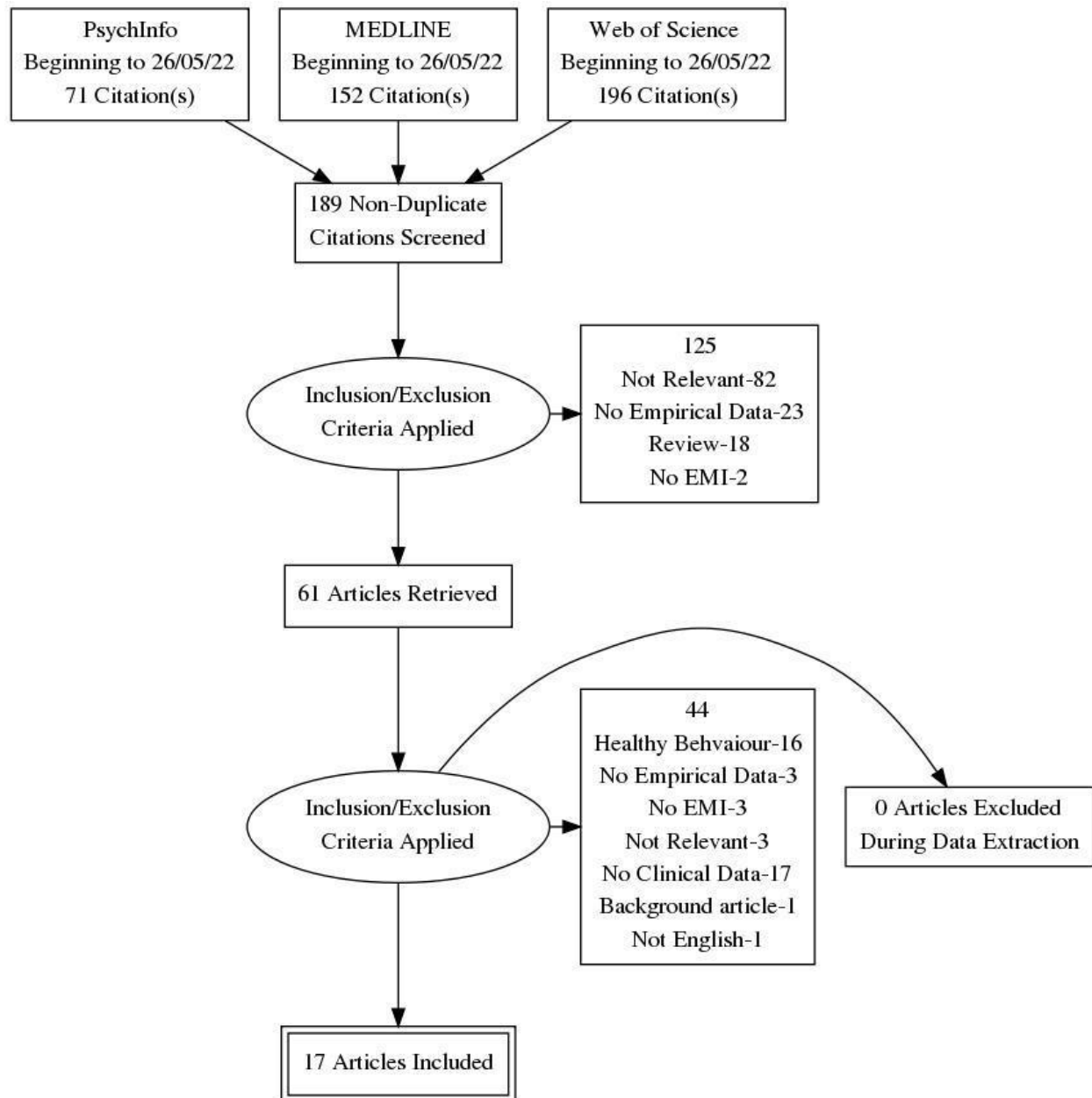
Study Selection

Titles and Abstracts were screened independently by an individual (AD) who then decided to include or exclude the studies based on the criteria described earlier in this paper. Furthermore, duplicates were deleted as well as the exclusion of studies that were either: irrelevant topics, had no empirical data for comparison and studies that did not have an EMI as part of their intervention condition.

Results

As seen in the flowchart below (figure 1) there were a total of 17 studies which met all

the inclusion criteria for this review and so have been included in the qualitative analysis. The

earliest study being published in 2014 (Wenze et al, 2014) with two studies being published as

late as 2022 (Bernstein et al, 2022 and Myin-Germeys et al, 2022). The median publication year

was 2020 with six of the 17 studies being published in that year.

Figure 1 Selection of Studies

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┌──────────────────┐  ┌──────────────────┐  ┌──────────────────┐
│     PsychInfo    │  │     MEDLINE      │  │  Web of Science  │
│ Beginning to     │  │ Beginning to     │  │ Beginning to     │
│   26/05/22       │  │   26/05/22       │  │   26/05/22       │
│  71 Citation(s)  │  │ 152 Citation(s)  │  │ 196 Citation(s)  │
└──────────────────┘  └──────────────────┘  └──────────────────┘
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189 Non-Duplicate Citations Screened

Inclusion/Exclusion Criteria Applied

125
Not Relevant-82
No Empirical Data-23
Review-18
No EMI-2

61 Articles Retrieved

Inclusion/Exclusion Criteria Applied

44
Healthy Behvaiour-16
No Empirical Data-3
No EMI-3
Not Relevant-3
No Clinical Data-17
Background article-1
Not English-1

0 Articles Excluded During Data Extraction

17 Articles Included

Study Characteristics

The total number of participants used for data analysis across the studies included in this review are 1916 with a mean of 112 per study. University students were used in three of the studies totalling 574 of the total participants across all studies. The most common population used were adults (18+). The youngest participant was 9 years old and the oldest 65 years old. 16

of the 17 studies used a combination of smartphones and applications to deliver the EMIs, with

one study opting to use a web based EMI which could also be accessed by computer, smartphone

and tablet (Newman et al, 2020). There were only two studies which used a method of empirical

sensoring (Versluis et al, 2018 and Thonon et al, 2021). Nine studies chose to include the use of

both EMIs and Ecological Momentary Assessments (EMAs) and nine used the EMI in

conjunction with a more tradition therapeutic method during the study. Six of the studies chose to

tailor the EMI specifically to each individual participating (Depp et al, 2015; Fulford et al, 2021;

Hanssen et al, 2020; Thompson et al, 2020; Van Aubel et al, 2020 and Wenze et al, 2016). Please

see figure 2. There were multiple differing conditions assessed during the studies included in this

review and for convenience and further analysis, these studies were grouped into one of seven

categories; Mood Disorders, Anxiety, Schizophrenia, Substance Use Disorders, Stress, Psychosis

and Hope. Please see figure 4 for details.

Figure 2. Summary of study characteristics and results.
Note. M=Mean age, SD=Standard Deviation, GAD=Generalised Anxiety Disorder,
SUD=Substance Use Disorder, SAD=Social Anxiety Disorder, MDD=Major Depressive
Disorder, SZA=Schizophrenic Affective Disorder, EMA=Ecological Momentary Assessment,
EMI=Ecological Momentary Intervention, CBT-p=Cognitive Behavioural Therapy for Psychosis,
ACT-DL=Acceptance and Commitment Therapy in Daily Life, CBT=Cognitive Behavioural
Therapy, BD=Bipolar Disorder, Sig=Significant, RMSSD=Root Mean Square of

Study Name	Population	Characteristics	Outcome Masure	Blended Therapy	EMA and EMI	Results	Conclusions
Bernstein et al (2022)	Clinically depressed adults	25 M=33.48 (SD=13.84)	Self Report measures Anger/Hopelessness/Gratefulness/Anxiety	Group + Ind Psychotherapy + Medication	Yes	Sig for Anger, Hopelessness + Gratefulness	Highlights role of practice for CBT
Daugherty et al (2018)	Convenience sample	112 Age range 18-25	Synder Hope Scale	No	No	Sig increase in hope but low	EMI can increase hope but

	University students					statistical power	reasons why unclear
Depp et al (2015)	Clinically diagnosed Bipolar	104 M=47.5 (SD=12.8)	Clinician rated questionnaire	Medication	Yes	Sig decrease in depressive symptoms but mild symptom severity	Shows positive effect of tailored interventions
Everitt et al (2021)	General population	235 M=32.97 (SD=10.92)	Self reported questionnaires	No	Yes	Sig decrease in dep, anxiety and negative automatic thoughts	Shows efficacy for EMI and depression but JITP not effective
Fulford et al (2021)	Clinically diagnosed Schizophrenia	31 M=46 (SD=11)	Interview and self reported measures	No	Yes	Increase in daily functioning and decrease in positive symptoms	EMI shows promise as standalone intervention but small sample
Hanssen et al (2020)	Clinically diagnosed Schizophrenia	50 M=37.0 (SD=8.6)	Self reported questionnaires	No	Yes	Decrease of momentary psychotic symptoms	Show promise of tailored feedback but effects maybe tied to monitoring of symptoms
Myin-G ermeys et al (2022)	Ultra high risk or 1st episode psychosis	115 M=25 (SD=6)	Semi structured interview	CBT-p and ACT-DL	No	No sig for primary measure but some for secondary	Further replications needed to establish effects

Newman et al (2020)	Self reported GAD	100 M=21.40 SD=NR	Self reported questionnaires	No	No	Sig decrease of anxiety symptoms but not at prolonged follow up	Provides support for self-help interventions
Nguyen-Feng et al (2019)	Convenience sample University students	362 M=21.3 (SD=4.2)	Self reported questionnaires	No	Yes	No sig between conditions but higher effect for history of abuse EMI	Highlights need for interventions targeted for specific risk groups
Scott et al (2020)	Recovering from SUD diagnosis	401 M=44.2 (SD=11.0)	Days of abstinence	45% receiving outpatient treatment	Yes	Sig effect of EMI and indirect effect of EMA on abstinence duration	Shows how EMAs can increase EMI usage but other treatments accessed were not tracked
Silk et al (2020)	Children meeting diagnostic criteria for GAD/SAD	34 M=11.40 (SD=1.62)	Clinical interviews with patient and parent	CBT	No	sig number of participants no longer met diagnostic criteria posttreatment	Shows feasibility for EMI usage for children but separation of CBT and EMI effects unclear
Thompson et al (2020)	Homeless youth convenience sample	60 M=19.2 (SD=0.84)	Frequency of alcohol, marijuana and sexual risk behaviours	No	No	Sig reduction in alcohol use and unprotected sex	Provides evidence for feasibility of use of EMIs in youth but short study length

Thonon et al (2021)	Clinically diagnosed Schizophrenia, MDD and SZA	9 M=31.25 (SD=5.85)	Clinical interviews and steps counter	Group therapy	No	sig increase in motivation and apathy symptoms	Shows how EMIs can be used to enhance treatment. But small sample size
van Aubel et al (2020)	Convenience sample individuals with mild symptoms of dep or psychosis	55 M=21.36 (SD=2.39)	Clinical interviews and self report questionnaires	ACT-DL	Yes	Decline in symptoms across measures but steeper for clinical interviews in EMI condition relative to active control	Although mixed results, ACT-DL shows to sig reduce symptoms measured by clinical interviews
Versluis et al (2018)	Individuals experiencing work stress	136 M=43.71 (SD=11.39)	Changes in RMSSD and questionnaires	No	Yes	No sig findings for primary or secondary outcomes	Results maybe due to poor participation and completion rate of EMI exercises
Wenze et al (2014)	Individuals diagnosed with Bipolar disorder	14 M=40.86 (SD=12.15)	Self report questionnaires	BD associated treatment	Yes	Not powered to find treatment effects but sig decrease in depressive symptoms	High adherence rates and positive feedback show feasibility of EMIs

| Wenze et al (2016) | Individuals diagnosed with Bipolar disorder | 8 M=44 (SD=11.58) | Structured clinical interviews and self report questionnaires | 4 weekly therapy sessions | Yes | sig decrease in concerns about treatment and sig increase in insight | Results show feasibility for EMI usage for treatment adherence but small sample |

Figure 3. Ecological Momentary Intervention content and duration.
Note. RMSSD=root mean square of successive differences of Heart rate and heart rate variability, CBT=Cognitive Behavioural Therapy, SST=Socioemotional selectivity theory, EMA=Ecological Momentary Intervention

Study	Content	Tailoring	Sesnoring	Intensity	Duration
Bernstein et al (2022)	Guided skills practice of CBT skills	No	No	3 skills practice prompts per day	4 weeks
Daugherty et al (2018)	Multimedia photos + messages of hope	No	No	Unscheduled in the moment prompting	4 weeks
Depp et al (2015)	Interactive content	Personalised interventions given from real time data	No	2 surveys per day	10 weeks
Everitt et al (2021)	4 audio files of brief mindfulness and relaxation exercises	No	No	1 file per day then free use	2 weeks
Fulford et al (2021)	Custom feedback, some CBT and SST exercises	Set goals that form intervention + feedback based on own rating in EMA	No	2 per day	60 days
Hanssen et al (2020)	Questionnaires and personalised feedback suggestions	Feedback from app about daily entries	No	2 per day	3 weeks
Germeys et al (2022)	Questionnaires, exercises, and metaphors	Exercises and metaphors based off previous ACT session	No	8 per day for 3 days following treatment session	8 weeks
Newman et al (2020)	Psychoeducation and skills practice tools		No	One new 10-minute session per day 40 total	3 months

Nguyen-Feng et al (2019)	Psychoeducation videos and written exercises	No	No	Written exercises 3 days a week. Motivation messages daily	2 weeks
Scott et al (2020)	Games, psychoeducation, links to self help materials (meetings, treatment locations)	Intervention given tailored to EMA response	No	EMAs prompted 5 times a day.	6 months
Silk et al (2020)	Skill builder activities, skills coach, mini games	No	No	1 per day	8 weeks
Thompson et al (2020)	Questionnaire about behaviour, tip bank and links for treatment resources	Personalised feedback	No	1 per day	4 weeks
Thonon et al (2021)	Projection and reminiscence prompts, guided multi sensory imagery audio	No	MiBand 3 -Stepometer	2 per day	4 weeks
van Aubel et al (2020)	Questionnaires, multimedia metaphors and exercises	Metaphor or exercise shown dictated by questionnaire answers	No	8 prompts per day	6 weeks
Versluis et al (2018)	Questionnaires and mindfulness exercises	No	RMSSD	5 prompts per day	4 weeks
Wenze et al (2014)	Questionnaires and intervention messages addressing treatment non-adherence	No	No	2 prompts per day	2 weeks
Wenze et al (2016)	Questionnaires and feedback messages	Semi-individualised feedback messages	No	2 prompts per day	60 days

Anxiety

There are two studies included in the anxiety grouping (Newman et al, 2020 and Silk et al, 2020). The Depression Anxiety Stress Scales-Short Form (DASS) stress subscale was used by Newman and colleagues in order to measure symptoms of anxiety in their participants. More

specifically, the DASS measures of arousal, inability to relax and how irritable the participant is, among other symptoms. In this study participants were given access to one new EMI per day with a total of 40 being offered over the three-month intervention period. Outcome measurements showed an improvement of anxiety related symptoms (-0.408) and greater probability of remission at the end of the intervention stage of the study when compared to the non-treatment control group. These results were consistent at the six month follow up. Silk et al (2020) echoed these results in their study with children who met the diagnostic criteria for generalised anxiety disorder (GAD). As they found that 67% of the sample no longer met diagnostic criteria after the treatment phase which grew to 86% at the two month follow-up. Additional results showed a decrease in child and parent reported symptom severity (cohen's d = 1.09 and 1.15 respectively) at post treatment which continued at the two month follow up with a cohen's d of 0.56 for child reported symptom severity and 0.47 for parent reported symptom severity when compared to baseline levels. Furthermore, skills acquisition from cognitive behavioural therapy (CBT) was measured from child and parent reports of thought challenging with parents reporting a cohen's d of 0.68 and children reporting a cohen's d of 1.00 when compared to the baseline scores.

Schizophrenia

Three studies focused on the Schizophrenia patient group (Fulford et al, 2021; Hanssen et al, 2020 and Thonon et al, 2021). Two of them used the Experience Sampling Method (ESM) to measure momentary symptoms and motivation symptoms. Additionally, Thonon et al (2021) used the Brief Negative Symptom Scale (BNSS) and the Functional Remission of General Schizophrenia (FROGS) to measure daily functioning. Thonon and colleagues found that

individuals who did not complete the EMI course scored higher on the BNSS indicating more frequent negative symptoms than those who completed the courses cohen's d for completers =-1.73 decreased to -1.10 at follow up when compared to non-completers. Further findings included a higher FROGS rating for completers which were all consistent at follow up. Hanssen et al (2020) found that there was a significant decrease of psychotic symptoms in participants in the EMI condition with a -.30 effect size when compared to the control condition. Fulford et al (2021) used the Social Functioning Scale to determine social functioning ability across participants and found a moderate increase from baseline to treatment termination (Cohen's d=0.44). However, this regressed at follow up. They also found a moderate decrease of positive symptoms from baseline, which was consistent at follow up with an effect size of 0.45.

Substance Abuse Disorder

Two studies used the clinical patient group of individuals with Substance Abuse Disorder (SUD) (Scott et al, 2020 and Thompson et al, 2020). Thompson et al (2020) used a sample of 40 18-21 year olds and observed their use of alcohol, marijuana and unprotected sex as their primary outcome measurement. Their EMI was a smartphone application which provided participants with various personalised information outlets and motivational messages. They found that there was a significant reduction of the primary outcome measurements when compared to the treatment as usual group. Which included a significant reduction of participant's usage of alcoholic drinks (p=0.23) marijuana (p=0.46) unprotected sex (p=0.12) and their usage of drugs before sex (p=0.19). On the other hand, Scott et al (2020) chose to use days of abstinence in the six months following the intake as their primary outcome measurement. This study was a three armed randomized control trial (RCT) with the three conditions being an EMI

condition, an EMA condition and a final condition combining both EMA and EMIs together.

Whilst there was an increase in abstinence in the EMI condition the same could not be said for

the other conditions, however, the EMA and EMI condition did increase the EMI usage of

participants across the length of the study.

Mood Disorders

There were a total of six studies which used mood disorders as their condition of choice,

which was the most common disorder studied in this review (Wenze et al 2014, Wenze et al

2016, Van Aubel et al 2020, Everitt et al 2021, Depp et al 2015 and Bernstein et al 2022). These

studies used a variety of outcome measurements however, all used self rated questionnaires of

some kind to assess mood rating and symptom frequency and severity over the course of the

study. Wenze et al 2016 found no significant change in mood ratings or depressive symptoms

from baseline to the 1 and 3 month follow ups. However, the study was not powered in order to

identify treatment effects. There were some significant changes in the attitude of participants

who received the EMI, towards medications (d=0.56) and missed medication doses decreased

moderately (d=0.71) than compared to the control group who did not receive the EMI. Likewise,

Wenze et al 2014 found no change in mood ratings. But they did find that adherence to the

condition was very good and participants scored significantly lower at post treatment than

baseline on the Quick Inventory of Depressive Symptomology (QIDS). Further studies, namely

Depp et al 2015 and Van Aubel et al 2020 showcased significant reductions of depressive and

manic symptoms across multiple outcome measurements (Young Mania Rating Scale,

Montgomery Asberg Depression Rating Scale). With Depp and colleagues finding a moderate

effect size of 0.49 across the MADRS scale from baseline to 12 week follow up, however this

decreased at 24 week follow up. Everitt et al (2021) Found a significant decrease in depressive symptoms at the three month follow up (cohen's d=-0.30) and automatic negative thoughts (cohen's d=-0.37) from the EMI condition when compared to the active control condition. Finally, Bernstein et al (2022) used anger and anxiety subscales of the Patient-Reported Outcomes Measurement Information System (PROMIS) as their primary outcome measurement. They found that there were positive correlations between the PROMIS Anger scores for hopelessness and anger from the intervention group which were not present in the control condition. Furthermore, there was a significant negative effect of the intervention on gratefulness scores of participants. Only one of these studies did not use the EMI in conjunction with traditional therapies (Everitt et al, 2021). Additionally, there was one study which did not use EMAs in tandem with the EMI intervention (Van Aubel et al 2020). Two studies tailored the intervention to the specific participants (Van Aubel et al, 2020 and Depp et al, 2015) with a further study partially tailoring the intervention contents (Wenze et al, 2016). All studies used smartphone applications as their dedicated delivery method for their EMIs also.

Stress

Two studies assessed levels of stress and the effect that EMIs can have on them (Nguyen-Feng et al, 2019 and Versluis et al, 2018). Nguyen-Feng et al (2019) used a number of different outcome measurements to measure levels of stress, depressive symptoms and anxiety. Their study on university students found that those who had a previous history of abuse responded significantly better to the EMI condition than those in the EMA condition in terms of a reduction of depressive and stress related symptoms. With effect sizes of a moderate range across depressive symptoms (Cohen's d= -0.53), stress (Cohen's d= -0.43) and positive affect

(Cohen's d= 0.4) when compared to healthy controls. Interestingly, this was not the case when observing the effect of the EMI condition on students who had no previous history of abuse, and it was found that the EMA condition gave rise to significantly better results than the EMI condition. Versluis et al (2019) used heart variability monitors as their primary outcome measurement but also used a multitude of questionnaires as their secondary outcome measurement. However, neither outcome measurement gave rise to any significant differences across conditions.

Psychosis

Myin-Germeys et al (2022) was the only studied included in this review that observed the levels of psychotic distress in their participants as their primary outcome measurement. They did this using the Comprehensive Assessment of at Risk Mental States (CAARMS) at post intervention and 6-12 month follow ups. There was no significant effect between the EMI group and the control group. However, as a secondary outcome measurement they observed the change in momentary psychotic distress and found there was a significant improvement of negative symptoms in the EMI group when compared to the control group as measured by the BPRS negative subscale with effect sizes of 0.6 and 0.7 respectively at the six month and 12 month follow ups.

Hope

Finally, there was one study which looked at improving hope in individuals through positive interventions (Daughtery et al, 2018). Using the Snyder Hope Scale among other questionnaires they found that there was a significant interaction effect between the intervention group and control group and their scores on the Snyder Hope Scale. Illustrating a significant

positive effect for the use of EMIs in improving scores on the Synder Hope Scale. However, the

reasons why are clouded due to low statistical power and randomisation of groups of participants

rather than each individual.

Figure 4 Summary of Intervention Targets

Mood Disorders	Schizophrenia	Anxiety	Stress	SAD	Hope	Psychosis
Bernstein et al (2022)	Fulford et al (2021)	Newman et al (2020)	Nguyen-Feng et al (2019)	Scott et al (2020)	Daugherty et al (2018)	Germeys et al (2022)
Depp et al (2015)	Hanssen et al (2020)	Silk et al (2020)	Versluis et al (2018)	Thompson et al (2020)		
Everitt et al (2021)	Thonon et al (2021)					
van Aubel et al (2020)						
Wenze et al (2014)						
Wenze et al (2016)						

Upon further analysis of the studies included in this review the researchers thought it

applicable to conduct some exploratory analysis based off the different features included in the

studies which are listed in figure 1. Therefore, the following analysis will compare results from

studies which included sensors, blended therapy, EMAs or tailoring against those that did not.

Effect of the use of sensors in conjunction with EMIs

There were two studies which used sensors in their experiments (Versluis et al, 2018 and

Thonon et al, 2021). Versluis and colleagues used an ekgMove sensor which converted ECG data

into heart rate variability and heart rate. The root mean square of successive differences

(RMSSD) was then used as an outcome measurement. There was however no significant

difference in this variable between the EMI condition and the control. This trend was consistent

from pre to post intervention (p=0.206) and at follow up (p= 0.251). Thonon et al (2021)

concurred with these findings. They used a MiBand 3 sensor which calculated the number of

steps the participants were taking on a daily basis. This outcome measurement yielded a weak β

coefficient of 0.18. These studies seem to suggest that there is little benefit to the use of these

sensors as a primary outcome measurement.

Effect of blended therapy in conjunction with EMIs

Of the nine studies which used a combination of traditional treatment methods with EMIs

67% of them yielded results of moderate (>0.5) effect sizes when compared to control groups.

With another 11% yielding an effect size of 0.49. 22% of studies using BT yielded no significant

results for their outcome measurements. In comparison to the eight studies which did not include

a traditional treatment method none reached effect sizes above 0.45 in comparison to control

groups for any of their outcome measurements. In terms of long term positive effects, four of the

studies using BT maintained an effect size of over 0.5 compared to a non-significant effect size

of the control groups. Whereas those that did not include BT maintained effect sizes in relation to

their post treatment levels in both studies that used a long term follow up measurement.

Effect of the use of EMAs in conjunction with EMIs compared to EMIs alone

As reported earlier in this paper there were a total of nine studies which chose to use

EMAs alongside the delivery of their EMIs. Six of these studies found significant effects of the

use of EMIs and EMAs on their outcome measurements. Four of these studies further separated

intervention conditions into ones which included the use of EMAs and EMIs, EMIs alone as well

as EMAs alone. Of these four studies only one found a significant effect of the use of EMAs on

their outcome measurement (Scott et al, 2020). They found that there was a small, indirect significant effect of EMAs on abstinence length via EMI usage.

Effect of tailoring interventions and application exercises to participants

There was a total of seven studies which decided to tailor, either individual interventions to their participants or the layout and content of the application to their participants depending on goals they set with researchers. Thompson et al (2020) gave their participants personalised feedback on their data, given through EMAs, via prompts to use the EMIs the participants had access to. They found that the personalised feedback condition gave rise to a significant decrease in substance abuse behaviour. This personalised feedback theme was consistent with studies by Fulford et al (2021) and Hanssen et al (2020). Both reported significant effects of EMI usage on measurement outcomes but it is difficult to say how much of a role the personalisation had in the production of the effects. Interestingly, studies which chose to include tailored content relied on EMAs in order to gain information about the state of the participant at that moment in order to tailor the intervention they receive to be in correlation with their mental and physical state at that time.

Discussion

This literature review aimed to provide an overview of the current studies on EMIs and their usage in different environments. There were four research questions that were stated at the start of this study. The first being the investigation for a universal delivery method. From the results of this review it could be suggested that smartphone applications are the most common medium for delivering EMIs. The second research question was to assess the accessibility of interventions for individuals experiencing serious mental health issues or diagnoses. Ther results

from this study suggest that EMIs can be administered across a wide scope of conditions without

sacrificing effectiveness. The final research question was directed towards the effect of including

traditional therapeutic techniques when administering the EMIs. The exploratory analysis

suggests that the use of blended therapy does affect the effectiveness of the EMI, increasing the

effectiveness in the majority of cases studied in this review.

Because this study is one of the first, to the researcher's knowledge, that has synthesised

and compared data from a moderate number of EMI studies containing control groups and

actively targeting clinical symptoms there is no consensus in how the results should look in

theory. Interestingly, with the previous research conducted by Jiménez-Muñoz and colleagues

(2022) there was a positive effect of EMIs on the reduction of suicidal ideations and behaviours.

When widening the scope to include symptoms of mood disorders as a whole there were mixed

results. For example, Bernstien et al (2022) found a reduction in harmful emotion regulation but

others did not find any significant effectiveness. Furthermore, it is worth noting that Everrit et al

(2021) was the only mood disorder study to not include traditional therapeutic techniques but

their study produced the highest effect size for the use of EMIs in improving depressive and

anxiety based symptoms. It is hard to explain the variance in the results however, one possible

explanation can be that the usage of micro-interventions that monitor, prompt and contain

intervention content is more effective when used for individuals who do not have any mood

disorder diagnosis. On the other hand, these results could be as a result of the recruitment

methods of Everrit who state that participants were not needed to complete eligibility criteria and

were recruited from the general population. Perhaps EMIs are more effective as a standalone

treatment when used to treat mild depressive and anxiety based symptoms.

Additionally, when comparing the efficacy of using blended therapy intervention

techniques to those interventions that did not include additional therapeutic resources the study

shows that the use of blended therapy is largely advantageous for the efficacy of EMIs.

Furthermore, the results seem to suggest that effects produced by the EMIs and blended therapy

combinations continue for longer than those that don't use blended therapy. It is hard to

accurately explain reasons for this because the type of therapy that is used in conjunction with

the EMIs vary as well as the content of the EMIs themselves. However, one possible explanation

is that the EMIs are effective at promoting skill practice in daily life. This allows individuals to

practice and further enhance the skills which they are taught during traditional therapeutic

sessions which could explain the prolonged effectiveness of EMIs when used in conjunction with

therapeutic techniques. These explanations would be in line with the reasoning suggested by

Rizvi et al that EMIs are well equipped to be used to promote engagement with previously

learned skills.

Another interesting finding from this review was that there were such a small number of

studies which met the inclusion criteria whilst using sensors as a medium for information

gathering of the individual's physical and mental state. The two studies which used sensors did

not find any significant effects associated with them. Previous suggestions of research such as

Balaskas et al (2021) guided the inspection of sensor usage in EMI delivery, so to see no

significant results is curious. However, it may be possible to explain these results because both

studies used the sensor data as their primary outcome measurement whereas sensors may be

better used as a basis for the delivery of just in time interventions due to their objective nature,

they can provide important information about the individual that may otherwise be difficult to

obtain without human assessment. This area of research is promising however it is still in its

infancy so further research is required.

The ability to tailor content and interventions to individuals is one positive attribute of

using smartphone apps to administer EMIs. The tailoring that was conducted in seven studies in

this review show that it is advantageous to include this as a method of potentially increasing

effectiveness, especially in those with substance abuse disorders. These results may be explained

due to the personalisation of the app and its contents because it allows individuals to engage

more often with the intervention and allows the intervention to target specific areas of concern

for each individual and so administering treatment where it is needed.

EMI duration ranged from two weeks to six months across studies included in this

review, with exploratory analysis it revealed that duration did not play a significant role in the

effectiveness of EMIs as shown with Scott and their colleagues who used EMIs across a six

month period measuring days of abstinence and finding a small significant increase in the EMI

condition when compared to the EMA and control condition but not as large of a significant

increase as was expected.

EMI content was largely centred around psychoeducation and interactive exercises which

the participants were able to access and complete during any stage of the study. These exercises

varied in content with some choosing an audio grounded approach with guided meditation and

relaxation exercises whilst others chose a written and interactive approach to the exercises

included in their EMIs. However, both types of exercises were able to reinforce skills and teach

new skills to participants which were related to their current treatment methods and their

psychological deficits. This approach appears to be most common when discussing the content

and use of EMIs to treat different mental health issues within patients and can often be combined with traditional techniques to enhance the experience and skills acquisition of the participants.

Prompting and its frequency also varied across studies. With the most frequent prompting being eight times per day and the least being once per day. Prompting was often initiated through notifications on the participants' phone at scheduled intervals during the day and would often prompt participants to complete one of the questionnaires included in the application or to complete one of the skills exercises. The frequency of prompts had little direct effect on the effectiveness of EMIs but did have an indirect effect due to the increase usage and access of the EMI that was produced due to the frequency of prompting the participants. Therefore, future research into producing effective EMIs may choose to observe the effect of increased usage via prompting in a more direct manner as this could provide an elegant way of promoting EMI engagement across participants.

The results from this study have various theoretical implications. For example, the results produced here offer insight into the interaction between EMIs and a wide range of mental health symptoms. Additionally, the comparison of efficacy to treat symptoms was inspected in this study which to the authors knowledge is one of the first to do so. Therefore, this study can be used to guide further research into EMIs by shining a light on areas in which EMIs are more effective and identifying those areas where they are perhaps not so effective. Further practical implications of this research are the comparison and identification of mental health issues and diagnoses which may be better suited to the use of EMIs than others. As well as identifying possible areas which help to improve EMI efficacy such as tailoring or blended therapy. This information should be taken into consideration when research is being conducted in the field of

any of the aforementioned mental health conditions. Furthermore, the information provided about the various features that can improve EMI effectiveness is important to consider during the development of other EMI applications or additionally when administering any EMI.

There are a number of limitations with this research which should be taken into account when looking at the results. For example, the research was conducted by a singular researcher (AD) therefore, there is the likelihood of bias when using the inclusion and exclusion criteria. This bias then may in turn produce skewed or unrepresentative results as there may be other studies not included that should have been and vice versa. Although steps were taken to reduce the amount of bias that would be present in the study by using predefined criteria and a consistent search string, bias could nevertheless be present. Another disadvantage of this study is that it attempts to loosely group and compare study results and outcome measures when there is a wide variety and therefore it is hard to draw concrete conclusions due to the nature of the studies that are grouped. However, it is still important to observe these results in the chance of trends or patterns showing improved efficacy for example.

There are multiple avenues which should be explored in further research using the results from this study. Firstly, future research should aim to provide clearer comparisons between the use of EMI with blended therapy and without. This can be done by studying similar mental health symptoms as well as using the gold standard of experimental comparisons randomised controlled trials. This will allow for direct comparison of a control group and intervention group but may also allow for the splitting of intervention features in order to identify if certain features are objectively more effective than others. Additionally, future research should aim to investigate the relationship between the use of EMAs and EMIs in conjunction with each other.

Furthermore, research should focus on how data is obtained through the EMAs which could then in turn influence the content that is given by the EMI. For example, if using EMIs and EMAs as an intervention for depression one may use select items from established depression inventories to obtain in the moment data which could change the type of intervention that is given. Feasibility and acceptability of EMIs have widely been reported to be high and this is no different in this study. Therefore, future research should explore different areas of application for EMIs. One such area could be the acquisition and reinforcement of skills. For example, EMIs may be an elegant intervention to increase compensatory strategy learning in patients with memory impairments for example. As the content of the EMI can be easily tailored it can allow for clinicians to tailor the EMI to whatever skill they are trying to reinforce with the patient. Sensors should be investigated more frequently because they have high potential in terms of data retrieval. The data collected from body sensors can indicate times of high risk for the patient and so interventions can be delivered in the time of highest need. Furthermore, research may choose to view the feasibility of using wearable apparatus such as smart watches as a way of prompting or delivering very specific EMIs to patients who may have trouble with losing their smartphones, for example patients with dementia.

Conclusion

To conclude, this study synthesised previous research on the use of EMIs and their effectiveness on several mental health issues across a wide range of patient types. The results show promise for the use of EMIs as a tool to help alleviate mental health symptoms. Further preliminary analysis suggests some features of EMIs can be more suited and effective than others when used for treating certain symptoms. This study provides a foundation for future research

which can use these results to explore multiple new avenues for the use and effectiveness of

EMIs. Such as using them in conjunction with compensatory strategies for those suffering from

memory deficits.

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