Using digital mood-monitoring technology to support the assessment, engagement, and empowerment of young people presenting to mental health services with affective instability

By Muna Dubad

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Declaration

This thesis is submitted to the University of Warwick in support of my application for the degree of Doctor of Philosophy. It has been composed by myself and has not been submitted in any previous application for any degree.

Abstract

Young people (10 – 24 years) are disproportionately affected by mental illness and affective instability. They are also the largest information and communication technology user group. The use of digital mood-monitoring technology, including mood-monitoring applications (apps), has been identified as a potentially effective method to engage and empower young people. Its use is also in line with current government health policies.

The aim of the PhD was to explore how digital mood-monitoring technology, specifically a mood-monitoring app, could be used to support the assessment, engagement, and empowerment of young patients with affective instability.

Four work packages were completed to answer the research aim, including: (1) a systematic review; (2) the process of identifying the optimal mood-monitoring app; (3) the quantitative digital mood-monitoring study; and (4) the qualitative digital mood-monitoring study.

Findings from the systematic review demonstrated the potential of apps to improve engagement, although this was not supported by the qualitative and quantitative study. Results from both the systematic review and qualitative study suggested apps can aid assessment in clinical settings. However, evidence in the quantitative study was less clear, which showed no significant difference in momentary affective instability between patients and a healthy comparison group. Qualitative findings suggested apps have the potential to empower young patients by increasing their ability to manage moods. Apps may also have important benefits for clinicians (e.g., informing relapse prevention plans). Finally, use of the app significantly reduced retrospectively measured impulsivity and momentary negative mood intensity. The qualitative study similarly suggested apps may improve problems with impulsivity. Potential explanations for each finding are discussed in their respective chapters.

The strengths and weaknesses of the PhD, as well as potential implications for practice, are discussed in the thesis summary.

List of abbreviations

ADHD	Attention Deficit Hyperactivity Disorder
ALS-SF	Affective Lability Scale – Short Form
ANOVA	Analysis of Variance
App	Application
BPD	Borderline Personality Disorder
cCBT	Computerised Cognitive Behavioural Therapy
CWPT	Coventry and Warwickshire Partnership NHS Trust
DERS-SF	Difficulties in Emotion Regulation Scale- Short Form
DHI	Digital Health Intervention
EMA	Ecological Momentary Assessment
FTB	Forward Thinking Birmingham
GHQ-12	General Health Questionnaire-12
HCP	Healthy Comparison Participants
HFASD	High-Functioning Autism/Asperger's Disorder
ICC	Interclass Correlation Coefficients
MSSD	Mean Squared Successive Difference
RCT	Randomised Controlled Trial
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
SAS	Statistical Analysis Software
SD	Standard Deviation
SSD	Squared Successive Difference
SPSS	Statistical Package for the Social Sciences
uMARS	Mobile Application Rating Scale: User Version
YPSG	Young Person's Steering Group

Chapter 1: Affect, affective instability, and psychopathology

Chapter overview

The purpose of this chapter is to introduce affect, affective instability, and its association with psychopathology. First, this chapter will introduce affective instability and the different components of affect. It will then summarise the prevalence of affective instability in clinical and non-clinical populations. The final part of the chapter will address the potential aetiology of affective instability and related psychopathology. It specifically adopts a developmental perspective, focusing on its manifestation from early infancy to young adulthood.

1.1 Affect and affective instability

It is typical to experience shifts between positive and negative affect in everyday life (Trull et al., 2015). Affect is therefore a dynamic experience. However, some individuals experience affective instability, which is characterised by a pattern of rapid, recurrent, and large changes in intense affect over time with a difficulty in regulating these changes or their behavioural consequences (Koval et al., 2013, Marwaha et al., 2014). Although affective instability is frequently addressed in psychiatric research, there is no mutually agreed terminology (Marwaha et al., 2014). Instead, this clinical symptom is interchangeably termed affective instability, mood instability, emotional instability, affective and emotional dysregulation, affective lability, and mood swings. Whilst these labels describe similar phenomena, many researchers posit that moods, emotions, and temperament (i.e., biologically-based individual differences that determine someone's affective experiences and behavioural responses across situations), represent unique constructs, each associated with specific temporal, causal, and behavioural characteristics (Goldsmith, 1994, Compas et al., 2004). The following sections describe the

distinctive features of emotion, mood, and temperament in more detail and are summarised in Table 1.

Table 1: Characteristic features of emotions, moods, and temperament (adapted from Goldsmith (1994), p.72)

	Affective experience		
Features	Emotion	Mood	Temperament
Temporal	Fleeting (typically lasts for seconds)	Enduring (may last for days or weeks)	Long-term (may be stable across months or years)
Causal	Reactive/specific, closely related to cause	Global/non-specific, temporally remote from cause	Potentially a biological or genetic disposition, possible environmental interactions
Behavioural	Goal-directed	Typically, non-goal directed	Ingrained patterns of behaviour which are consistent across situations

1.1.1 Temporal differences

As seen in Figure 1, emotions are typically perceived as a fleeting affective state, usually not lasting more than a few seconds (Goldsmith, 1994). Moods, however, reflect enduring affective states, which can persist for days, or sometimes weeks (Larsen, 2000). Of note, although emotions tend to be of a shorter duration, they are also thought to be experienced as more intensely than moods. Temperament is categorised as a long-term individual trait, which is considered stable across months or years (Goldsmith, 1994).

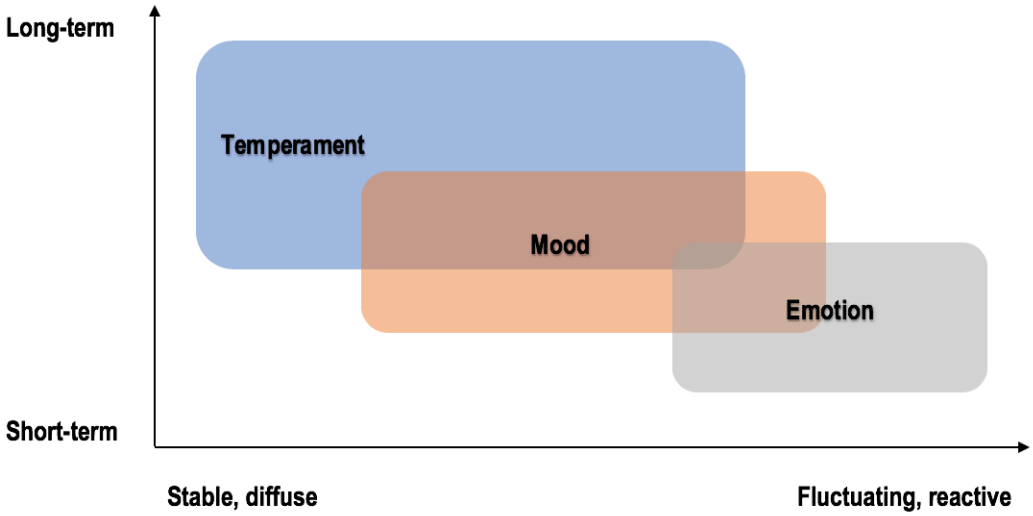

Figure 1: Temporal features of temperament, mood, and emotion (reused with permission from Lottridge et al. (2011), p. 201)

1.1.2 Causal differences

Affective components can also be distinguished in terms of their perceived causes (Larsen, 2000, Frijda, 2009, Ekkekakis, 2012). Emotions are often brought forth by something, responses to something, and generally about something (e.g., an event). An individual may experience sadness in response to bad news for example. Thus, emotions tend to closely or automatically follow their eliciting cause or stimulus (Ekkekakis, 2012). Conversely, a distinguishing feature of mood is that it is global and non-specific (Ekkekakis, 2012, Larsen, 2000). Unlike emotions, moods can be about nothing in particular (e.g., feeling anxious for no clear reason which persists in the absence of causal events) or be about everything (e.g., feeling irritable towards anything and anyone). Although moods fundamentally do have a cause, such as hormonal fluctuations (Steiner et al., 2003); compared to emotions, they are typically further removed from their cause (Ekkekakis, 2012, Larsen, 2000). As such, an individual might find it more difficult to identify what has specifically elicited a mood (Ekkekakis, 2012). Temperament, particularly affective temperament, is considered to be strongly determined by biological and genetic factors, potentially involving the central serotonergic (e.g., depressive

temperaments) and dopaminergic (hyperthymic temperament) systems (Rihmer et al., 2010). Despite this biological predisposition, temperamental traits do appear to interact or are influenced by environmental factors, such as parenting styles (Rioux et al., 2016).

1.1.3 Behavioural differences

People may exhibit behavioural differences in response to an emotion, mood, or in line with their temperament (Larsen, 2000, Lindhout et al., 2009). Given that emotions (e.g., fear) are typically experienced in response to a specific object or event (e.g., walking alone in a dark alley), a person is likely to engage in specific goal-directed behaviours associated with the emotion (e.g., walk faster), and experience physiological changes (e.g., adrenaline) (Larsen, 2000). As moods generally lack a clear causal object or event, an individual may not experience the same immediate urge to display specific goal-directed and mood-congruent behaviours.

This distinction may have implications for the management of emotions compared to moods (Beedie et al., 2005, Larsen, 2000). Emotion regulation strategies may help individuals with changing their, potentially maladaptive, behavioural responses to environmental stimuli or focus on the identification or reappraisal of specific triggers or causes (Beedie et al., 2005). As moods are not usually about or triggered by something, mood regulation strategies focus less on changing external stressors, and more on altering internal affective experiences, e.g., breathing exercises to reduce anxiety (Beedie et al., 2005, Larsen, 2000). In some circumstances, it is important to address external factors that may contribute to an individual's moods (Larsen, 2000). For example, an individual's chronic low mood may be exacerbated by ongoing financial difficulties. Offering support with managing their finances may help improve their financial situation, and indirectly also improve their mood. Nevertheless, the primary focus in mood

regulation is to alter moods, either through direct or indirect methods, with a lesser focus on managing responses to external triggers or events (Beedie et al., 2005, Larsen, 2000).

As explained above, temperaments do not necessarily describe a person's present state of mind, but rather reflect an individual's usual response or disposition across situations (Goldsmith, 1994). Children with a shy temperament for example, might be more reserved or timid in social or unfamiliar situations (Lindhout et al., 2009). Evidence suggests that emotions and moods are strongly influenced or predicted by an individual's temperament (Goryńska et al., 2015, Compas et al., 2004). A person with a neurotic temperament for example has a tendency to experience negative affective states, such as depression or shame (Miller and Pilkonis, 2006). Affective instability is believed to be a related but distinct trait, which is stable over time, and predisposes an individual towards fluctuations in affect (Kamen et al., 2010, Miller and Pilkonis, 2006, Miller et al., 2009).

Section 1.2 will review how affective instability may manifest across development. It will also describe the potential biological and environmental causes which have been linked to this trait. However, prior to this, a brief discussion of terminology issues is warranted. Although researchers have attempted to distinguish moods from emotions (as illustrated above), the terms are used interchangeably across studies (Beedie et al., 2005). Consequently, it can be difficult to determine whether researchers are referring to the same phenomenon using different terminology or are describing distinct affective experiences. As such, this thesis will use affect as an all-encompassing term covering emotions and moods (Frijda, 1994). Although the thesis will include studies which discuss both emotions and moods, including problems with instability or dysregulation, it will use the terminology presented when describing primary work.

1.2 Affective instability and psychopathology across development

1.2.1 Prevalence and manifestation of affective instability across clinical and non-clinical populations

Affective instability is relatively common and exists on a continuum of severity, affecting people from both clinical and non-clinical populations (Hilt et al., 2011). In the Adult Psychiatric Morbidity Survey (2007), 13.9% of the general population of England were affected by mood instability (Marwaha et al., 2013). Much higher rates were documented in people with mental health conditions, ranging from 49.2% for people with generalised anxiety disorder to 60.9% for people with depression. Affective instability is therefore a transdiagnostic symptom which cuts across a range of disorders (see Table 2 for an overview of a selection of disorders, which are addressed in the remainder of this chapter). Like most mental health problems (Kessler et al., 2007), affective instability appears most common in young people (and females), with rates diminishing with age (Marwaha et al., 2013, Patel et al., 2015). The World Health Organisation (1986) defines young people as individuals between the ages of 10 to 24 years. This definition comprises two sub-categories, including 'adolescents' (age range= 10 – 19 years) and 'youth' (age range= 15 – 24 years).

Table 2: Affective instability across psychiatric disorders

Condition	Manifestation of affective instability	Estimated prevalence rates[1]
Bipolar disorders	Severe elevations and fluctuations in affective states, changes in energy levels, and associated cognitive, physical, and behavioural symptoms (Mansell et al., 2007, Anderson et al., 2012).	22.6 – 83.3% (Patel et al., 2015, Geller et al., 1998)[2]
Depression	Negative cognitive biases may affect the way everyday events are experienced, and subsequently result in more intense and/or more frequent fluctuations in affective reactions (Mathews and MacLeod, 2005, Thompson et al., 2011).	60.9% (Marwaha et al., 2013)[3]

Condition	Manifestation of affective instability	Estimated prevalence rates[1]
Borderline personality disorder (BPD)	Affective instability is a diagnostic criterion for BPD and characterised by recurrent and abrupt changes in mood, which may be in response to external events (Trull et al., 2015, Nica and Links, 2009).	17.8% (Patel et al., 2015)[4]
Anxiety disorders	Heightened emotional reactivity, partly due to cognitive biases, and maladaptive regulation strategies, may contribute to affective instability (Farmer and Kashdan, 2014).	49.2% (Marwaha et al., 2013)[5]
Attention deficit hyperactivity disorder (ADHD)	Experiences of mood lability (e.g., rapid changes to excitability), emotional impulsivity, and difficulty with tolerating frustrations (Childress and Sallee, 2015).	25-70% (Shaw et al., 2014)[2]

Notes: 1) Affective instability was defined and measured differently across studies. Rates may therefore not be directly comparable. 2) Prevalence rates appeared substantially higher in younger compared to older individuals. 3) The figure reported here refers to people with a depressive episode. 4) Limited information was available regarding prevalence rates for people with BPD. The figure reported here refers to people with personality disorders in general. Rates may vary for people with BPD. 5) The figure reported here refers to people with generalised anxiety disorder. Rates vary across other anxiety disorders (e.g., panic disorder).

1.2.2 Manifestation of affective instability across development

Despite high prevalence in young people, problems with affective instability can be detected as early as infancy (Stringaris et al., 2012, Hilt et al., 2011). Evidence suggests that early dysregulation (e.g., prolonged crying) may increase the risk of future regulatory problems (Winsper and Wolke, 2014, Caspi, 2000, Meyer et al., 2009, Althoff et al., 2010). Moreover, it may predict severe levels of co-developing internalising (e.g., reports of worries) and externalising (e.g., reports of distractibility) symptoms, which can subsequently increase the risk of adolescent mental health problems such as BPD symptoms (Winsper et al., 2019). Early affective and behavioural dysregulation (e.g., emotional lability, impulsivity) may also increase risk of interpersonal difficulties, lack of educational attainment, unemployment, and engagement in criminal behaviours in young adulthood (Caspi, 2000). Affective instability, characterised by regulatory problems, is therefore a temperamental trait that can be identified early in the life course, potentially starts a trajectory of future dysregulation, and increases risk of psychopathology and psychosocial difficulties (Winsper and Wolke, 2014, Caspi, 2000, Steinberg and Drabick, 2015). This highlights the importance of early intervention. In light of

this evidence, the sections below will discuss affective instability across three broad developmental periods: 1) infancy and toddlerhood; 2) early to late childhood; 3) adolescence to young adulthood. It will also describe some of the biological and/or environmental influences which may affect the manifestation of this trait.

Infancy and toddlerhood

Approximately one fifth of infants experience regulatory problems, such as prolonged crying, sleeping difficulties, and feeding problems, in their first year of life (Hemmi et al., 2011). These regulatory problems are thought to reflect early markers of affective instability and may have genetic origins (Steinberg and Drabick, 2015). Coccaro, Ong, Seroczynski, and Bergeman (2012) for example, reported significant genetic influences on affect lability and affect intensity in a study involving 182 monozygotic and 119 dizygotic middle-aged male twins. More recently, Ward et al. (2019) conducted the largest genetic study of mood instability in a cohort of 363,705 middle-aged UK residents. The study identified 46 unique loci (the location of a gene on a chromosome (Turner, 2013)) that were related to mood instability, which had a heritability estimate of 9%. There was a higher proportion of females amongst participants with mood instability compared to participants without. Mean ages were also lower for cases compared to controls. As affective instability appears most common in young people and females (Marwaha et al., 2013), future studies should specifically explore the potential impact of gender and age on the genetic variations in this trait (Ward et al., 2019, Coccaro et al., 2012).

As regulatory capacities develop, infants and toddlers gradually learn to self-soothe (Steinberg and Drabick, 2015). The role of the caregiver is critical at this developmental stage, particularly as some brain structures (e.g., hippocampus, temporal cortex) are immature at birth and are strongly influenced by an infant's social experiences (Gerhardt, 2004, Steinberg and Drabick,

2015). Positive interactions between a caregiver and an infant (e.g., a caregiver's smile) activate a biochemical response such as beta-endorphins (a natural opioid), which help promote the growth of the prefrontal cortex (Gerhardt, 2004). These developments strengthen an infant's ability to self-regulate and engage in complex social interactions. Conversely, a negative biochemical response such as cortisol (a stress hormone) may also be triggered in response to a caregiver's negative facial expressions. Thus, a caregiver's interaction in early development may have both positive and negative effects on the developing brain. Caregivers may experience difficulties with soothing infants who have challenging temperaments and express reduced sensitivity (Ghera et al., 2006). Kochanska and Kim (2013) also found that toddlers with challenging temperaments were more likely to experience behavioural problems (e.g., tantrums) when caregivers were less responsive, yet had fewer problems when caregivers were highly responsive. Thus, there may be a bi-directional relationship between early dysregulation and parenting styles (Crowell et al., 2015).

The importance of early life relationships are emphasised across different theoretical models. Bowlby's theory of attachment (1969) for example, proposed that children display a range of attachment behaviours (e.g., smiling) from birth through which they seek and maintain proximity with attachment figures (Bowlby, 1969, Mikulincer et al., 2003, Bowlby, 1988). Attachment figures are those who can provide support and comfort, help regulate distress, and offer a secure base from which the environment can be confidently explored. An infant develops attachment security when they can rely on their attachment figure who is responsive to their attachment needs and proximity seeking behaviours (Mikulincer et al., 2003, Bowlby, 1988). In contrast, when attachment figures are not available, not sensitive or responsive to an infant's needs, and distress cannot be alleviated through proximity seeking behaviours, a person will not be able to develop attachment security. Children and young people with an insecure attachment style may struggle with tolerating and reflecting on their emotions (Gerhardt, 2004), have more mental health problems and interpersonal difficulties (Brown and Wright, 2003), and

experience higher levels of stress, irrespective of their individual temperaments (Gerhardt, 2004, Gunnar et al., 1996).

Early to late childhood

Although regulatory problems are typically short-lived (Hemmi et al., 2011), a minority of infants and toddlers experience severe affective and behavioural dysregulation during childhood, particularly when regulatory problems co-occur (Winsper and Wolke, 2014). Such challenging behaviours may provoke hostile, unresponsive, and/or punitive responses from caregivers and further reinforce or contribute to emotion dysregulation (Besnard et al., 2013, Steinberg and Drabick, 2015). Moreover, they may result in the development of psychiatric disorders.

Linehan's (1993) biosocial model for example, proposes that BPD is mainly a disorder of emotion dysregulation, characterised by general regulation difficulties across all types of emotional responding (Linehan, 1993, Crowell et al., 2009). It is thought to develop in childhood, where a child with a genetic vulnerability to affective instability is exposed to pervasive emotionally invalidating environments (Sauer and Baer, 2010, Linehan, 1993). This environment can be experienced as conflicting from the perspective of a child (Linehan, 1993, Crowell et al., 2009). That is, whilst the extreme expression of emotions are intermittently reinforced in emotionally invalidating environments, at the same time, these environments communicate to the child that such extreme expressions are unjustified and that they should manage these emotions internally and independently. As a result, the child fails to acquire the ability to comprehend, label, regulate, or endure emotional responses. Alternatively, the child learns to fluctuate between inhibiting emotions and extreme emotional instability, and does not learn how to solve the issues that contribute to these affective responses.

It should finally be noted that the development of the brain remains susceptible to external, adverse influences during childhood. Whilst positive social experiences may promote the development of the brain (see above), adverse childhood experiences such as child abuse, may trigger neurobiological changes that can have long-term negative effects on a child's affect regulation skills (Koenigsberg, 2010). Hanson et al. (2010) for example, reported decreased volumes in the orbitofrontal cortex of children who experienced physical abuse. This brain structure supports the regulation and adaptation of emotional responses in different environments (Rempel-Clower, 2007). Reduced orbitofrontal cortex volumes also predicted difficulties in children's social functioning. Childhood sexual abuse has also been associated with reductions of the corpus callosum (Andersen et al., 2008). Structural changes in the corpus callosum, which is a tract that connects the two hemispheres, has been linked to emotional instability, impulsivity, and suicidal behaviours across disorders including BPD, bipolar disorder, and ADHD (Matsuo et al., 2010, Lischke et al., 2017, Luders et al., 2009).

Adolescence to young adulthood

Adolescence is characterised by important developmental changes that affect individuals' affective experiences (Maciejewski et al., 2015). For instance, neurobiological evidence suggests that adolescents are at a developmental stage where neurobiological systems mature asynchronously. Whilst the 'socio-emotional' system (i.e., the limbic striatal system) is understood to reach maturation very quickly, the 'cognitive control' system (i.e., the pre-frontal cortex and associated circuits) gradually develops until young adulthood (Steinberg, 2010, Shulman et al., 2016, Shadur and Lejuez, 2015, Strang et al., 2013). According to the 'dual systems' model, depicted in Figure 2, this discrepancy in developments may increase young people's vulnerability to affective instability (Shadur and Lejuez, 2015). In brief, the socio-

emotional system, which includes structures such as the amygdala, is responsible for functions such as arousal, emotional responses, and sensation-seeking (Steinberg, 2010, Shulman et al., 2016, Shadur and Lejuez, 2015, Strang et al., 2013). Furthermore, the cognitive control system supports functions such as planning and decision-making as well as self-regulation and control (e.g., impulse or emotional control). Whilst the earlier activation of the socio-emotional system during adolescence heightens emotional reactivity and lability in response to stimuli (e.g., events), young people may struggle to effectively regulate these affective experiences as a result of their underdeveloped cognitive control system. With age, the reactivity of the socioemotional system decreases, whereas the strength and efficiency of the cognitive control system increases (Strang et al., 2013).

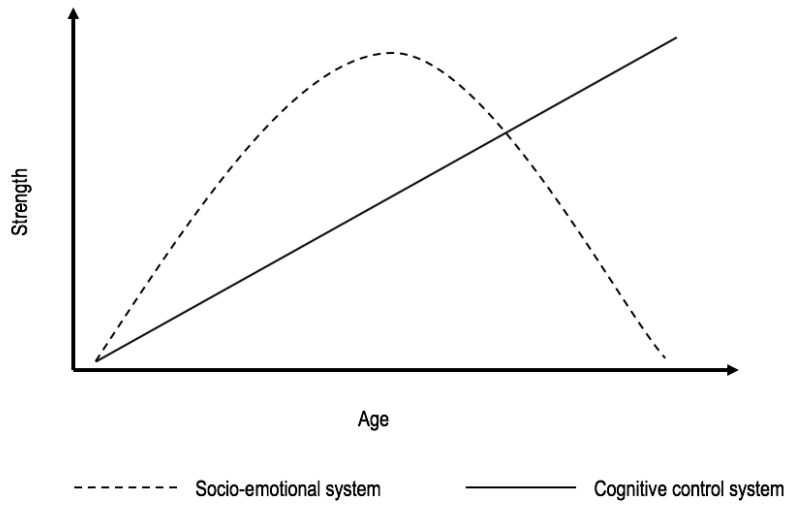

Figure 2: The dual systems model adapted, with permission, from Shulman et al. (2016), p. 105.

Evidence suggests that imbalances in neurobiological systems may increase risk of psychiatric disorders (Shadur and Lejuez, 2015). Hare et al. (2008) for example, reported hyperactivity in the amygdala of adolescents compared to children and adults in emotional contexts. Moreover,

heightened anxiety was related to decreased levels of connectivity between the prefrontal cortex and the amygdala. This association may be of particular relevance during young people's transition from adolescence to adulthood. During this time, young people typically experience increased levels of responsibility (e.g., financial) and independence (Hare et al., 2008, Maciejewski et al., 2015), which may induce stress or uncertainty, and subsequently increase variability in anxiety (Maciejewski et al., 2015). Moreover, they are expected to self-regulate more often, despite their emerging cognitive control system and regulation skills (Maciejewski et al., 2015, Shadur and Lejuez, 2015). It should be noted that regulation difficulties may be exacerbated in young people with genetic or environmental risk factors (Shadur and Lejuez, 2015, Casey et al., 2008). Thatcher et al. (2014) for example, reported increased levels of amygdala activity in adolescents with a parental history of substance use disorder (classed as a high-risk group) compared to adolescents without a parental history (classed as a low risk group).

The dual-systems model has also been applied to explain increases in sensation seeking and risk-taking amongst young people (Shulman et al., 2016). Harden and Tucker-Drob (2011) for example, employed a longitudinal design to investigate changes in impulsivity and sensation-seeking across ages 12 to 24 years. Consistent with the model, there was a reduction in impulsivity through adolescence which subsequently settled into young adulthood. Conversely, there was a strong increase in sensation-seeking until mid-adolescence, which then gradually declined into early adulthood. These findings reflect the gradual maturation of the cognitive control system and reduction in reactivity of the socio-emotional system, respectively.

Risk behaviours, such as dangerous driving, increase young people's risk of mortality and morbidity (Smith et al., 2013, Casey et al., 2008). Although the dual-systems model offers important insight into the occurrence of such hazardous behaviours, these need to be considered alongside co-occurring socio-environmental changes (Blakemore, 2018, Smith et

al., 2013). First, parental supervision typically decreases from childhood to adolescence. Consequently, adolescents have more opportunities to explore and engage in risk behaviours. Second, as parental influences diminish during adolescence, peers take on a greater role in adolescents' lives. Evidence suggests adolescents are more likely to take risks in the presence of peers (Chein et al., 2011). These behaviours may be displayed in order to illustrate their association with others or avoid social exclusion (Blakemore, 2018, Smith et al., 2013).

Although peers may encourage positive or pro-social behaviours such as volunteering (Blakemore, 2018), they may also influence maladaptive or anti-social behaviours via different social learning processes (Hilt et al., 2011, Monahan et al., 2009). Homophily, for example, describes the tendency to seek out peers who have similar attributes (Nangle et al., 2004). As such, a young person who is aggressive, may seek the company of other aggressive peers (Hilt et al., 2011). This may subsequently normalise or reinforce regulatory problems. Furthermore, social contagion, which describes the spreading of behaviour among peer groups, has been linked to increases in dysregulated behaviours such as disordered eating (Eisenberg and Neumark-Sztainer, 2010) and non-suicidal self-injurious behaviours (Jarvi et al., 2013) amongst young peer groups. Social contagion may therefore model or reinforce regulatory difficulties (Hilt et al., 2011).

Potential gender differences in peer relations and their impact on regulation should also be highlighted. Co-rumination for example, which describes the excessive discussion, speculation, and revisiting of problems between relationships partners (Rose et al., 2014), is more commonly displayed by young females compared to males (Hilt et al., 2011, Calmes and Roberts, 2008). Although this process has been linked to improved friendship satisfaction (Calmes and Roberts, 2008), they may also increase anxiety and depressive symptoms (Hilt et al., 2011, Calmes and Roberts, 2008) and non-suicidal self-injurious behaviours in young people (Lloyd, 2014). The relationship between rumination, negative affect, and maladaptive behaviours is described in

Selby's (2008) cascade model (Tuna and Bozo, 2014, Selby et al., 2008, Selby et al., 2009). It proposes that an event that provokes negative emotions, increases rumination about the negative experience, which then further increases distress. The repetition of this cycle leads to an intense experience, in which the use of adaptive distraction skills are no longer effective, and maladaptive strategies (e.g., self-injurious behaviours) are used instead. Such maladaptive behaviours can interfere with the process of rumination and divert attention away from their ruminative thoughts to bodily sensations (e.g., pain).

1.2.3 Integrative model

Together, these findings suggest that affective instability: 1) is a temperamental trait that can be identified early in the life course; 2) may be viewed as a starting point of a trajectory of self-regulatory problems; and 3) may predict future psychopathology and psychosocial impairments. A simplified outline of the development and manifestation of affective instability across development, based on the evidence presented in this chapter, is provided in Figure 3 below. In reality, there is likely a much more complicated interaction between factors described in the model (as indicated by the dotted line) and other potential causal influences. A full discussion of these interactions is beyond the scope of this chapter but are worth further investigation.

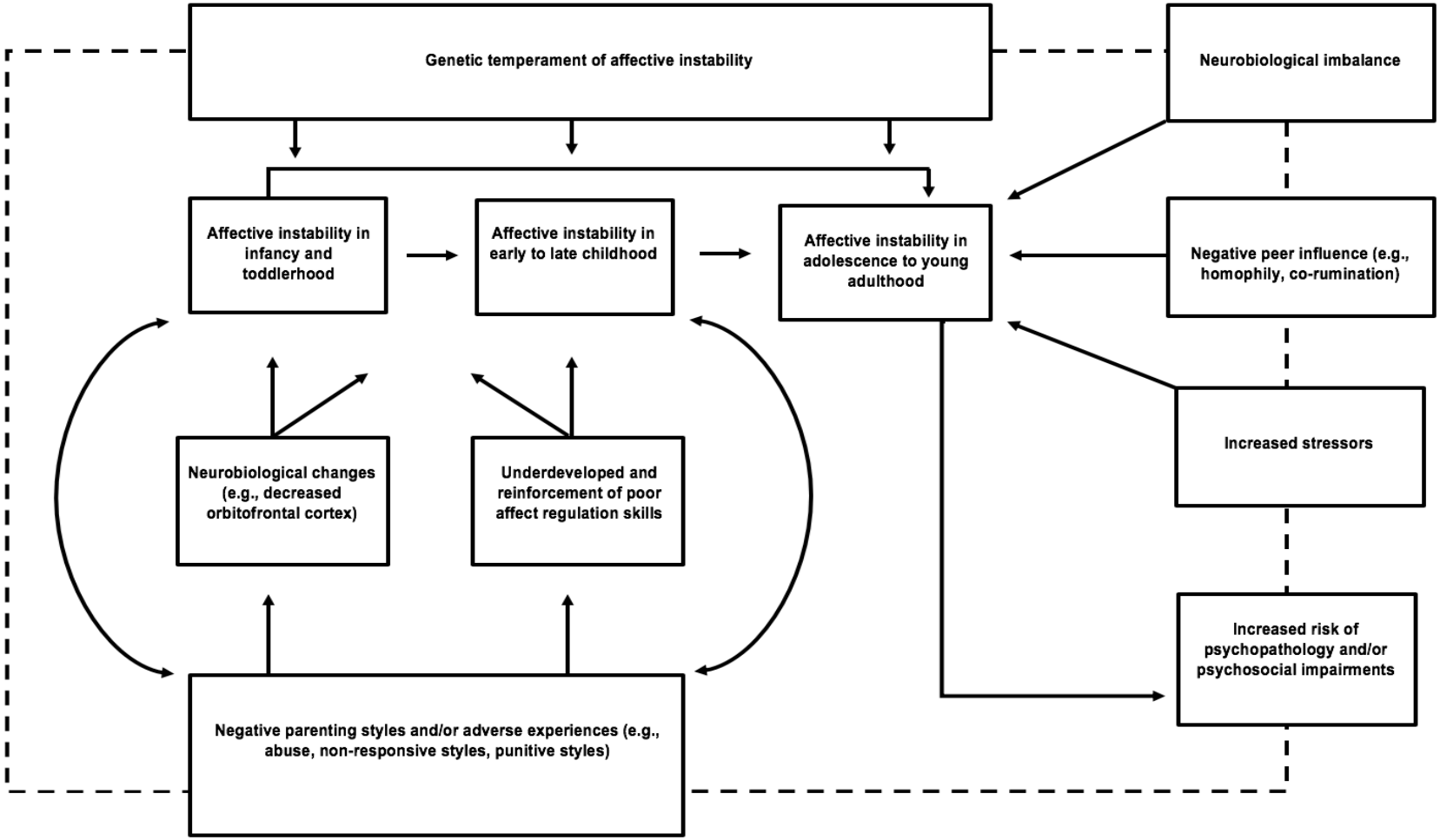

Figure 3: A simplified developmental model of affective instability

Chapter summary

This chapter introduced the concept of affect and affective instability. It discussed the different terminology used to describe affective instability (e.g., mood instability). It also highlighted the potential causal, behavioural, and temporal differences and links between moods, emotions, and temperament. It was proposed that affective instability is a temperamental trait which can influence individual propensities towards dysregulated affect. The chapter subsequently described the prevalence of this trait in the general population and across disorders, highlighting the disproportionate rates in young people and females. The final part of the chapter discussed the manifestation of affective instability from early infancy to young adulthood, and described the potential biological (e.g., neurobiological factors, genetic factors) and environmental (e.g., attachment quality, adverse childhood experiences) influences that affect the development of this trait. These findings were integrated into a simplified developmental model of affective instability.

Chapter 2: Digital mental health

Chapter overview

The previous chapter introduced affect, affective instability, and its association with psychopathology. This chapter will explore youth mental health support and the potential of digital technology to transform mental health services. First, there will be a discussion on the importance of early intervention, the facilitators of and barriers to formal mental health support, and self-help methods. There will then be a focus on technology and the available types of digital health interventions. The final part will address ecological momentary assessment, including the strengths and limitations of this method. A summary is provided at the end the chapter.

2.1 Youth mental health support

2.1.1 The case for early intervention

Approximately half of all lifetime cases of mental health problems develop by the age of 14, whereas around three quarters of cases start by the age of 24 (Kessler et al., 2007). Despite their early onset, mental health problems are often not effectively treated until much later in life (McGorry et al., 2011). Reports suggest that only 30% of children and young people with a mental health problem have received suitable treatment at the right time (Mental Health Foundation, 2016). A report by Khan (2016) showed that typically there is a delay of a decade between when symptoms are first experienced by young people and when they actually receive help. Taking into consideration the increased demand on child and adolescent mental health services, and a scarcity of trained mental health professionals (Hollis et al., 2017), mental health services are struggling to deliver support during this critical period of development (McGorry et al., 2007b).

The lack of mental health support can have devastating consequences for young people (McGorry et al., 2007b). Adolescence and young adulthood are characterised by increased responsibilities and independence, during which the foundations for adult life are established. The disabling and disrupting effect which mental health problems can have during this unique and sensitive developmental period can severely limit young people's potential. Studies have demonstrated multiple poor outcomes associated with youth mental health problems, including more severe and chronic psychopathology (McGorry et al., 2011), increased risk of suicide (Bilsen, 2018), greater disruption to young people's education and poor academic achievement (McGorry et al., 2007b, Green et al., 2005), unstable employment or unemployment (McGorry et al., 2007b, Goodman et al., 2011), and poor family and social functioning (McGorry et al., 2007b). Young people can struggle to disembark from this negative developmental trajectory (Moffitt et al., 2011). This therefore demonstrates the importance of early intervention for youth which has the potential to improve young people's social and functional recovery, can prevent symptoms from transitioning into long-term mental health problems or crises, and may eliminate the requirement for specialist, and possibly more expensive, mental health care or hospitalisation (Connor, 2017, Fryers and Brugha, 2013, McGorry et al., 2007a).

2.1.2 Formal mental health support: Barriers and facilitators

Although young people are likely to seek informal support from friends or relatives for mental health problems, they show more hesitation in consulting and engaging with professional services (Rickwood et al., 2007, Gulliver et al., 2010, DiGiuseppe et al., 1996). A UK-based cross-sectional study by Salaheddin and Mason (2016) showed that 35% of young adults aged 18-25 years with self-reported emotional or mental health problems had not sought formal or informal support. Some of the barriers to help-seeking included fear of stigma and negative

perceptions (e.g., perceiving help-seeking as “pathetic”), lack of insight or difficulty with communicating mental health issues, and a preference to manage problems independently.

It is worth noting that self-reported rates of help-seeking were higher in Salaheddin and Mason’s (2016) study compared to previous UK-based studies. Biddle et al. (2004) for example, showed that only 7.5% of young males and 8.9% of young females with minor mental health problems sought help from a GP. This increase may be attributed to the range of public mental health campaigns and awareness initiatives that have been launched in the last 15 years (e.g., ‘Time to Change’, ‘Heads Together’, ‘Children’s Mental Health Week’), which can improve attitudes, mental health literacy, and help-seeking (Evans-Lacko et al., 2014, Wright et al., 2006). Other facilitators of young people’s help-seeking behaviours may include positive previous experiences with help-seeking, feelings of competence in expressing emotions, and established and trusted rapport with potential mental health services (Rickwood et al., 2007, Gulliver et al., 2010).

2.1.3 Self-help methods

Young people often use self-help tools to manage their mental health problems (Rickwood et al., 2007), which may include psycho-education on mental health symptoms and effective coping strategies (Mind in Brighton and Hove, 2019). Horgan and Sweeney (2010) found that 30.8% of young respondents accessed mental health information on the Internet. Furthermore, 68% of respondents reported a willingness to access the Internet for mental health information and support. Self-help methods allow young people to take responsibility for their condition, may improve young people’s sense of control over their mental health, and can increase feelings of empowerment (Lewis et al., 2003). A 2017 Government Green Paper recognised the potential benefits of self-help tools both for young people who do not need mental health treatment and as an adjunct for existing treatment and crisis interventions (Department of

Health and Department for Education, 2017). Self-help methods can provide young people with a self-management plan during times of distress and may also improve access to support (e.g., for young people who are on waiting lists or in between regular appointments). This may prevent the deterioration of young people's mental health problems and potentially lower levels of dropout by maintaining or improving young people's engagement with services.

2.2 Digital mental health

2.2.1 Digital mental health technology and digital health interventions (DHIs)

The use of digital technology and DHIs are increasingly recognised as having great potential for mental health services (Hollis et al., 2017). Digital technology can deliver more accessible treatment and potentially reduce the pressure on face-to-face mental health services (Hollis et al., 2017, Hollis et al., 2015). DHIs and digital health services have transformed substantially over the years given the continuous advances in technology (Hollis et al., 2017). Early DHIs, such as computerised cognitive behavioural therapy (cCBT), required a wired Internet connection, making them immobile. In contrast, more recent cCBT programmes can be accessed wirelessly from different locations, contain more dynamic content, offer higher levels of interactivity, and be adapted to young people's needs.

There are a range of digital platforms through which DHIs can offer information, support, and therapy for mental health problems. These often consist of content (e.g., educational text) and/or processes (e.g., mood monitors) that are specifically associated with a targeted mental health problem and offer different levels of interactivity. 'Mood Gym' for instance, is a website which contains different modules aimed at the understanding and management of depression through text, animations, quizzes, and other content (Hollis et al., 2017, Christensen et al., 2002). Despite young people's interest and increased use of Internet Technology for their

mental health (Griffiths and Christensen, 2006), clinicians may not feel comfortable with encouraging people to consult these resources due to concerns over their quality (Griffiths and Christensen, 2006). Moreover, some web-based interventions, such as 'Sleepio' (2019) may come at a cost to end users (Mental Health Foundation, 2019). However, as people do access these webpages, it is important for clinicians to acknowledge and discuss the use of self-help websites, including potential cost barriers, and if appropriate, recommend high-quality online resources (Griffiths and Christensen, 2006).

2.2.2 Mobile digital technologies

Mobile digital technologies, such as smartphones, have continued to increase in popularity, and have resulted in the development of mobile DHIs (Hollis et al., 2017). Mobile phones play an essential role in young people's lives (Walsh et al., 2008). Figures by Ofcom (2018) suggest that smartphone ownership is as high as 95% in 16-24 year olds. Given this ready access to and familiarity with such devices, incorporating smartphone technology into mental health treatment may improve young people's experiences with mental health services. The importance of technology, including smartphone technology, and its potential to substantially transform mental health services are emphasised in the Annual Report of the Chief Medical Officer (Department of Health, 2013) and the 'Five Year Forward View for Mental Health' report by the Mental Health Taskforce Strategy (2016). However, the impacts of technology on young people's mental health require further exploration (Department of Health and Department for Education, 2017), especially with concerns over the harmful effects of increased levels of screen time on young people's physical health, mental health, sleep, and quality of life (Stiglic and Viner, 2019, Lemola et al., 2015). Smartphone technology has the potential to offer opportunities for more objective and reliable assessment, diagnosis, and monitoring of mental health problems (Department of Health, 2013). Supporting people with using smartphone

technology to monitor their mental health and sharing smartphone data with their clinician may also foster a greater sense of involvement in their care.

2.2.3 Smartphone applications and implications

Technology-based support

As smartphones improve in functionality and develop advanced features, opportunities for innovation in treatment and assessment also continue to grow. One aspect of smartphone technology that has shown on-going developments and has the potential to play an important role in mental health services is the smartphone application (also known as "app"). Smartphone apps were first developed in 2008 (Donker et al., 2013) and are a form of mobile software that can be installed on personal phones. Since their introduction, an increasing number of mental health focused apps have been developed (Torous and Roberts, 2017), many of which contain features that encourage the use of effective self-regulation skills that can potentially positively influence wellbeing (Tregarthen et al., 2015, Rizvi et al., 2011).

Recent systematic review findings by Wang et al. (2018), which examined evidence for people across all ages, indicated the potential of apps to effectively monitor or improve psychiatric symptoms. Moreover, a scoping review by Gindidis et al. (2019), which specifically focused on adolescents, suggested that apps can support young people's engagement with treatment, and help them meet their therapeutic goals. Research supports the use of apps, particularly as an adjunct to treatment (Gindidis et al., 2019), but evidence for their effectiveness in young people is limited (Grist et al., 2017). The paucity of evidence based apps therefore continues to pose a concern (Donker et al., 2013). Fortunately, high quality digital self-help tools are now also available on the NHS Apps library, which are NHS endorsed and tested apps (NHS, 2019).

Moreover, a 'Digital Development Lab' was funded by NHS England (Department of Health and Department for Education, 2017). This lab identified and fast-tracked the development of six mental health apps aimed at children and young people.

Ecological momentary assessment

Research suggests that traditional retrospective monitoring and analytical tools do not effectively measure the individual dynamic affective processes over time and possibly introduce different forms of bias, e.g., retrospective memory bias (Reid et al., 2009, Schwartz et al., 1999) into the assessment process (Trull et al., 2015). In contrast, mental health apps have the capacity for ecological momentary assessment (EMA). Through prompts or notifications, which can be sent as and when required, EMA methods enable individuals to monitor their symptoms in real-time in their own environment. This can improve ecological validity (Shiffman et al., 2008). Ben-Zeev et al. (2009) demonstrated the difference in bias between EMA-based and retrospective self-reports in a study comparing a group of participants with and without depression. Retrospective ratings of positive and negative affect were exaggerated by both groups in comparison to their EMA ratings, thus suggesting greater inaccuracies or memory bias. However, participants with depression were more likely to inaccurately recall negative, but not positive affect. It is therefore important for clinicians and researchers to consider time-sensitive methods, such as EMA (Trull et al., 2015, Ebner-Priemer and Trull, 2009).

The assessment of variables (e.g., mood) through EMA, can also increase individuals' awareness of these variables, and may consequently encourage positive behavioural or cognitive change (Frates et al., 2011, Runyan et al., 2013, Runyan and Steinke, 2015). This effect is referred to as assessment reactivity (Schrimsher and Filtz, 2011, van Ballegooijen et

al., 2016). For example, previous behavioural studies on alcohol abuse indicated that repeated self-monitoring in itself was often sufficient in reducing the frequency of problematic behaviours by increasing awareness of the assessed behaviour (Shiffman et al., 2008, van Ballegooijen et al., 2016, Schrimsher and Filtz, 2011). This monitoring process helped identify the target behaviours and draw attention to personal responsibility (Schrimsher and Filtz, 2011, van Ballegooijen et al., 2016). Self-monitoring therefore has the potential to increase self-awareness and understanding of inner experiences, may provide insight into possible explanations for reactions (Cohen et al., 2013), and is an essential aspect of effective affect regulation (Parkinson and Totterdell, 1999, Thomas and Segal, 2006).

The improvement in awareness may also be linked to mindfulness, which describes a state of full awareness and acceptance of moment-to-moment internal and external experiences (Kabat-Zinn, 2003). Mindfulness is similarly connected to affect regulation (Teper et al., 2013) as well as psychological wellbeing (Brown and Ryan, 2003). Mindfulness techniques may teach individuals to accept the presence of certain thoughts or feelings and to mentally note these thoughts, without evaluating or judging them, which can improve problems with impulsivity (Peters et al., 2011) and may prevent symptoms from becoming more severe (Follette et al., 2006).

Overall, the potential of smartphone-based EMA self-monitoring methods seems promising. Nevertheless, whilst EMA can minimise or eliminate recall bias, EMA data may still be sensitive to other types of bias. Self-report bias, for example, can lead to the under- or over-reporting of variables or events due to individuals aiming to present themselves in a certain light (Donaldson and Grant-Vallone, 2002). As seen in other self-report methods, momentary data can also be influenced by deception, self-deception, and may need to be supplemented with other sources

of information (e.g., informant reports) to draw firmer conclusions (Kessler et al., 2000, Shiffman et al., 2008). Alternative methods that are less sensitive to such influences require further exploration. For example, smartphone sensor data such as GPS location, which can be automatically collected without app users' direct input, may be used to predict depression (Saeb et al., 2015). Finally, there are also potential risks associated with the use of smartphone mental health apps. For example, data loss (e.g., due to the loss of a smartphone) could result in a breach of privacy and confidentiality (Prentice and Dobson, 2014). Given the sensitivity of information on self-monitoring apps, appropriate measures should be implemented to protect the data of app users (e.g., the use of a PIN to access an app).

Chapter summary

This chapter discussed the provision of youth mental health support and highlighted the importance of early intervention to promote recovery and prevent chronic mental illness. Potential barriers (e.g., fear of stigma) and facilitators (e.g., established and trusted rapports with potential mental health providers) for seeking formal mental health support were examined, followed by a brief discussion on the potential for informal mental health support and self-help to potentially benefit youth. This chapter introduced digital technology and digital health interventions, describing the advances that were made in this field, including the improvements in the functionality and features of smartphone apps, and the growing possibilities for innovation and assessment. Finally, there was a discussion on EMA methods, which may reduce risks of memory bias, yet may also be sensitive to other types of bias (e.g., self-report bias) and pose risks (e.g., data loss).

Chapter 3: Overview of research aims, questions, and methodology

Chapter overview

The previous chapters provided a background into affective instability and digital mental health. This chapter describes the main research aim of the PhD, which is a mixed methods study that consists of four work packages, including: (1) a systematic review; (2) the process of identifying the optimal mood-monitoring app; (3) the quantitative digital mood-monitoring study; and (4) the qualitative digital mood-monitoring study. Also included is a rationale for each work package, and an overview of their specific aims and research questions.

3.1 Main research aim

Affective instability is a prominent transdiagnostic symptom and risk factor for a range of mental health disorders (Spindler et al., 2016). It most commonly affects young people (Marwaha et al., 2013). Implementing mobile mood-monitoring technologies, such as mood-monitoring apps, in this population may provide a window of opportunity to engage and help young people. The overall aim of this PhD was to gain an understanding of how digital mood-monitoring technology could be used to support the assessment, engagement, and empowerment of young people with affective instability.

3.2 Work packages

3.2.1 Systematic review

Despite the potential and the widespread advocacy for digital mental health technologies (Firth et al., 2016, Sandstrom et al., 2016a), there were no existing systematic reviews collating evidence for the use of mood-monitoring apps in young people. Systematic reviews are

considered the gold standard of literature reviews (Smith and Noble, 2016). Advantages of systematic reviews include their capacity to integrate large quantities of information into a coherent format (Mulrow, 1994). Systematic reviews also facilitate cross study comparisons. This can help determine the generalisability of findings but also highlight conflicting results. Risk of bias is reduced through the use of pre-determined strategies, which may also improve the reproducibility of findings. Thus, a systematic review was conducted in order to gather, critically evaluate, and synthesise evidence from multiple studies in order to obtain a reliable and accurate understanding of the evidence-base (Boland et al., 2017, Centre for Reviews and Dissemination, 2009, Smith and Noble, 2016). Findings from the review also informed the aims, objectives, and outcomes for the subsequent parts of the PhD.

Aim:

- To examine the psychometric properties, usability, and clinical impacts of mobile mood-monitoring apps in young people.

Research questions:

1. What are the psychometric properties of mobile mood-monitoring apps?
2. What is their usability?
3. What are their positive and negative clinical impacts?

3.2.2 Identification of the optimal mood-monitoring app

As seen in Figure 4, this work package was completed in two stages:

- Stage 1: Systematic review framework for the identification of apps.

The strategy used to identify the optimal mood-monitoring app was based on a systematic review framework, as seen in previous studies (Nicholas et al., 2015). This included the application of a search strategy, the assessment of apps against eligibility criteria, and a quality

assessment of apps. The three apps with the highest quality assessment scores were reviewed with young people, students, and professionals (see Stage 2).

- Stage 2: Consultation and information security check

The consultation of young people in the decision-making process can help increase their sense of ownership, feelings of responsibility, and confidence about sharing their unique views (Browning, 2005). By collaborating with young people from a local steering group (see Chapter 5 for further details), the app used in the latter stages of the PhD was informed by young people and more consistent with their needs and wishes (Davies et al., 2014, Barnicot and Ramchandani, 2015, Browning, 2005). Moreover, alternative perspectives on selected apps were obtained from students and professionals (e.g., clinicians), many of whom are key to the uptake of this technology in real-life settings. Finally, app developers were also contacted and asked to provide information about the app's data protection and security measures. Thus, the app for the mood-monitoring study was chosen based on feedback from the steering group, students, and professionals, alongside an examination of the app features and security settings.

Aim:

- To compare and contrast available smartphone apps and determine which one is most suitable for mood-monitoring.

Research questions:

1. What high-quality mood-monitoring apps are available from app stores?
2. How are pre-selected mood-monitoring apps perceived by a young person's steering group, students, and professionals?
3. What do young people value in mood-monitoring apps?

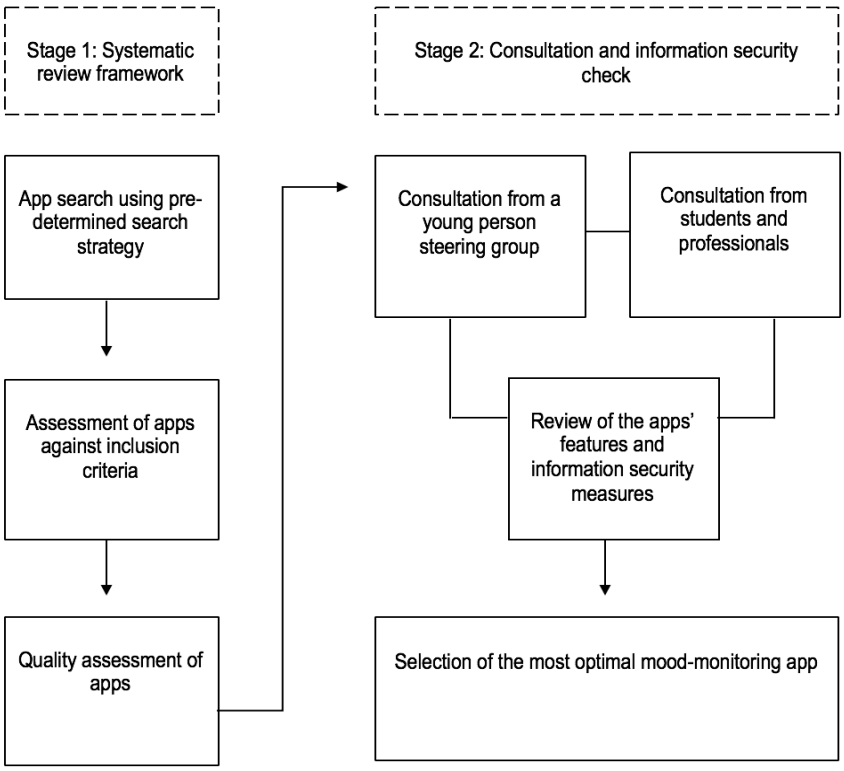

Figure 4: Overview of the two-stage decision making process for the identification of the optimal mood-monitoring app

3.2.3 Digital mood-monitoring technology: A quantitative investigation

Mobile mood-monitoring technologies may help facilitate the collection of rich data (e.g., temporal sequencing and variability of mood fluctuations) and provide a more accurate reflection of the frequency and fluctuations of mood disorder symptoms (Mokros, 1993). What remained largely unknown was whether a publicly accessible mood-monitoring app could: 1) effectively capture affective instability in young people presenting to mental health services; and 2) potentially improve mental health outcomes. By addressing current gaps in the research (e.g., research into the link between digital mood-monitoring and quantitatively measured engagement) and moving forward existing research that was more extensively examined (e.g., research on the feasibility of apps), this study was designed to make a unique contribution to this field.

Aim:

The aim of this study was to investigate affective instability in young people using the 'Catch It' mood-monitoring app. Specifically, young people presenting to mental health services with a range of diagnoses (in which affective instability forms a key component) were compared to a healthy comparison group.

Research questions

1. Are there group (clinical and healthy) differences in momentary affective instability?
2. Does use of the 'Catch It' app impact on clinical symptoms across all participants, including:
    - Momentary positive and negative mood intensity ratings;
    - Retrospectively assessed emotion regulation difficulties; emotional awareness; emotional clarity; impulsivity; and affective shifts.
3. Does use of the 'Catch It' app improve (retrospectively assessed) engagement in patients accessing services?

Rationales behind the specific research questions are provided in Chapter 6.

3.2.4 Digital mood-monitoring technology: A qualitative investigation

Quantitative and qualitative research methods each have different advantages and disadvantages and can be used to complement one another (Bölte, 2014) Although the quantitative digital mood-monitoring study could provide important objective data on the usefulness and impacts of mood-monitoring apps, a qualitative method was employed to tap into patients' (and other stakeholders) subjective experiences and elucidate potential mechanisms underlying effects (Greenhalgh et al., 2016, Bölte, 2014). Thus, it could provide a deeper understanding of individual perceptions and experiences, the findings of which could be

translated into clinical practice (Holloway and Galvin, 2016, Bölte, 2014, Greenhalgh et al., 2016).

Aim:

- To qualitatively investigate the usability, clinical utility, and impacts of the 'Catch It' app from the perspective of young patients and clinicians in mental health services.

Research questions:

1) What are young patients and clinicians' perceptions of the 'Catch It' app?
2) What are the clinical and treatment benefits of the 'Catch It' app from the perspective of young patients and clinicians?
3) What patient and clinician identified factors influence engagement and disengagement with the 'Catch It' app and how may its clinical utility be improved?

Chapter summary

This chapter described the overall aim of the PhD and briefly summarised each individual work package's rationale, specific aims, and research questions. Full details and findings of the systematic review, the process of identifying the optimal mood-monitoring app, and the quantitative and qualitative digital mood-monitoring studies are provided in chapters 4, 5, 6, 7, and 8.

Chapter 4: A systematic review of the psychometric properties, usability, and clinical impacts of mobile mood-monitoring applications in young people

Chapter overview

The aim of this chapter is to systematically review the evidence for the psychometric properties, usability, and positive and negative clinical impacts of mood-monitoring apps in young people. First, this chapter will provide a brief introduction into the area. It will subsequently outline the methods and describe the results. The main findings will then be discussed, including the strengths and limitations of the review.

The review (Dubad et al., 2018) was published in *Psychological Medicine* prior to submission of the thesis. This chapter presents a slightly amended version to reduce repetition from previous chapters. The published article is included in Appendix 1.

4.1 Introduction

Mental health services increasingly use apps (Olff, 2015), many of which have the capacity for ecological momentary assessment (EMA) to monitor mood (Sandstrom et al., 2016b). Several reviews with mainly adult populations (e.g., Torous and Powell, 2015, Walsh et al., 2016, Naslund et al., 2015, Bakker et al., 2016, Donker et al., 2013, Faurholt-Jepsen et al., 2016, Nicholas et al., 2015) have appraised evidence for the use of mood-monitoring apps. Studies included in these reviews provide some evidence for the psychometric properties, e.g., internal consistency (Palmier-Claus et al., 2012) and concurrent validity (Faurholt-Jepsen et al., 2014) of these apps. There is also evidence for usability (Bardram et al., 2013). Participation rates are generally high across studies sampling adults, ranging from 65% (Depp et al., 2015) to 88% (Ainsworth et al., 2013), though Depp et al. (2012) reported much higher completion rates for

paper and pencil compared to app measures (82.9% vs. 42.1%). Evidence also suggests that apps may help people with mental health problems to monitor triggers (Bardram et al., 2013), that the capacity to convey experience can be therapeutic, and that apps could be a useful tool for improving patient-clinician communication (Palmier-Claus et al., 2013).

Less is known about the use of mental health apps, particularly mood-monitoring apps, in young people (10-24 years). A scoping review by Seko et al. (2014) suggested that mood-monitoring apps are positively perceived by youth (Matthews et al., 2008a), may improve treatment adherence (Matthews et al., 2008b), and possibly improve mental wellbeing (Kauer et al., 2012). While intriguing, findings were preliminary due to the low quality of available evidence (NCCMH, 2014), the small number of studies on mood-monitoring apps specifically, and the limited number of apps studied (n=2) (NCCMH, 2014, Seko et al., 2014).

In summary, mood-monitoring apps could offer a potentially important step change in the assessment of mood and delivery of youth mental health services. Despite this potential and the widespread advocacy for their use (Firth et al., 2016, Sandstrom et al., 2016a), there are no extant reviews examining the psychometric properties, usability, and clinical impacts of mood-monitoring apps in young populations. Therefore, a systematic review was completed to address the following research questions: (1) what are the psychometric properties of mobile mood-monitoring apps; (2) what is their usability; (3) and what are their positive and negative clinical impacts among clinical and non-clinical young populations?

4.2 Method

Following an initial scoping review, MD (PhD candidate) developed a systematic review protocol delineating the planned methodology. The review was carried out and documented in

adherence to this protocol and in line with the PRISMA ("Preferred Reporting Items for Systematic Reviews and Meta-Analyses") statement (Moher et al., 2009).

4.2.1 Information sources and search strategy

The following sources were searched: MEDLINE, Embase, PsycINFO, ProQuest Dissertations & Theses, ProQuest SciTech Collection, the Association for Computing Machinery (ACM) Guide to Computing Literature, and Web of Science for articles published from 2008 (the year when the first app was launched (Donker et al., 2013)) to December 2015. Search terms were informed by previous reviews (Seko et al., 2014), and modified following advice from a medical librarian (Samantha Johnson), MD's supervisors (Professor Steven Marwaha and Dr Catherine Winsper), and field experts, including Professor Caroline Meyer (Professor of Applied Psychology) and Sunčica Hadžidedić Baždarević (PhD candidate in Computer Science/Affective Computing). The search was conducted by combining five groups of terms (see Table 3) relating to: type of technology (e.g., "mhealth"), type of assessment (e.g., "ambulatory assessment"), mood-related outcome or problem (e.g., "bipolar disorder"), youth population (e.g., "youth"), usability/treatment related outcomes, and psychometric properties (e.g., "reliability," "validity"). MD was interested in all forms of validity potentially examined in the app literature, e.g., concurrent, face, or predictive (Faurholt-Jepsen et al., 2016), though a paucity of studies was anticipated due to the novelty of the field.

Table 3: Overview of search terms

Group 1	Group 2	Group 3	Group 4	Group 5
mhealth OR telehealth OR telemedicine OR digital* OR *phone* OR mobile OR app	monitor* OR track* OR chart* OR experience sampl* OR ambulatory assessment OR real-time subjective emotionality assessment OR ecological momentary assessment OR self-surveillance	mood* OR emotion* OR valence OR alcohol* OR substance us* OR mental health OR bipolar disorder OR depress* OR borderline personality disorder OR anx* OR *regulat* OR instab* OR labil*	youth* OR adolescen* OR young* OR child* OR teen* OR student*	therap* OR self* OR assess* OR treat* OR manag* OR clinical OR impact* OR benefit* OR improve* OR useful* OR acceptab* OR feasib* OR reliab* OR valid* OR sensitivity OR specificity OR psychometric* OR compl* OR adher* OR interven*

MD conducted a hand search of articles published in *Cyberpsychology, Behavior and Social Network*, the *Journal of Medical Internet Research* (JMIR), the *JMIR Mental Health*, and the *JMIR mHealth and uHealth* over the last five years. An additional search of the first fifteen pages of Google Scholar was conducted (using the search terms: "mood," "phone," "app," and "monitoring"). Reference lists and in-text citations of relevant articles were inspected. Finally, subject experts were approached to identify additional articles, including: Professor John Geddes (Professor of Epidemiological Psychiatry at the University of Oxford), Dr Jennifer Martin (Programme Manager at MindTech), 'The Mental Elf' (a mental health blogging organisation), and Jakob Bardram (Chief Scientific Officer at Monsenso Apps).

4.2.2 Study selection

Inclusion criteria were:

1. Apps must have been developed for, and delivered through, mobile phones or smartphones;
2. Participants aged 10 to 24 years as consistent with the World Health Organisation's definition of young people (World Health Organisation, 1986);
3. Published and unpublished studies reported in the grey literature (e.g., dissertations);
4. Studies must have been published in the English language;
5. Studies must have been published in 2008 or later;
6. Studies must have included community or clinical populations (to ensure the inclusion of young people who are sub-clinical, who may subsequently access care).

4.2.3 Screening procedure

Following removal of duplicates, MD and Maria Livanou (PhD candidate from the University of Warwick) independently screened 100% of titles and abstracts for full text retrieval. MD assessed full text articles against the inclusion criteria and extracted relevant data.

4.2.4 Quality assessment

Similar to Faurholt-Jepsen et al.'s (2016) systematic review, MD evaluated the quality of included studies for potential risk of bias using Cochrane's Risk of Bias tool, in which studies are allocated a rating of high, low, or unclear risk of bias (Higgins et al., 2011).

4.2.5 Data synthesis

Quantitative and qualitative data were synthesised narratively.

4.3 Results

4.3.1 Study selection

A total of 1747 articles were identified in the initial search, and nineteen from the hand search (Figure 5). Following removal of duplicates, 1176 abstracts were screened, 86 of which were selected for full text retrieval. There was a high level of agreement between raters (Kappa = .90). In total, 64 articles were excluded following full-text review. Three additional articles were identified following inspection of included studies. Twenty-five articles were included in the final review.

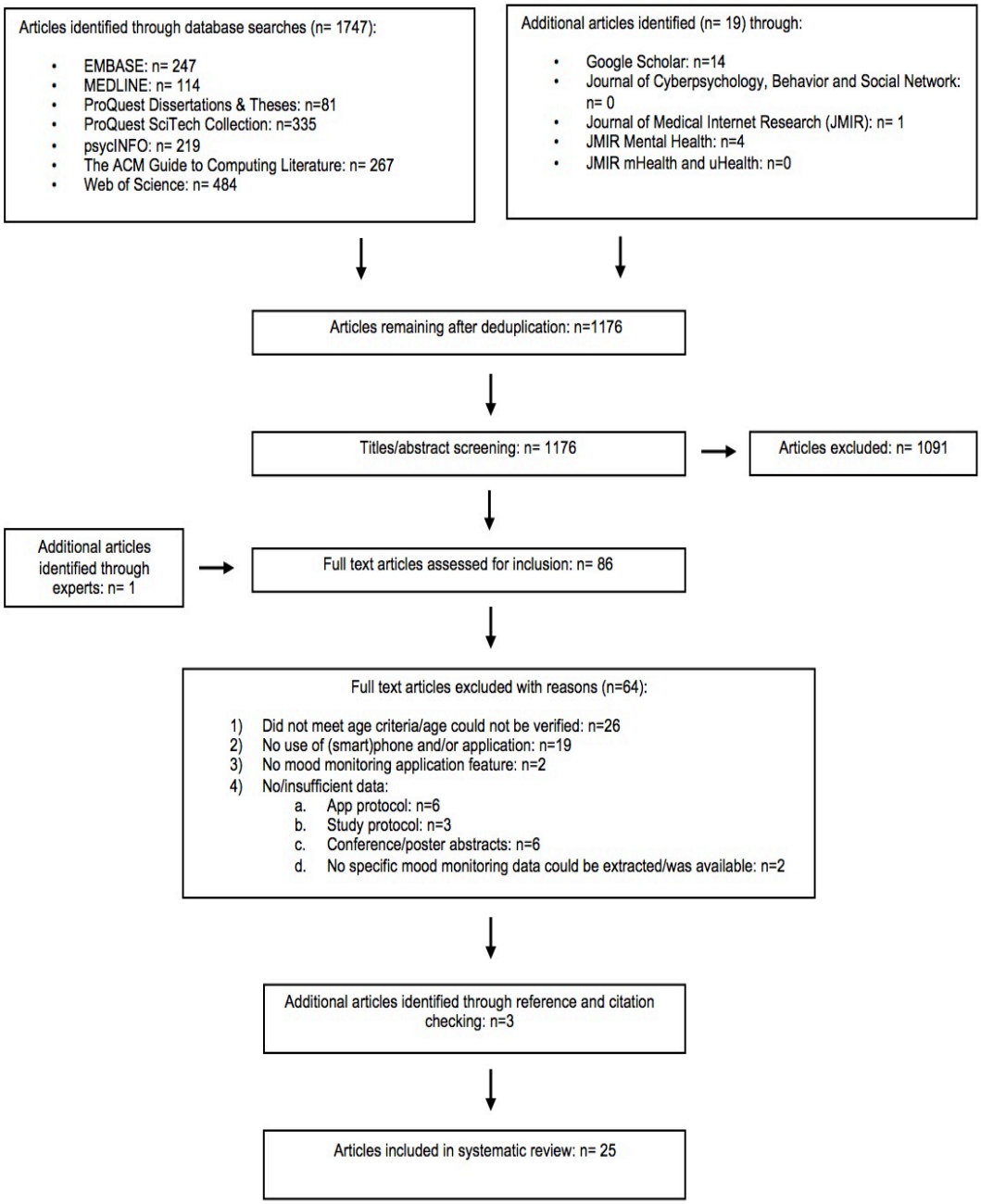

Figure 5: Flowchart of literature search results and selection of studies

4.3.2 Study characteristics

Table 4 outlines study methodology, the characteristics and features assessed in the studies, and main findings. Three studies reported on a randomised controlled trial (RCT): one was the primary RCT (Reid et al., 2011), and two reported secondary analyses with the same dataset (Kauer et al., 2012, Reid et al., 2013). The remaining papers mostly reported feasibility

(Tregarthen et al., 2015) or pilot (Matthews et al., 2008b) studies, and typically employed non-experimental designs (Huh et al., 2014). The search identified 19 published studies and six unpublished studies (four conference proceedings; two theses). The majority of studies (n=16) were quantitative; the remaining nine employed mixed methods.

Sample size in respective studies ranged from 6 to 108,996 participants. Eight studies recruited healthy participants. Eleven studies recruited participants from clinical populations including young people with a range of mental health, emotional, or behavioural problems such as depression (n=8); high-functioning autism/Asperger's disorder (n=2); and substance or alcohol use (n=1). The remaining six studies recruited participants from mixed populations comprising healthy, mentally ill, or substance-using individuals. Mean ages across studies ranged from 10.95 to 23.7 years.

Methods across studies varied greatly. For example, some studies lent participants a phone; whereas others let participants use their own device. See Table 4 for a description of the different data collection methods used in each study. As observed in the adult literature, terminology also varied greatly across studies (please see usability section for more details). Various apps were used, the most frequent of which was the 'Mobiletype' program (Reid et al., 2009). Mood outcomes varied across studies and measured affect (e.g., mood) or affect-related behaviours (e.g., interpersonal hostility). Outcomes were monitored over variable time periods. The shortest period was 24 hours (Bossmann et al., 2013), the longest 326 days (Matthews and Doherty, 2011). Monitoring schedules also varied, and could comprise hourly, daily, or weekly monitoring, or requirements to complete measures a fixed number of times per day (with or without pre-specified time intervals). Reimbursements or incentives were available in eighteen studies (e.g., payments, gift vouchers).

Table 4: Study details including the author (year,) study purpose, sample characteristics, intervention details, and a summary of the main findings

Author (year)	Study purpose	Sample characteristics	Intervention [a]	Main findings
Ansell et al. (2015)	To explore the effects of marijuana use on impulsivity and hostility in everyday life using smartphone-based EMA.	• Sample size: N=43 (M= 23.7 years) • Population type: Young recreational substance users • Comparison/control: None • Location: United States • Data collection: In-person research	• App name: Not specified • Operation system: Not specified • Accessibility: No web/general/app store access • Device: Not specified • Measurements: Daily alcohol, tobacco, and marijuana use; daily impulsivity & daily interpersonal hostility • Monitoring period: 14 days, monitoring schedule varied. Compliance monitored for irregularities by research staff. • Incentive/reimbursement: Payments + bonus payment for 95% survey response rate.	Psychometric properties: • Reliability: Acceptable to excellent internal consistency [b] Usability: • Participation rate: Impulsivity: 96% completed data; interpersonal interactions: >99% completed data Clinical impacts: • Potential implications for problems with (perceived) interpersonal hostility
Bachmann et al. (2015)	To examine the usability and unobtrusiveness of the MoA^2 app.	• Sample size: N= 9 (M= 23.4 years) • Population type: Healthy/non-clinical participants • Comparison/control: None • Location: Germany • Data collection: In-person research	• App name: MoA^2 • Operation system: Android • Accessibility: No web/general/app store access • Device: Participants used study phones (Google Nexus 4) or personal Android smartphone • Measurements: Mood, tiredness, and stress level • Monitoring period: 12 prompts p/day for 4 days • Incentive/reimbursement: No payment	Psychometric properties: Not studied Usability: • Participants' perception: App perceived as user-friendly and convenient Clinical impacts: Not studied/reported

Author (year)	Study purpose	Sample characteristics	Intervention [a]	Main findings
Ben-Zeev et al. (2015)[c]	To examine if smartphone sensor data can be used to measure behaviour and mental health.	• Sample size: N= 47 (M= 22.5 years) • Population type: Students reporting varying levels of depression symptoms • Comparison/control: None • Location: United States • Data collection: In-person research	• App name: StudentLife • Operation system: Android • Accessibility: No web/general/app store access • Device: Participants were offered an Android study smartphone – type not specified • Measurements: Momentary stress and automated sensor data • Monitoring period: 10 weeks (sensor data gathered automatically; stress ratings completed daily, 5 days per week) • Incentive/reimbursement: (Raffle) prizes	Psychometric properties: • Concurrent validity: Significant moderate relationship between averaged app-assessed stress ratings and retrospective post-study questionnaire scores on a measure of perceived stress ($r = .41$, $p < .01$) Usability: • Participation rate: Average weekly response rate was 4.92 days a week (98.4%) Clinical impacts: Not studied/reported
Bossmann et al. (2013)	To clarify the relationship between everyday physical activity and affective states over a one-day period.	• Sample size: N=62 (M= 21.4 years) • Population type: Healthy/non-clinical students • Comparison/control: None • Location: Germany • Data collection: In-person research	• App name: MyExperience movisens Edition version 594 • Operation system: Android • Accessibility: Web/general access only • Device: Participants were provided with an HTC Touch 2 smartphone • Measurements: Valence, calmness, and energetic arousal • Monitoring period: One day – affect measurements every hour after waking up • Incentive/reimbursement: No payment	Psychometric properties: Not studied Usability: • Participation rate: o Mean completion rate was 10.5 electronic diaries per participant o Please note that 15 participants were excluded for missing data Clinical impacts: Not studied/reported

Author (year)	Study purpose	Sample characteristics	Intervention [a]	Main findings
Crooke et al. (2013)	To examine the relationship between varying rates of alcohol use and positive and negative mood through EMA.	• Sample size: N=41 (M=15.4 years) • Population type: Young people with varying levels of alcohol intake • Comparison/control: None • Location: Australia • Data collection: In-person research	• App name: Mobiletype • Operation system: Not specified • Accessibility: No web/general/app store access • Device: Participants were lent a Nokia 6630 • Measurements: Activities, company, location, mood, responses to stressful events and coping, and questions on participants' previous evening's alcohol and cannabis use • Monitoring period: 4x p/day on 20 randomised days over the 31-day study period • Incentive/reimbursement: Partial reimbursement/ gift voucher (Value: $25)	Psychometric properties: Not studied Usability: • Participation rate: 58.3% (AM diaries) and 43.8% (PM diaries) completed mood assessments Clinical impacts: • Potential implications for youth alcohol interventions.
Dennis et al. (2015)	To assess the feasibility of smartphone-based EMA and recovery support ecological momentary interventions (EMI) via smartphones. The study also assessed the feasibility of using EMA and EMI to predict substance use in the following week.	• Sample size: N=29 (M= 16.6 years) • Population type: Adolescents with different clinical problems • Comparison/control: None • Location: United States • Data collection: In-person research	• App name: Addiction Comprehensive Health Enhancement Support System (ACHESS) • Operation system: Android • Accessibility: Web/general access only • Device: Participants provided with a smartphone – type not specified • Measurements: Feelings, activities, location and social context, and drug and alcohol related measurements • Monitoring period: 6x p/day for 6 weeks. Compliance monitored for irregularities by research staff. • Incentive/reimbursement: Payment – Up to $50 per week for adherence to all study requirements	Psychometric properties: Not studied Usability: • Participation rate: 89% of assessments completed • Participants' perception: o App-based EMA perceived as "not too long" (95%), "very easy" or "easy to learn how to do" (100%), and "very easy" or "easy to complete 6 EMAs per day" (94%) o Of note, one participant withdrew early from the study due to frustrations with software problems. Clinical impacts: • Potential implications for relapse prevention

Author (year)	Study purpose	Sample characteristics	Intervention [a]	Main findings
Dunton et al. (2014)[d]	Using EMA to bi-directionally explore how affective and physical feeling states are associated with physical activity.	• Sample size: N=119 (M= 10.95 years) • Population type: Children with varying BMI levels • Comparison/control: None • Location: United States • Data collection: In-person research	• App name: MyExperience • Operation system: Windows • Accessibility: Web/general access only • Device: Participants were lent an HTC Shadow. • Measurements: Main activity type, social context, physical location, mood, and enjoyment • Monitoring period: Monitoring period: 3 to 7 random prompts p/day within pre-specified times over 2 data collection waves (duration: 4 days per wave), separated by 6 months • Incentive/reimbursement: Up to $40 (compensatory) payment	Psychometric properties: • Reliability: Acceptable to good internal consistency [b] Usability: • Participation rate: 76% of assessments completed on average Clinical impacts: Not studied/reported
Dunton et al. (2011)[d]	To assess if the level and experience of children's leisure-time physical activity vary with social and physical contexts by means of EMA.	• Sample size: N=121 (M= 11.02 years) • Population type: Children with varying BMI levels • Comparison/control: None • Location: United States • Data collection: In-person research	• App name: MyExperience • Operation system: Windows • Accessibility: Web/general access only • Device: Participants were lent an HTC Shadow. • Measurements: Main activity type, social context, physical location, mood, and enjoyment • Monitoring period: 3 to 7 random prompts p/day within pre-specified times over 4 days • Incentive/reimbursement: Up to $40 (compensatory) payment	Psychometric properties: • Reliability: Acceptable to good internal consistency [b] Usability: • Participation rate: 80.3% of assessments completed on average Clinical impacts: Not studied/reported

Author (year)	Study purpose	Sample characteristics	Intervention [a]	Main findings
Huh et al. (2014)	To examine the contextual antecedents to smoking in a sample of Korean American young adult smokers through EMA.	• Sample size: N=22 (M=21.23 years) • Population type: Young adult smokers • Comparison/control: None • Location: United States • Data collection: In-person research	• App name: ActiPal (MEI Ltd.) • Operation system: Android • Accessibility: Web/general access only (demo app) • Measurements: Affect, perceived stress, cigarette craving, and other contextual and environmental measures • Device: Android enabled phones (study phones provided if participants owned iPhones) • Monitoring period: Random non-smoking signal contingent (5x p/day for 7 days) + event-contingent prompts over a 7 day period. Compliance closely monitored by research staff. • Incentive/reimbursement: Not reported	Psychometric properties: • Reliability: Questionable to acceptable internal consistency [b] Usability: • Participation rate: 92.4% of assessments completed on average • Participants' perception: It should be noted that one participant withdrew from the study due to technical difficulties with the EMA app Clinical impacts: Not studied/reported
Kauer et al. (2012)[e]	A secondary analysis that investigated the relationships between self-monitoring, emotional self-awareness, and depression through EMA.	• Sample size: N=69 (M= 18.5 years) • Population type: Young people with mild or more severe mental health/emotional problems • Comparison/control: Attention comparison (n=49, M= 17.4 years). • Location: Australia • Data collection: In-person research	See Reid et al. (2011)	Psychometric properties: Not studied Usability: • Participation rate: Completion rates were 52.9% for the intervention group and 59.6% for the comparison group Clinical impacts: Implications for depression symptoms

Author (year)	Study purpose	Sample characteristics	Intervention [a]	Main findings
Kauer et al. (2009)[g]	To assess the feasibility and usefulness of a mobile phone-based EMA app to gather information on alcohol use and related behaviours.	• Sample size: N=18 (mean ages 15.9 years (females) and 15.8 years (males)) in study 1; n=6 (mean ages 18.3 years (females) and 19.5 years (males)) in study 2 • Population type: Healthy/non-clinical students in study 1 and high-risk drinkers in study 2 • Comparison/control: None • Location: Australia • Data collection: In-person research	• App name: Mobiletype • Operation system: Not specified • Accessibility: No web/general/app store access • Device: Participants were lent a Nokia 6630 • Measurements: Activity, mood, stress, alcohol, and cannabis use • Monitoring period: 4x p/day for one week • Incentive/reimbursement: Partial reimbursement/gift voucher (Value: $25)	Psychometric properties: Not studied Usability: • Participation rate: Better compliance for school-based adolescents than older adolescent high-risk drinkers Clinical impacts: Not studied /reported
Kenny et al. (2015)	To assess the feasibility of the CopeSmart app.	• Sample size: N=43 (M=16.0 years) • Population type: Healthy/non-clinical adolescents • Comparison/control: None • Location: Ireland • Data collection: In-person research	• App name: CopeSmart • Operation system: Android + iOS • Accessibility: No web/general/app store access • Device: App was downloaded on participants' Android or iOS phones • Measurements: Happiness, anger, sadness, stress and worries • Monitoring period: One week • Incentive/reimbursement: No monetary incentive	Psychometric properties: Not studied Usability: • Participation rate: Participants engaged with the app on four out of seven days (57.1%) • Participants' perception: The app's interface layout was liked by 79% of participants. Furthermore, the app was perceived as easy to use (93%); minor technical difficulties with logging on were experienced by 7% of participants; 70% of participants would use the app in the future; 74% believed the app would be used by other young people; and 70% would recommend the app to a friend. Clinical impacts: • Implications for self-awareness

Khor et al. (2014a)[f]	To assess the utility of the Mobiletype program to examine adolescents with High-Functioning Autism/Asperger's Disorder's (HFASD) stressors and coping.	• Sample size: N=31 (M=14.46 years) + parents • Population type: Adolescents with HFASD • Comparison/control: None • Location: Australia • Data collection: In-person research	• App name: Mobiletype (adapted) • Operation system: Not specified • Accessibility: No web/general/app store access • Device: Participants were lent a Sony Ericson 7501i • Measurements: Mood, stress, last time and daily stress • Monitoring period: 4x p/day for 2 weeks • Incentive/reimbursement: Partial reimbursement (Value: $20)	Psychometric properties: • Concurrent validity: o Mostly poor to moderate correlations between data from the retrospective Responses to Stress Questionnaire (Connor-Smith et al., 2000) and mobile app data recording participants' responses to stress. o A significant moderate to strong correlation for the "involuntary engagement" factor: r =.70, p <.01; parent-report: r =.48, p <.01. o A significant strong correlation for the "primary control engagement coping" factor: r =.53, p <.05. • Face validity: o The face validity was measured by assessing how well the app captured participants' current situation, thoughts and feelings. o The highest ratings were reported for the app's ability to capture participants' feelings (67%); followed by its ability to capture participants' current situation (63%); and finally its ability to measure participants' thoughts (50%). Usability: • Participation rate: Participants responded to 61.8% of prompts. o Note that a substantial proportion of participants gradually stopped responding throughout the study; while every participant completed at least one entry on the first day, completion rates reduced to 45% on day 14.

Author (year)	Study purpose	Sample characteristics	Intervention [a]	Main findings
				○ Also note that there was a significant positive correlation between full scale IQ and compliance rates (r =.46, p <.01). Clinical impacts: Not studied/reported
Khor et al. (2014b) [f]	To investigate how daily hassles, coping, and behaviour and emotional problems are related in adolescents with HFASD.	See Khor et al. (2014a)	See Khor et al. (2014a)	Psychometric properties: Not studied Usability: Not studied/reported Clinical impacts: • Implications for emotional and behavioural problems
Loventoft et al. (2012)	To find out whether people treated for depression would be interested in using a smartphone app for support in their daily lives.	• Sample size: N= 6 (ages 17-24, no means reported) • Population type: Young people with recent depression treatment • Comparison/control: None • Location: Denmark • Data collection: In-person research	• App name: Daybuilder • Operation system: Android • Accessibility: No web/general/app store access • Device: Participants provided with Android device with App installed • Measurements: Weekly Major Depression Inventory; daily mood, appetite and sleep • Monitoring period: Four weeks • Incentive/reimbursement: Payment of 500 DKK ($95 or two hours salary)	Psychometric properties: Not studied Usability: • Participation rate: Different compliance rates across app features – no obvious pattern. Mean normalised compliance for daily registrations of approximately 30%; mean normalised compliance for weekly registrations of approximately 50% • Participants' perception: User experience negatively affected by technological difficulties; clinicians highlighted the usefulness of self-monitoring when combined with therapy. Clinical impacts: • Implications for treatment

Author (year)	Study purpose	Sample characteristics	Intervention [a]	Main findings
Matthews & Doherty (2011)	To assess the issues around the use of mobile phones for mood charting with the aim to improve adolescent engagement.	• Sample size: N=9 (M= 13.78 years) • Population type: Young people with depression, mood disorders, self-harm and anger management • Comparison/control: None • Location: Ireland • Data collection: In-person research	• App name: Mobile Mood Diary (MMD) • Operation system: Not specified • Accessibility: No web/general/app store access • Device: App downloaded on clients' phones • Measurements: Energy, sleep, and mood + free area for thought entries • Monitoring period: min. 1x p/day for 2 sessions • Incentive/reimbursement: Reimbursement where necessary	Psychometric properties: Not studied Usability: • Participation rate: 65% response on average Clinical impacts: • Implications for treatment
Matthews et al. (2008b)	To explore the effectiveness of mobile phone versus pen-and-paper for mood tracking.	• Sample size: N=73 (M= 14.87 years) • Population type: Healthy/non-clinical students • Comparison/control: Paper-based diary condition (n=52) • Location: Ireland • Data collection: In-person research	• App name: MMD • Operation system: Not specified • Accessibility: No web/general/app store access • Device: App downloaded on students' phones • Measurements: Energy, sleep, and mood + free area for thought entries • Monitoring period: 1x p/day for 2 weeks • Incentive/reimbursement: None	Psychometric properties: Not studied Usability: • Participation rate: Mobile group significantly more responsive than paper-diary group ($t = -2.324$, $p < .05$) • Participants' perception: Participants preferred mobile technology. Clinical impacts: Not studied/reported

Author (year)	Study purpose	Sample characteristics	Intervention [a]	Main findings
Reid et al. (2009)[g]	A study aimed at developing, piloting and reviewing a youth focused mobile phone program to track young people's experiences in real time.	• Sample size: Focus group (n=11, mean age not reported) and pilot study (males (n=5, M=15.8years) and females (n=13, M= 15.9 years) • Population type: Students • Comparison/control: None • Location: Australia • Data collection: In-person research	See Kauer et al. (2009)	Psychometric properties: Not studied Usability: • Participation rate: o Participants' completed 76% of diaries. o However, response rates decreased from 91% on day 1 to 67% on day 7. o Of note, one-third of the sample stated that they did not always respond honestly to items if a specific response would result in further questioning. • Participants' perception: The study's initial response rate suggested mobile technology may not be preferred or adopted by all young people. Nevertheless, the app was overall viewed as youth-friendly and non-invasive. Clinical impacts: Not studied/reported
Reid et al. (2011)[e]	A randomised controlled trial (RCT) to investigate some of the mental health benefits of the mobiletype program.	• Sample size: N=68 (M=18.5 years) • Population type: Mild/more mental health or emotional problems • Comparison/control: Comparison program (n=46, M= 17.4 years) • Location: Australia • Data collection: In-person research	• App name: Mobiletype • Operation system: Not specified • Accessibility: No web/general/app store access • Device: Participants were lent a Sony Ericsson Z750i mobile phone • Measurements: Current activities, company, location, mood, recent stressful events, responses to stressful events, alcohol consumption, cannabis use, and sleep, exercise and diet related questions • Monitoring period: Min. 2x/day for 2-4 weeks. • Incentive/reimbursement: Partial reimbursement (A$30) and gift cards (A$20) for post-questionnaires completion (maximum A$60)	Psychometric properties: Not studied Usability: • Participation rate: response rates for the intervention group: 52.9%; comparison group: 60.9% Clinical impacts: • No significant effects on mental health outcomes; potential implications for self-awareness

Author (year)	Study purpose	Sample characteristics	Intervention [a]	Main findings
Reid et al. (2013)[e]	To assess the utility of Mobiletype in a primary care setting (secondary analysis)	See Reid et al. (2011)	See Reid et al. (2011)	Psychometric properties: Not studied Usability: Not studied/reported Clinical impacts: • Potential implications for treatment and clinicians' understanding of patients.
Reid et al. (2012)	To review Mobiletype in clinical settings.	• Sample size: n=47 (M=15.59 years) • Mental health/clinical status: Adolescents with varied (medical) disorders. • Comparison/control: None • Location: Australia • Data collection: In-person research	• App name: Mobiletype • Operation system: Not specified • Accessibility: No web/general/app store access • Device: Participants were lent a ZTE F851 JAVA MIDP 2.0 phone with $50 credit • Measurements: Location, activity, company, mood, stressful events, responses to stressful events, alcohol and cannabis use, sleep, exercise and diet-related questions • Monitoring period: 4 random prompts p/day for 2-4 weeks (min. completion: 1x p/day) • Incentive/reimbursement: None	Psychometric properties: • Face validity: o The face validity was measured by assessing how well the app captured participants' current situation, thoughts and feelings. o The highest ratings were reported for the app's ability to capture participants' feelings (86%); followed by its ability to capture participants' current situation (83%); and finally its ability to measure participants' thoughts (57%). Usability: • Participation rate: Participants completed 91% of entries in week 1 Clinical impacts: • Potential implications for assessment and management

Author (year)	Study purpose	Sample characteristics	Intervention [a]	Main findings
Sacco (2015)	To examine the feasibility and utility of a smartphone app developed to assess five areas of functioning associated with depression.	• Sample size: N=114 (M= 19.36 years) • Population type: Students with varying levels of depression symptoms. • Comparison/control: None • Location: United States • Data collection: In-person research	• App name: Android Health and Wellness UDTracker App • Operation system: Android • Accessibility: No web/general/app store access • Device: App installed on participants' own Android enabled phones • Measurements: Depression, mood, social functioning, cognitive and lifestyle factors, coping/emotion regulation (daily or weekly) • Monitoring period: 14 days. Assessment times varied across measures: 1x p/evening (e.g., Positive and Negative Affect Scale (Watson et al. 1988), 1x p/morning (sleep questionnaire, adapted from Pittsburgh Sleep Quality Index (Buysse et al. 1989)), and 1 x p/week (e.g., items from the COPE scale (Carver et al. 1989)) • Incentive/reimbursement: Extra/research participation course credit	Psychometric properties: Not studied Usability: • Participation rate: 85-93% response rate across different measures • Participants' perception: o App perceived as "easy to use" (95.6%); "a little" to "not at all" irritating (90.3%). o The monotony of responding to the same survey questions (15%); the high frequency of the pop-up notifications (9%), and the drain on the phone's battery life (8%) were perceived as irritating. Participants suggested more varied survey questions (23%), fewer crashes, bugs or freezes (9%) and provided suggestions for novel technical features (13%). o Some participants also enjoyed the user-friendliness of the app (40%) and the pop-up-reminder feature (17%). Clinical impacts: • Potential implications for self-reflection on emotions or behaviours

Author (year)	Study purpose	Sample characteristics	Intervention [a]	Main findings
Scotti (2015)	To assess the efficacy, acceptability and feasibility of the school-based DBT skills group for the treatment of adolescent eating disorders and sub-diagnostic problematic eating behaviours.	• Sample size: High school students (N=4, M=16.75 years) and middle school students (N=3, M= 13.67 years) • Population type: Students with ED symptoms or body image concerns. • Comparison/control: Two high school students who had withdrawn (M= 16.5 years) • Location: United States • Data collection: In-person research	• App name: Not specified • Operation system: Not specified • Accessibility: Unknown web/general access, no app store access • Device: Participants own smartphones –type not specified • Measurements: Individual eating disorder related behaviours and cognitions/feelings • Study/monitoring period: 12 weeks • Incentive/reimbursement: Academic credit and/or prize draw	Psychometric properties: Not studied Usability: • Participants' perception: preference for paper-and-pencil tracking by some participants Clinical impacts: Not studied/reported
Tregarthen et al. (2015)	To describe a smartphone app for the self-monitoring of eating disorder symptoms, evaluate characteristics of app users, and assess the feasibility and utilization of the app for self-monitoring purposes.	• Sample size: N=108,996 (M= 22 years (reported by 48,830 users)) • Population type: People with varying levels of ED severity • Comparison/control: None • Study Location: United States • Data collection: Crowd-sourcing	• App name: Recovery Record • Operation system: Android + iOs • Accessibility: General/web and app store access • Device: Own (iOS or Android) smartphone – type not specified • Measurements: Meals and eating disorder related behaviours/cognitions/feelings/urges • Monitoring period: Overall usage data not available – 6 monitoring prompts p/day • Incentive: None	Psychometric properties: Not studied Usability: • Participation rate: 89% of participants monitored ≥3 meals; 67% continued to monitor at 30 days • Participants' response: app received high user ratings Clinical impacts: Not studied/reported

Author (year)	Study purpose	Sample characteristics	Intervention [a]	Main findings
Wang et al. (2014) [c]	To measure university students' mental health, academic performance and behavioural trends using the StudentLife app.	• Sample size: N=48 (M= 22.8 years) • Population type: University students with varying depression scores. • Comparison/control: None • Location: United States • Data collection: In-person research	• App name: StudentLife • Operation system: Android • Accessibility: No web/general/app store access • Device: Participants either used their own Android phones (primary users) or were offered an Android Nexus 4a (secondary users) • Measurements: Momentary mood, sleep, social, physical exercise, activity, and behavior; automated sensor data. • Monitoring period: 10 weeks • Incentive: (Raffle) prizes	Psychometric properties: • Concurrent validity: Significant moderate relationship between averaged app-assessed stress ratings and retrospective post-study questionnaire scores on a measure of perceived stress ($r = .41$, $p < .01$) Usability: • Participation rate: Response rates for participants who used own phones: 65%; response rates for participants who used study phones: 72% Clinical impacts: Not studied/reported

[a] The accessibility of mood monitoring apps was assessed through a search of Google and three app stores (iTunes, Google Play and Microsoft store) in June 2016.

[b] Please refer to table 6 for coefficient values.

[c] These studies (Ben-Zeev et al. (2015) and Wang et al. (2014)) report findings from the same study and used the same sample (confirmed by Rui Wang via email).

[d] These studies (Dunton et al. (2011) and Dunton et al. (2014)) used the same sample (confirmed by Genevieve Dunton via email).

[e] These studies (Kauer et al. (2012), Reid et al. (2011), and Reid et al. (2013)) used data from the same RCT (confirmed in the individual papers).

[f] These studies (Khor et al. (2014a) and Khor et al. (2014b)) used the same sample (confirmed by Angela Khor via email).

[g] These studies (Kauer et al. (2009) and Reid et al. (2009)) partly utilised the same data (confirmed in Kauer et al.'s (2009) paper).

4.3.3 Quality assessment

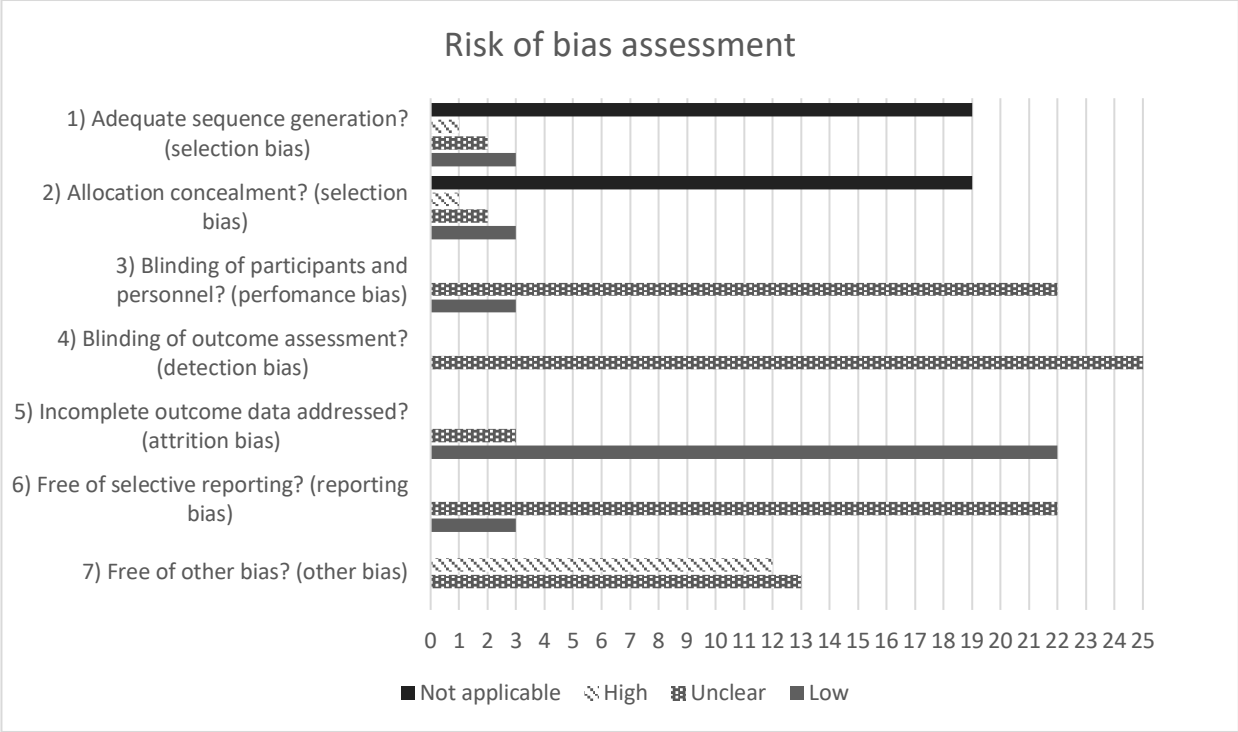

Figure 6: Risk of bias across

Notes: **1) Adequate sequence generation:** this domain describes what method was used to generate the allocation sequence (e.g., random allocation to interventions). This helps assess whether the method should produce comparable groups. **2) Allocation concealment:** this domain describes what method was used to conceal the allocation sequence (e.g., inadequate concealment). This helps assess whether the allocation to interventions could potentially have been foreseen before or during the enrolment. **3) Blinding of participants and personnel:** this domain describes what measures were used, if any, to blind participants and personnel from knowing which intervention the participant received. This domain also describes whether these measures were effective**. 4) Blinding of outcome assessment:** this domain describes what measures were used, if any, to blind outcome assessors from knowing which intervention the participant received. This domain also describes whether these measures were effective. **5) Incomplete outcome data:** this domain describes whether the completeness of outcome data for each main outcome was addressed, including attrition and exclusions from the analysis. **6) Selective reporting:** this domain addresses how the authors examined the possibility of selective outcome reporting and what the authors found. **7) Other bias:** this domain describes any other important sources of bias.

See Figure 6 for an overall depiction of the risk of bias domains across studies. Risk of selection bias was difficult to assess in many studies, as they often lacked treatment, control, or comparison groups. Across the review:

- Three studies (all using the same RCT data) were deemed at low risk of selection bias due to a clear description of the randomisation and concealment allocation process (Kauer et al., 2012, Reid et al., 2011, Reid et al., 2013). Two studies were at unclear risk of selection bias because randomised sequence generation and method of allocation concealment were not sufficiently described (Matthews et al., 2008b, Reid et

al., 2009). One study was considered at high risk of selection bias (Scotti, 2015) as there was no random allocation process for the control condition.

- Only the RCT study (3 publications) addressed the blinding of participants and personnel, and was thus considered at low risk of performance bias (Kauer et al., 2012, Reid et al., 2011, Reid et al., 2013). The risk of detection bias in these studies was unclear due to a lack of clarity on blinding of outcome assessments.
- Three studies were at unclear risk of attrition bias. In one study (Kenny et al., 2015), a number of participants were not included in the final sample due to restrictions on school access (no other information was available). Bossmann et al. (2013) excluded 15 participants from the final sample due to "missing data," but did not provide further information, including whether any analyses were performed to address missing data. Reid et al. (2012) was considered at unclear risk of attrition bias, as there was no information on the participants (21%) lost to follow-up. The remaining studies appeared to be at low risk of attrition bias.
- There was insufficient information to assess the risk of reporting bias in all studies but those of the RCT, which addressed pre-specified outcomes and appeared to be at low risk (Kauer et al., 2012, Reid et al., 2011, Reid et al., 2013).
- All studies appeared to be at unclear or high risk of other types of bias.

4.3.4 Psychometric properties of mood-monitoring apps

Nine studies reported on the reliability or validity of mood-monitoring apps.

Reliability

The internal consistency (correlation between items within a scale) was assessed in four studies (Ansell et al., 2015, Huh et al., 2014, Dunton et al., 2014, Dunton et al., 2011). As demonstrated in Table 5, levels ranged from questionable to excellent (George and Mallery, 2003).

Table 5: Internal consistency coefficients across studies and domains

	Alpha coefficients[1]									Omega coefficients[1]		
	Positive affect			*Negative affect*			*Perceived stress*			*Impulsivity*		
Authors	O	WS	BS	O	WS	BS	O	WS	BS	O	WS	BS
Ansell et al. (2015)	-	-	-	-	-	-	-	-	-	-	.78	.96
Dunton et al. (2011)	.88	-	-	.75	-	-	-	-	-	-	-	-
Dunton et al. (2014)	.87	-	-	.74	-	-	-	-	-	-	-	-
Huh et al. (2014)	.65	-	-	.78	-	-	.73	-	-	-	-	-

Note: 1) The Alpha and Omega coefficients are two measures of reliability (Deng and Chan, 2016). Although similar, it is suggested that the Alpha coefficient may underestimate reliability when unidimensional scale items have unequal covariance with the true score. The Omega coefficient is an alternative measure of reliability that can overcome these limitations (see Deng and Chan (2016) for a full discussion). O=Overall, WS= Within-subject level, BS= Between-subject level. Internal consistency coefficients values interpretation: " > .9 – Excellent, > .8 – Good, > .7 – Acceptable, > .6 – Questionable, > .5 – Poor, and < .5 – Unacceptable" (George & Mallery, 2003, pp.231)

Validity

Concurrent validity

Three studies examined concurrent validity (the correlation between an assessment and a previously validated assessment of the same construct). Concurrent validity was mostly moderate[1] across studies (see Table 4). Khor et al. (2014a) compared relationships between

[1] The strength of a correlation can be determined using Cohen's (1992) guidelines: *r* =.10 - .29 (weak); *r* =.30 - .49 (moderate), and *r* = .50 – 1.0 (strong)

participant and parent-reported data from the retrospective Responses to Stress Questionnaire (Connor-Smith et al., 2000) and mobile app data recording participants' responses to stress. Associations were stronger for self-reported compared to parent-reported retrospective data. In two studies of university students, Ben-Zeev et al. (2015) and Wang et al. (2014) compared momentary app and retrospective questionnaire data on perceived stress.

Face validity

Two studies described participants' views on the face validity of the 'Mobiletype' app (see Table 4 for numerical details). In both studies, participants were asked to rate how well the app captured their current situation, thoughts and feelings. Response options included 'poor to average' and 'good to excellent'. Reid et al. (2012), using a sample with various mental health problems, found that the app was relatively successful in capturing participants' feelings and current situation. Khor et al. (2014a), using a sample with high-functioning autism and Asperger's, found that the app was not quite as successful in these domains. In both studies, the apps were less successful in capturing participants' thoughts.

4.3.5 Usability of mood-monitoring apps

The 'usability' of mood-monitoring apps was defined in accordance with the International Organisation for Standardisation (2001) definition of usability, i.e., "the capability of the software product to be understood, learned, used and attractive to the user, when used under specified conditions". Consistent with previous systematic reviews (Donker et al., 2013), young people's participation rates (i.e., compliance, response, and completion) and how apps were perceived by young people (including their acceptability - how satisfied they were with the app, whether it could be used with ease) were included as markers of usability.

Participation rates

Twenty-one studies examined participation rates, which ranged from 30% to 99%. Average percentages were not computed in four studies. Instead, these studies described the mean number of mood entries per participant (Bossmann et al., 2013), between-group compliance (Kauer et al., 2009, Matthews et al., 2008b), or evidence of on-going compliance (Tregarthen et al., 2015) as described in Table 4. There was some indication that response rates were higher in studies with incentives. For example, Dennis et al. (2015) offered an incentive of $50 per week, and had a participation rate of 89% (see Table 4 for comparative rates and incentive details). Participation rates also appeared to be affected by response fatigue. In Reid et al. (2009), for instance, response rates decreased from 91% on day 1 to 67% on day 7. Finally, participation rates were potentially affected by sample-specific characteristics. In a study with high-functioning autistic participants, Khor et al. (2014a) found a significant positive correlation between full scale IQ and compliance rates ($r = .46$, $p < .01$).

Participants' perceptions

Nine studies considered participants' perceptions of the apps. Three of these studies specifically referred to the "acceptability" of apps. In Dennis et al. (2015), 95% of adolescents felt that the EMA app "was not too long." Tregarthen et al. (2015) measured app utilisation data as a proxy for acceptability. There were over 100, 000 users over a two-year period (with 89% using the application at least three times), which the authors interpreted as a demonstration of broad acceptability. While they did not define acceptability specifically, Reid et al. (2009) concluded that their app was "acceptable" based on the data they captured (e.g., completion rates, participants' feedback).

Across studies, 93% to 100% of respondents found apps easy to learn or use (Dennis et al., 2015, Kenny et al., 2015, Sacco, 2015). In addition, participants rated apps as useful (Kenny et al., 2015), convenient, user-friendly (Bachmann et al., 2015), youth-friendly, and non-invasive (Reid et al., 2009). Despite these positive experiences, technological difficulties (e.g., software crashes, reduced battery life) were reported to negatively affect user experience and participation (Loventoft et al., 2012, Huh et al., 2014, Dennis et al., 2015, Sacco, 2015). Although most young people reported a preference for mobile-phone mood charting in comparison to paper diaries (Matthews et al., 2008b), not all young people preferred mobile technology (Scotti, 2015, Reid et al., 2009). Scotti (2015), for example, found that several participants from a sub-clinical eating disorder sample favoured paper-and-pencil to track their data.

4.3.6 Positive and negative clinical impacts of mood-monitoring apps

Mental health and awareness

Five (two were from the same RCT) studies examined potential clinical impacts of the apps. Reid et al. (2011) found a significant improvement in emotional self-awareness, but no significant improvements in depression, anxiety or stress scores in youth with mental health or emotional problems. In a secondary analysis of the same RCT, Kauer et al. (2012) reported an indirect association between app use and depression symptoms via increased emotional self-awareness. The app, however, did not significantly reduce rumination. Qualitative feedback from two studies also suggested that mood-monitoring apps can help improve self-awareness (Kenny et al., 2015), and self-reflection on emotions or behaviours (Sacco, 2015). Though they did not test this premise directly, Ansell et al. (2015) hypothesised that app-based monitoring could have promoted self-awareness in participants subsequently reducing (perceived) interpersonal hostility. Finally, in Khor et al (2014b), parents rated their children with high-

functioning autism as showing fewer symptoms of behaviour and emotional problems following use of the self-monitoring app.

Treatment implications

Five studies reported results that could have implications for the prevention and treatment of mental health problems. Mobile app data gathered by Dennis et al. (2015) was used to identify high-risk groups for substance use, which could potentially help with relapse prevention. Crooke et al. (2013) suggested that mood-monitoring apps could help investigate adolescents' motivations for drinking, thus informing the development of interventions. Qualitative feedback from therapists suggests that the use of mobile apps could help facilitate engagement with participants suffering from various mental health problems (Matthews and Doherty, 2011). Reid et al. (2012) reported that the 'Mobiletype' app facilitated the assessment and management of youth mental health problems and reduced consultation time with paediatricians; the data captured enabled more individually-focused consultations, which assisted in rapport building and communication. In the third of a series of papers detailing their RCT, Reid et al. (2013) explored the potential treatment benefits of 'Mobiletype'. In comparison to the control programme, the app significantly increased GPs' understanding of their patients' health and current functioning, and aided diagnoses, communication, medication, and referrals. However, there was no significant effect on doctor's confidence, doctor-patient rapport, or pathways to care. Finally, in a conference paper by Loventoft et al. (2012), clinicians highlighted the usefulness of self-monitoring when combined with therapy.

4.4 Discussion

The aim of this review was to summarise and evaluate evidence for the use of mobile mood-monitoring apps in young people (aged 10 to 24 years) from clinical and non-clinical

populations. The review specifically focused on psychometric properties, usability, and clinical impacts.

4.4.1 Psychometric properties of mood-monitoring apps

Few studies assessed psychometric properties. There was limited evidence for reliability, with 4 studies demonstrating questionable to excellent levels of internal consistency. Studies examining concurrent (n=3) and face (n=2) validity were also sparse, making it difficult to draw firm conclusions. Face validity findings, for example, could have been moderated by sample characteristics, e.g., reduced insight in participants with autism (Khor et al., 2014a). The limited assessment of psychometric properties observed in the youth literature mirrors the adult literature. Evidence for concurrent validity in adult populations is inconclusive (Depp et al., 2012, Palmier-Claus et al., 2012, Faurholt-Jepsen et al., 2014). Inconsistent methodology across studies, e.g., momentary (e.g., Depp et al., 2012) versus retrospective assessments (e.g., Faurholt-Jepsen et al., 2014), varying periods between the event and participants' recollection of the event (e.g., Palmier-Claus et al., 2012), likely contribute to variable findings.

Previous evidence suggests that real-time mood measurement methods (e.g., EMA) only have a modest correlation with retrospective assessments, such as questionnaires (Ebner-Priemer and Trull, 2009). This leads to the conceptual question of whether retrospective measures are the most appropriate comparators when assessing the validity of mood monitoring apps. Questionnaires measure an individual's retrospective view of their mood state over a number of days. While they are subject to recall bias, this bias incorporates other emotional processing (e.g., contexts) that the more instantaneous assessment of mood (e.g., EMA) may not capture, or at least as richly. Thus, the two assessment methods may be measuring different types of affective experience. As it is difficult to draw robust conclusions about the validity of apps using retrospective assessments, future studies should further examine psychometric properties

using other sources of comparative data, e.g., active smartphone app data (i.e., app assessments) with passive sensor smartphone data (e.g., Nicholas et al., 2015, Sandstrom et al., 2016b), and associations with clinical rating scales (Faurholt-Jepsen et al., 2016).

4.4.2 Usability of mood-monitoring apps

The usability of mood-monitoring apps was more extensively studied, and overall studies suggest that apps are usable for young people. However, there were some within-and between-study differences in participants' perceptions of apps, and participation rates. Generally, participation rates were lower in studies where participants had mental health difficulties (Reid et al., 2011, Kauer et al., 2012), problematic drinking patterns (Kauer et al., 2009), or autism spectrum disorders - especially those with lower IQ ((Khor et al., 2014a). In particular, participation levels were low for those living without set routines (Kauer et al., 2009). This is an important consideration, as youths with mood-related problems, e.g., borderline personality disorder, often have disorganised daily routines (Fleischer et al., 2012). This suggests a need to tailor apps for different clinical populations (Kauer et al., 2009).

Some studies indicated that incentives could positively influence participation rates (e.g., Dennis et al., 2015, Ansell et al., 2015). It may not be financially feasible to offer incentives in non-research settings. However, results tentatively suggest that participation rates may be better for mobile apps than traditional paper-based assessments irrespective of incentives (Matthews et al., 2008b). Participation rates for paper-based diaries are as low as 11% (Stone et al., 2003) compared to 52-99% for mood monitoring apps in the current review. This supports that apps could lead to better adherence rates than non-digital assessment tools in young populations. Factors that could improve participation rates include the use of less intensive

assessments (e.g., once-daily rather than multiple times), shorter assessments, and the incorporation of staff monitoring or automatic reminders (e.g., Huh et al., 2014).

Studies from the adult literature are somewhat congruent in supporting the usability of mood-monitoring apps (e.g., Bardram et al., 2013), though evidence suggests that increasing age (e.g., "middle age") may lower likelihood of mood monitoring app use (Depp et al., 2012). Both adult (Palmier-Claus et al., 2013) and adolescent (Bradford and Rickwood, 2014) populations expressed some reservations about using apps due to the perceived risk of reduced personal contact (Palmier-Claus et al., 2013).

Overall the review demonstrated that young people positively perceive apps (Reid et al., 2009) and would be willing to use this technology in real-life settings (e.g., Kenny et al., 2015, Tregarthen et al., 2015). Very few studies considered clinician perspectives on mood-monitoring apps. Matthews and Doherty (2011) found that therapists' confidence with technology was the biggest barrier to the use of mood apps. More qualitative studies are now needed to further explore young peoples' (and clinicians') perceptions (Hollis et al., 2017) to increase understanding of factors pertinent to the uptake of mood monitoring apps in real life settings.

4.4.3 Positive and negative clinical impacts of mood-monitoring apps

Few of the included studies assessed the clinical impacts of the mood-monitoring apps. Although evidence was generally positive (e.g., facilitating assessment, management, and GPs' understanding), most studies relied on subjective participant feedback (e.g., Sacco, 2015) rather than RCT methodology with objective outcome measures. Of note, Reid et al. (2009) found that participants did not always respond to questions truthfully to avoid having to answer further questions. Thus, this type of assessment could potentially lead to the inaccurate assessment (and treatment) of mental health problems.

The preliminary evidence very tentatively suggests that electronic mood-monitoring apps could function as an intervention tool (Faurholt-Jepsen et al., 2016, Seko et al., 2014, Olff, 2015). Specifically, results from the one RCT indicated that mood-monitoring apps might reduce depression in youths by increasing their levels of emotional awareness (Kauer et al., 2012). Similarly, though in a non-experimental study, Khor et al. (2014b) reported that self-monitoring improved parent-reported behavioural and emotional problems in participants with autism. While these results are promising, they require replication and future studies may further explore the mechanisms via which apps could potentially impact on clinical outcomes. One possibility is that mood apps could have a positive impact on clinical symptoms due to patient/participant expectations regarding their benefits. This phenomenon, coined the digital placebo effect, is an overlooked area which also merits future investigation (Torous and Firth, 2016).

It was not possible to fully examine the potential negative impacts of mood-monitoring apps in young populations, as they were not directly investigated in studies. A small number of adult studies have reported on the negative effects of mood-monitoring apps. There is some suggestion that apps may increase negative reactivity (Ainsworth et al., 2013), increase focus on negative symptoms and thoughts (Palmier-Claus et al., 2013), and potentially maintain depressive symptoms (Faurholt-Jepsen et al., 2015). Given the evidence from the adult literature, research on the possible harmful effects of app use in youths is needed before these tools are routinely used in clinical practice. Part of this endeavour should seek to identify the optimal balance between a monitoring schedule which accurately captures affective dynamic processes, while minimising respondent workload (Bolger et al., 2003, Trull et al., 2015). This is important because too high a workload could affect participation rates. Further, the

responsibility of self-monitoring (if onerous) could impose too much burden on young people (Shiffman et al., 2008), might result in unnecessary pressure (Seko et al., 2014, Lupton, 2013), and exacerbate mental health problems (Conner and Reid, 2012, Faurholt-Jepsen et al., 2015).

Future work may investigate potential risk issues surrounding the use of mood-monitoring apps. For example, their use could lead to an over-reliance on technology in young populations, which could exacerbate mental health problems (Thomée et al., 2011). There could also be information-security related risks (e.g., digital theft) that could compromise confidentiality (Prentice and Dobson, 2014). Finally, youths could use apps as a replacement for treatment and health monitoring (Tregarthen et al., 2015). Considering the importance of the therapeutic alliance for successful treatment outcomes (Karver et al., 2006), the efficacy of smartphone apps could be reduced if they are used without clinicians' involvement (Prentice and Dobson, 2014).

4.4.4 Strengths and limitations

This appears to be the first review to systematically examine and quality-assess the evidence for the psychometric properties, usability, and clinical outcomes of mood-monitoring apps in youth. However, the results should be considered through the lens of a number of limitations.

First, despite undertaking a comprehensive search, there were very few high-quality studies available for inclusion in the review. There was only one primary RCT highlighting the need for more trials on the efficacy of mood-monitoring apps in young people. Indeed, the quality assessment indicated that the majority of studies included some form of bias. For example, many studies were at high or unclear risk of sampling (e.g., self-selected samples) and attrition bias. This could have affected the generalisability of the findings or led to an over estimation of

positive effects, e.g., the findings may only apply to individuals with less severe psychopathology who are more likely to engage with services.

Furthermore, studies demonstrated a great variability in terminology (especially for implementation outcomes, e.g., acceptability) making interpretations and cross-study comparisons difficult (inconsistent terminology is also a common feature of the adult app literature). For example, we found that "acceptability" was defined very differently across studies, ranging from proxy markers, i.e., utilisation data (Tregarthen et al., 2015) to participants' experience of burden (Dennis et al., 2015). This highlights the need for more careful delineation and measurement of implementation outcomes in future work (Proctor et al., 2011).

There were also large variations in samples and methodologies, again making cross-study comparisons difficult and quantitative synthesis (i.e., meta-analysis) impossible. Thus, some of the conclusions remain tentative pending further rigorous, higher quality research (e.g., RCTs).

It should finally be noted that studies in this review often used apps that were specifically developed for the study, and therefore not publicly available through app platforms (e.g., iTunes). Thus, there is a need for more research to assess the evidence for apps that are freely downloaded and used by youth, and whether their use can be incorporated into clinical care (Nicholas et al., 2015).

4.4.5 Clinical and research implications

Mood-monitoring apps could potentially have positive effects in both clinical and sub-clinical young populations. Indeed, mood-monitoring apps may help young people identify and address burgeoning mental health and substance use problems (Dennis et al., 2015), and possibly utilise more adaptive coping strategies (Kauer et al., 2012). Further research is needed to examine the effects of these apps in samples with serious mental disorders, such as bipolar

disorder (Grunerbl et al., 2015), borderline personality disorder (Lederer et al., 2014), and psychosis (Ben-Zeev et al., 2014, Palmier-Claus et al., 2014).

Evidence, though limited, suggests that mood-monitoring apps could potentially aid diagnosis and treatment decision-making (Reid et al., 2013). Future studies should explore whether this technology could aid in the assessment of disorders that can be difficult to differentiate, such as borderline personality disorder and bipolar disorder (Yen et al., 2015), by providing rich data about the timing and extent of mood fluctuations. As technological innovations have been endorsed at a government level, integrating mood-monitoring apps within mental health services may improve access and relieve some of the strain these services are currently experiencing (e.g., by improving access to mental health treatment (Department of Health, 2013)). However, to date, the potential positive and negative impacts of apps have not been sufficiently investigated in youth.

Chapter summary

This aim of this chapter was to systematically review the psychometric properties, usability, and positive and negative impacts of mood-monitoring apps in studies focusing on youth. The review identified 25 articles which were synthesised narratively, quality assessed, and compared with evidence from adult studies. Evidence for the psychometric properties of apps was limited, but indicated moderate concurrent validity and questionable-to-excellent internal consistency. Participation rates were variable (30-99%) and were affected by methodological (e.g., payments) and individual factors (e.g., IQ score). Findings also suggested mobile mood-monitoring apps are positively perceived by youth, may reduce depressive symptoms by increasing emotional awareness, and could aid in the detection of mental health and substance use problems. There was very limited evidence on potential negative impacts. Finally, there

was a discussion on the strengths and limitations of this work package and recommendations for future research were made.

Chapter 5: Identification of the optimal mood-monitoring app

Chapter overview

The previous chapter presented a systematic review of the literature on the use of mood-monitoring apps for young people. The aim of this chapter is to compare and contrast publicly available smartphone apps and determine which one is most suitable for mood-monitoring from the perspective of young people, students, and professionals. This chapter presents the process through which the mood-monitoring app for the comparative quantitative and qualitative digital mood-monitoring study in Chapters 6 and 7 was identified. The first part of the chapter will provide a brief introduction following which the aims and research questions are outlined. It will then describe the methods, which include: 1) the app search strategy; 2) app selection; 3) quality assessment; and 4) consultation strategy.

5.1 Introduction

There are now over 10,000 mental health focused apps available (Torous and Roberts, 2017). Many of these apps have the capacity to monitor mood and other mental health related symptoms (Torous et al., 2018a), which is a fundamental aspect of the treatment and management of psychiatric conditions such as bipolar disorder and depression (Nicholas et al., 2015). Although an app may appear suitable, the majority of apps that are currently available to the public have not been supported by evidence, are not appropriate for clinical use, and do not have basic privacy policies (Torous et al., 2018a, Torous et al., 2018b). Moreover, a substantial number of apps that do have a privacy policy use language that may be incomprehensible to many app users (Glenn and Monteith, 2014). Data acquired from health apps, categorised as “sensitive” by data protection laws, may also be transferred with minimal

to no protection or encryption, and sold for commercial purposes without consumers' knowledge (Armstrong, 2016).

The aim of this chapter was to compare and contrast smartphone apps that are publicly accessible and determine which one is most suitable for the digital mood-monitoring study. There was a two-stage process: 1) apply a systematic review framework to the identification of apps, including a quality assessment; 2) consult young people, professionals (e.g., psychologists), and students. This process better ensured that the chosen mood-monitoring app was secure, clinically suitable, of good quality, and informed by young people's needs and wishes. Specifically, this chapter aimed to answer the following research questions:

1. What high-quality mood-monitoring apps are available from app stores?
2. How are pre-selected mood-monitoring apps perceived by a young person's steering group, students, and professionals?
3. What do young people value in mood-monitoring apps?

5.2 Method

5.2.1 App search strategy

The Google Play store (Google Play, 2016) and iTunes Mac app (Apple, 2016) were searched to identify mental health apps that contain a mood-monitoring feature. The search strategy was informed by previous systematic reviews (Dubad et al., 2018, Nicholas et al., 2015) and revised following consultation during supervision. The following search terms were used: 'mood', 'emotion', 'feelings', 'affect', 'mood instability', 'affective instability', 'mood monitor', 'mood tracker', 'mood assessment', 'mood dysregulation', 'bipolar disorder', 'borderline personality disorder', 'depression', and 'mental health'.

5.2.2 App selection

Inclusion criteria

Apps were assessed against the following inclusion criteria:

1. (Genuine) mood-monitoring feature (e.g., no "prank" app);
2. English language functionality;
3. Available on both Google Play and iTunes;
4. Ability to export data from the app;
5. Available for free;
6. Fully functional (i.e., no demo app);
7. Predominantly focused on mood and/or mental health (e.g., no social media app).

Screening procedure

App names and descriptions were screened for their relevance to the study aim and objectives and assessed against the inclusion criteria. Apps that met the inclusion criteria were subsequently downloaded onto an iPhone and quality-assessed using the Mobile Application Rating Scale: User version (uMARS; Stoyanov et al., 2016).

Quality assessment

The uMARS is an end-user and simplified version of the Mobile Application Rating Scale (Stoyanov et al., 2015). The 20-item scale consists of four subscales measuring 'objective' app qualities including engagement, functionality, aesthetics, and the quality of information (see Appendix 2). An app quality mean score is generated by adding the scores for each subscale and dividing this sum by four. The scale also includes the 'App subjective quality' and the

'Perceived impact' subscale, which can be reported separately from the app quality mean score. Responses to items on these additional subscales, such as "*Would you pay for this app?*" ('App subjective quality') and "*This app has increased my awareness of the importance of addressing the health behaviour*" ('Perceived impact') may vary considerably across individuals and can be more difficult to judge than items on the 'objective' subscales (e.g., "*Does it allow you to customise the settings and preferences that you would like to (e.g. sound, content and notifications)?*"). As such, only the app quality mean score was taken into consideration. The uMARS total score has good to excellent internal consistency (Cronbach alpha= .90) and good test-retest reliability (calculated using interclass correlation coefficients (ICCs) over 1-2 month (ICC= .66) and 3-month periods (ICC= .70) (Stoyanov et al., 2016). The three highest scoring mood-monitoring apps were included for review by the consultation group (see below) and professionals. The restriction to three apps gave group members sufficient opportunity to use, review, and discuss the apps in the allocated time slot.

Consultation strategy

Young people's steering group

Participants

Feedback on the three selected mood-monitoring apps was sought from the National Institute for Health Research Clinical Research Network: West Midlands – Young Person's Steering Group (YPSG; GenerationR, 2014). The purpose of the YPSG is to share their views on the design, development, and delivery of a variety of research projects. The group consisted of 14 young people and varied in age (12-20 years), employment, and health status.

Materials

Participants were provided with a variety of mobile devices (e.g., iPhones, iPads), based on availability, which contained the three selected mood-monitoring apps. Participants had the choice to share their feedback verbally and/or write their views on anonymous feedback sheets. Due to the limited number of devices available, written feedback could be provided individually or in pairs if a device had been shared. The feedback sheets consisted of five open-ended questions (e.g., "Is the app easy to use?") and an option to give the app an overall score ('I would give [name app] a score of …/10').

Procedure

The 1-hour session started with brief introductions. MD subsequently provided the group with a general overview of the topic, and the aims for the research project and session. Following this, the group was asked to spend some time using and rating the mood-monitoring apps, paying particular attention to the mood-monitoring features of each app. MD, supported by the YPSG coordinator, then led a discussion during which each app was reviewed by the group. The group subsequently voted for their preferred app. There was a general discussion on mood-monitoring apps at the end of the session, which included questions such as *"is there anything that worries you about using these mood-monitoring apps?"* After gaining consent from participants, discussions were recorded anonymously and summarised in writing (Realpe et al., 2019). Group members' feedback was reported verbatim in quotation marks and italics.

Feedback from professionals and students

MD used social media and email to recruit professionals and students for their feedback. Responses were obtained from eight professionals and students, including one assistant psychologist, one forensic psychologist, one healthcare assistant (and student nurse), one operations director (IT), one psychiatrist, two trainee psychologists, and one university student (psychology). The apps were also reviewed, discussed, and ranked during supervision by Steven Marwaha (Professor of Psychiatry) and Catherine Winsper (Senior Research Fellow). Thus, feedback was obtained from nine professionals and one student from a variety of disciplinary backgrounds.

Participants had the option to share their feedback using an electronic survey (www.surveymonkey.com) or share their views face-to-face. Those who agreed to take part were asked to download each app, to spend a brief amount of time testing the different features of the apps, and to specifically consider the app's ease of use, the usefulness of the data it produces, and whether it would be useful in their own clinical practice (if applicable). They were subsequently asked to: 1) describe their job role; 2) rank the apps in order of preference; 3) provide reasons for their order of preference; 4) provide any further comments. Professionals and students' feedback was reported verbatim in quotation marks and italics.

Decision-making process

In line with University requirements, the developers of the apps were also contacted and asked to complete a form detailing the app's data protection and information security measures. Thus, the app for the mood-monitoring study was chosen based on feedback from the YPSG, students, and professionals, alongside an examination of the app features and security settings.

5.3 Results

5.3.1 App selection

The search identified 3564 apps, of which the vast majority (n=2673) originated from the Google Play app store (Google Play, 2016). Following the initial screening process, 42 apps were selected for further assessment. Nine of the apps met all inclusion criteria and were quality assessed. These 9 apps included: 'Tyneside Mind Mood Tracker' (The Creative Branch, 2016), 'iFeel Free' (Chiarini, R., 2016), 'MoodPanda' (Greenwood, J., 2014), 'Catch It – Making Sense of Your Moods' (The University of Liverpool, 2016), 'T2' (National Center for Telehealth & Technology, 2016) , 'Moodimodo' (Sinn, M., 2016), 'NHS Physical Health Monitor (for Lithium)' (Incentivated, 2015), 'Rise Up + Recover' (Recovery Warriors L.L.C., 2015), and 'Easy' (SILECI Apps, 2016), which is also known as 'Simple' in the Google Play app store.

5.3.2 Quality assessment

The three apps with the highest app quality mean score were the 'Tyneside Mind Mood Tracker' app, the 'Catch It' app, and the 'Rise Up' app. See Table 6 for an overview of the scores for each uMARS subscale and the overall app quality mean score. Table 7 outlines the features of each app.

Table 6: Quality assessment scores

Apps	Engagement mean score	Functionality mean score	Aesthetics mean score	Information mean score	App quality mean score
Tyneside Mind Mood Tracker	3.80	5.00	4.67	4.75	**4.56**
I Feel Free	4.00	4.00	4.67	3.75	4.11
MoodPanda	4.00	3.75	4.67	3.75	4.04
Catch It	3.60	5.00	4.67	5.00	**4.57**
T2	4.20	4.25	4.33	4.75	4.38
Moodimodo	4.00	4.75	4.67	4.00	4.36
NHS	3.60	5.00	4.33	5.00	4.48
Rise Up	4.60	5.00	4.67	4.75	**4.76**
Simple/Easy	3.20	5.00	4.67	3.50	4.09

Table 7: Features of short-listed apps

Features	Catch It	Rise Up + Recover	Tyneside Mind Mood Tracker
App developer	The University of Liverpool	Recovery Warriors	The Creative Branch
Usage disclaimer	Yes	Yes	Yes
Instructions	Yes	No	Yes
Built-in tracker	Yes	Yes	Yes
Scale	1-5	0-5	10 – 1
Scale descriptor	Weak - strong	None. Emotions are depicted by emojis	As good as it gets – as bad as it gets
Frequency of entries	One mood per diary entry	Multiple emotions per diary entry	One mood per diary entry
Option to customise scale/add moods	Yes	Yes	No
Type of assessment	Momentary & retrospective	Retrospective	Momentary
Built-in reminder	No	Yes	Yes
Built-in random reminder	No	No	No
Built-in reflection support	Yes	No	No
Coping skills suggestions	No	Yes	No
Export/synchronise data	Yes	Yes	Yes (online account)
In-app PIN	Yes	Yes	No
Option to add further notes/comments	Yes	Yes	Yes
Data information and security check	Completed	No response	Completed

5.3.3 YPSG feedback

Eight anonymous written feedback sheets were returned for the 'Catch It' app (Table 8), the 'Rise Up' app (Table 9), and the 'Tyneside Mind Mood Tracker' app (Table 10). Verbal feedback from YPSG members on the three apps was obtained in the group discussion that followed. Given the overlap in responses between young people's verbal and anonymous written feedback and the difficulty in separating these responses, an overall summary of respondents' feedback is provided below. The YPSG also engaged in a general discussion regarding the use of mood-monitoring apps. Key discussion points are summarised in section 5.3.4.

Catch It

YPSG members valued the design of the app (e.g., the colours) and features such as the PIN, the time stamp, and the reflection feature. Some of the negative feedback concerned the lack of a reminder to record moods, the large number of questions and steps, and the inability to record multiple moods. Feedback suggested the app was easy to use, although a minority found the app confusing. The majority of written responses indicated that the app could be useful in keeping track of mood or mental health, although only a minority would actually use the app in real life. The 'Catch It' app received an average score of 6.1 out of 10 (range= 4 to 8).

Table 8: Written feedback from the YPSG members for the Catch It app

Feedback sheet	What do you like the most about the app?	What do you like the least about the app?	Is the app easy to use?	Would this app help you keep track of your mood or mental health?	Would you use this app in real life?	Score
1	Clear steps; easy to use; nice colours	Too long-winded (too many questions); not enough options	No response	No response	No	6/10
2	Mood rating; colours; thoughts before event;	More mood options needed (more	Yes, well set out	Yes	Yes	8/10

Feedback sheet	What do you like the most about the app?	What do you like the least about the app?	Is the app easy to use?	Would this app help you keep track of your mood or mental health?	Would you use this app in real life?	Score
	reflection; you can look [sic]	than one); option to expand on where you are				
3	The colourful design is endearing and comforting; 'just now' option; pin lock	Doesn't give you actual concrete solutions	Yes, very	Yes	Yes	8/10
4	Tells you why you do things; multiple moods; and multiple logs; customisation	Not visual; not much freedom	Yes, takes you through it	Yes	No	6/10
5	Colours	Not many options	Confusing	No	No	4/10
6	You can write your mood if it is not on the list; you can add why; it has a recommendation to improve your mood; has examples on how to use it and is fast	No way to have a reminder to put your mood in	It is quite easy to use	Yes it is quite useful	Yes	7/10
7	Lay out; colours – but it would be nicer if you could pick your own → blue = negative mood	You have to record each mood individually; colours are depressing	Slightly confusing	No response	No	No response
8	Super easy to use	What does it do? Very simplistic	Very	Yes, but not sure how helpful it is	Unlikely	4/10

Rise Up

Reported strengths of the app included the option to record different moods at the same time, suggestions for coping strategies, and the range of additional features offered by the app (e.g., resources for support, access to music). The difficult interpretation of the mood log and the restriction to one daily log were some of the limitations of the app. Feedback suggested that the app was generally easy to use, although slight confusion arose regarding how to log/save

moods and view past recordings. The majority of written responses indicated that the app could be useful or potentially useful in keeping track of mood or mental health, and would be used or possibly used by YPSG members in real-life. The 'Rise Up' app received an average score of 7.4 (range= 6 to 9).

Table 9: Written feedback from the YPSG members for the Rise Up app

Feedback sheet	What do you like the most about the app?	What do you like the least about the app?	Is the app easy to use?	Would this app help you keep track of your mood or mental health?	Would you use this app in real life?	Score
1	Love the quotes; faces; allows multiple feelings; comments section; personalised; reminders; coping skills	Medication not drugs; only once a day	Yes	Yes	Yes	8/10
2	The scale of each emotion; quotes really nice; multiple emotions	Not much to do/expand on situation	Slightly, how to log/save confusing	Not really	No	6/10
3	The quotes; 911 distress	No response	Yes	Yes	Yes	7/10
4	Customisation; lots to do; quote	Daily log – only one per day; not easy to keep record	Tutorial?	No	No	6/10
5	You can put more options	No response	Yes	Yeah	50/100	9/10
6	The emoji makes it appeal to teenagers more; makes it fun; coping skills section; resources; and reminders. You can get support	The quotes cheesy; you can't save the mood into a diary	Yes and it is fun	Yes	Yes	8/10
7	Fill it in all at once; personalised	Lots of different areas	No response	No response	No response	No response
8	Lots of feelings! All the time! Doesn't try to do too much	Log is difficult to understand; editor is same as viewer	Mostly	Maybe	Possibly	8/10

Tyneside Mind Mood Tracker

YPSG members liked features such as the reminders and the graph, but negatively appraised the simplicity of the app and the app's rating scale. The app was generally perceived as easy

to use and the majority of responses suggested the app would be useful for keeping track of moods or mental health. Views on the real-life usage of the app were negative, with the majority of written responses suggesting the app would not be used in real life. The 'Tyneside Mind Mood Tracker' app received an average score of 5.3 (range= 4 to 7).

Table 10: Written feedback from the YPSG members for 'Tyneside Mind Mood Tracker'

Feedback sheet	What do you like the most about the app?	What do you like the least about the app?	Is the app easy to use?	Would this app help you keep track of your mood or mental health?	Would you use this app in real life?	Score
1	Colourful	Boring; not many options or flexibility	Yes	No	No	4/10
2	Colours for mood	Not much to do; boring	Yes	Yes, simple lay out	No	7/10
3	Easy to read	Hard to scale mood	Yes, relatively	Yes	No	4/10
4	Reminders; graph; log	0-10; doesn't give you the immediate option to describe your mood	Yes, easy to grasp	No	No	5/10
5	No response	No response	No response	No response	No response	No response
6	You can look back at your history of moods and you can clarify why you felt that way. You can also remind yourself to put a mood in.	It is quite slow. The colour scheme is quite bad for the moods and you can only select one mood at a time.	Yes it is quite simple.	Yes probably.	For a few days at a time.	6/10
7	No response	No response	No response	No response	No response	No response
8	Open-ended; graphs!	Very simple; 1-10 is very….vague	Yes	Yes, but not very informative	No	6/10

5.3.4 Mood-monitoring apps: A general discussion

Following the review of 'Catch It', 'Rise Up', and 'Tyneside Mind Mood Tracker', the YPSG engaged in a general discussion on mood-monitoring apps. For example, concerns were raised regarding the cost of mood-monitoring apps. It was noted that young people *"who don't have*

their own credit card linked to an account" need to be considered, as they would have to ask their parents to pay for an app, thus disclosing their use of the app. Another person commented *"why would I have to pay to get help?"* if a doctor suggested an app.

The group also stressed the importance of protecting app users and identified three issues. First, they emphasised the importance of protection against data loss. App users might spend a lot of time on mood-monitoring apps. There is a need for back-up storage options (e.g., online account/log-in, sharing options) to protect data in the event that data is suddenly lost, or when the user changes phones. Second, the YPSG highlighted the importance of transparent guidelines and consent procedures to protect app users against potential unauthorised data access. Specifically, users need to know who has access to the data, where data is stored other than on your phone, whether data will be shared with anyone, and what will happen with your data. It was noted that a disclaimer should come up as soon as you download the app, where it explicitly states whether anyone else will have access to the data. The app should give the user a choice on whether or not they want to share their data. Finally, the YPSG discussed concerns regarding users' potential reliance on mood-monitoring or mental health apps. It was noted that people have become *"so cyber connected"*. Although these types of apps are meant to help with users' mental health, there is a risk of becoming solely dependent on the app. Thus, to protect users, there should be an emphasis that *"you can do this […] you can do this yourself as well"*.

Finally, the YPSG also expressed reservations regarding app icons and notifications. In order to encourage long-term engagement with mood-monitoring apps, it was suggested that apps should not be perceived as a chore. One way of achieving this, is by the careful phrasing of the notifications issued by the app. The group noted that the app notifications should be

encouraging and phrased positively, such as *"how are you feeling?"*, as opposed to reminders such as "*fill this in"* or *"you haven't done it for the past however many days"*. The group also commented that these notifications should be discreet. That is, an app user may not want friends to see what they are doing. There were concerns that friends may question why they are using an app if a mood notification is issued by the mood-monitoring app. Similarly, the design of the app icon itself should be subtle. For example, whilst the 'Rise Up' and 'Catch It' app icons did not describe the purpose of the app, the 'Tyneside Mind' mood tracker app *"says, like, mood checker […] in the title"* and was therefore perceived as less discreet. The group highlighted the importance of being able to tailor apps to the users' individual needs, which could resolve some of these issues and improve users' experience (e.g., tailoring the number of and type of notifications, the colours of apps, having the option to keep certain parts of the data private).

5.3.5 Feedback from professionals and a student

Nine professionals and a student ranked the apps in order of preference. 'Rise Up' was ranked first by the majority of respondents, followed by 'Catch It,' and then the 'Mind' app. Examples of feedback for each app are provided in Table 11.

Table 11: App ranking and feedback by professionals and the student

	Ranking (*n*)			
	1st	2nd	3rd	Comments
Catch It	3	5	2	• *'Catch up provides a good framework for challenging your thoughts.' (Assistant Psychologist)* • *'Catch it was somewhere in the middle, it did not have additional options other than tracking mood, but I liked the focus on thoughts and encouraging you to challenge your thoughts in a compassionate way*

	Ranking (*n*)			
				through asking how you would advise a friend to think about it.' (Trainee Psychologist 1)
Rise Up	5	1	4	• *'Had more content. I liked the options of coping strategies.' (Forensic Psychologist)* • *'I didn't like rise and recover as it's is based on eating disorders, which I couldn't relate to.' (University Student)*
Mind	2	4	4	• *'Mind Tracker got a better UX [Mobile User Experience] then Rise up.' (Operations Director)* • *'Limited to recording information. I did like the graph but I prefer the coping strategies and the thought challenging provided in the other apps.' (Trainee Psychologist 2)*

5.4 Discussion

5.4.1 Summary of app rankings

The most popular and highly rated mood-monitoring app was the 'Rise Up' app. Feedback suggested the app offered various useful features (e.g. suggestions for coping strategies), which users highly valued. In second place was the 'Catch It' app. Although the app offered fewer features than the 'Rise Up' app, respondents praised the app's reflective component. The lowest rated app was the 'Tyneside Mind Mood Tracker' app. Although 'Mood Tracker' was the only one that summarised data in a graph within the app, overall, it appeared this mood-monitoring tool was too simplistic and not sufficiently engaging.

5.4.2 Selection of mood-monitoring app: decision-making process and justifications

Despite the popularity of the 'Rise Up' app, there were a number of issues that could potentially cause problems during the mood-monitoring study. First, it was difficult to ascertain the security of the app and the data it produces. The security of the app was an important consideration in the decision-making process, in regard to protecting the confidentiality of data and privacy of

participants. The ‘Rise Up’ app developers were contacted to obtain this information, but no response was received. Second, the ‘Rise Up’ app targets people with eating disorders. Although the app can be used by people without an eating disorder diagnosis, there is a concern that the focus on eating disorders might deter some people from engaging with the app. For example, one of the respondents reportedly could not relate to this app because it is based on eating disorders. As such, it may be more beneficial to use an app which does not potentially exclude those of whom have not received a specific psychiatric diagnosis but do experience psychological distress (Bakker et al., 2016). Third, the app was restricted to one daily recording. Although this could still allow for the assessment of mood fluctuations across time, this type of retrospective recording may be subject to recall biases (Reid et al., 2009, Ebner-Priemer and Trull, 2009) and result in less accurate mood assessment (Reid et al., 2009, Schwartz et al., 1999). It was also felt that this restriction may limit the amount of data that can be collected during the data collection period.

For these reasons, and due to the low ratings for the ‘Mind Mood Tracker’ app, the ‘Catch It’ app was selected for the digital mood-monitoring study. The ‘Catch It’ app has an EMA feature which enables the assessment of mood in real-time on multiple occasions during the day (Wenze and Miller, 2010). This approach may allow for a better understanding of daily mood (van Knippenberg et al., 2016, Cristobal-Narvaez et al., 2016, Myin-Germeys et al., 2016) and increases ecological validity (Shiffman et al., 2008). Although the ‘Catch It’ app does not offer as many features as ‘Rise Up’, it does encourage users to record their thoughts, feelings, and behaviours. This gives app users the opportunity to reflect on their diary entries and self-monitor, which can increase emotional self-awareness, and subsequently improve emotion regulation (Dubad et al., 2018). In order to address the absence of a reminder feature, participants were asked to download a reminder app in the digital mood-monitoring studies in Chapter 6 and 7.

5.4.3 Strengths and limitations of the selection process

This work package had a number of strengths. First, the 'Catch It' app was selected through a two-stage decision-making process. Moreover, apps were searched using a systematic approach across two large app platforms. Perspectives were also obtained from different stakeholders. Collaborative work with the YPSG, in particular, offered important insight into young people's perspectives on mood-monitoring apps. The price of apps for example, was an important determinant in young people's uptake of apps. A review by Huang and Bashir (2017) demonstrated the negative impact of price on the adoption of apps, with most users downloading apps (including mental health apps) that have lower prices. It should be noted that apps that are available for free may still come at a cost, either as a result of in-app purchases to use certain advanced features or at the cost of the app user's personal mental health data, which may be sold without app users' awareness (Torous et al., 2018a, Armstrong, 2016). This therefore illustrates the importance of checking the app's privacy and data storage policies, to ensure the protection of app users' data.

Feedback from the YPSG also offered novel insight into the importance of the presentation or design of an app. That is, YPSG's concerns over the appearance of app icons and how this may be noticed by others, suggested young people may still feel self-conscious about using apps for their mental health, even though self-monitoring technologies typically offer more privacy than pen-and-paper diary methods (Matthews and Doherty, 2011). Similarly, Huang and Bashir (2017) found that fewer people adopted and reviewed anxiety apps of which the titles related to (symptoms) of this psychiatric condition compared to other apps. This further illustrates the potential risk of labelling and self-stigma that are associated with apps that use titles which are disorder- or symptom specific (Bakker et al., 2016, Huang and Bashir, 2017).

Despite these important findings, there were a number of limitations that should be highlighted. For example, due to limited time and resources, only one person (MD) searched for, extracted data from, and assessed the quality of apps, which may have increased the risk of errors (Boland et al., 2017). The use of formal evaluation and quality assessment forms could have improved the quality and rigour of the consultation process, particularly as verbal and written YPSG feedback could not be clearly distinguished, and feedback on apps from the professionals was limited due to time constraints. The uMARS, for example, could have been used, as it does not require the need for training or specialist knowledge (Stoyanov et al., 2016). An alternative evaluation method that could have been implemented was the smartphone app evaluation framework developed by the American Psychiatric Association (Torous et al., 2018b). This framework helps identify unsuitable and potentially unsafe apps through a four-stage process, taking into consideration app qualities such as the availability of privacy policies and the existence of evidence supporting the effectiveness of the app.

Chapter summary

This chapter compared and contrasted publicly available smartphone apps to determine which would be best to monitor mood from the perspective of a young person's steering group, students, and professionals. A large number of apps from commercial app stores were screened and assessed against eligibility criteria, following which a selected sub-group was quality assessed. The three apps with the highest quality assessment scores were reviewed by the YPSG, professionals, and a student. Feedback from both the YPSG and the field experts was considered, alongside an examination of the individual features and information security measures of each app. The 'Catch It' app was selected as the most appropriate for the digital mood-monitoring study, with the additional requirement that participants would be asked to download a reminder app when taking part in the studies described in chapter 6 and 7.

Chapter 6: Digital mood-monitoring technology - A quantitative investigation

Chapter overview

The previous chapter described the selection process for choosing the 'Catch It' mood-monitoring app. The current chapter investigates affective instability and related outcomes using the app in a clinical and healthy comparison group. The first part of the chapter provides an introduction into the area and describes the research questions and hypotheses. The chapter subsequently describes the methods and results, and discusses the main findings, strengths and limitations.

6.1 Introduction

Variations in the measurement and analysis of affective instability in past research has resulted in inconclusive findings (Santangelo et al., 2014). Researchers such as Ebner-Priemer et al. (2007) suggest that the statistical analysis of affective instability should take into consideration three important features: amplitude (i.e., the magnitude of mood changes), frequency (i.e., the rate of mood changes), and temporal dependency (i.e., the sequence of mood changes). The squared successive difference (SSD) index is an overall measure of affective instability that accounts for these features (Santangelo et al., 2014, Ebner-Priemer et al., 2007). This index measures successive differences between consecutive mood recordings, covering both increases and decreases in ratings, in which higher values indicate heightened instability. Group differences in SSDs can be analysed through the calculation of mean SSDs (MSSDs) per participant or by using multilevel models.

The SSD or MSSD index is increasingly used across studies. Santangelo et al. (2017) for example, used a smartphone app to investigate affective and interpersonal instability in a group

of female adolescents who engaged in non-suicidal self-injurious behaviours (n=26), and a healthy control group (n=20). Results showed significantly higher mean (square rooted)[2] SSDs in the clinical sample compared to healthy controls, indicating heightened affective instability and interpersonal instability. Participants showed good compliance with the monitoring schedule, which further supports the feasibility of mood-monitoring methods (Gordon-Smith et al., 2019). However, consistent with previous ecological momentary assessment (EMA) research (Houben et al., 2016), compliance was lower in the clinical than the control group.

Preliminary and limited evidence from EMA studies indicates that mood-monitoring tools may improve mental health outcomes and therapeutic engagement in youth (Dubad et al., 2018). Benefits may include increased self-awareness (Reid et al., 2011), which can (indirectly) improve young people's depressive symptoms (Kauer et al., 2012). In their pilot study, Kinderman et al. (2016) investigated the short-term impacts of the 'Catch It' app on users' moods. With each entry, app users: 1) rated the intensity of their positive or negative mood; 2) reflected on and cognitively appraised their mood by considering different perspectives; and 3) rated the intensity of their mood for a second time (see 'Methods' for further information). On average, the 'Catch It' app significantly increased app users' positive moods and significantly reduced negative moods from the first entry to the second entry. Although not tested in this study, the cognitive regulation strategy has been shown to reduce subjective, behavioural, physiological, and neural measures of emotional reactivity (Ochsner and Gross, 2005, Gruber et al., 2014).

Despite these encouraging findings, there are some weaknesses in the literature. A large proportion of EMA studies have either not taken advantage of smartphone app technology (Houben et al., 2016, Maciejewski et al., 2015) or employed apps which are not publicly

[2] SSDs were positively skewed. Square roots of SSDs were subsequently extracted to account for this issue.

accessible (Faurholt-Jepsen et al., 2019). Previous studies also predominantly focused on adult populations, non-clinical populations, and/or specific diagnostic groups, particularly borderline personality disorder (Trull et al., 2008, Hill and Updegraff, 2012, Faurholt-Jepsen et al., 2019). There is correlational evidence of a link between mindfulness and reductions in momentary (emotional lability) and retrospective (emotion regulation difficulties) indices of affective instability (Hill and Updegraff, 2012); however, there appear to be no experimental studies directly testing this. In view of these limitations, further research is needed to study the use and potential clinical impacts of publicly available app-based momentary assessment tools in young people with affective instability.

The aim of this work package was to investigate affective instability using the 'Catch It' app in young patients presenting to mental health services with a range of diagnoses, in which affective instability forms a key component. Patients were allocated to the 'clinical group' and compared against young people without mental health problems (hereafter referred to as the 'healthy comparison group'). Specifically, this work package used EMA and retrospective assessments to investigate: 1) differences in momentary affective instability between the clinical and healthy comparison group; 2) the impact of the 'Catch It' app on clinical symptoms across all participants; and 3) the impact of the 'Catch It' app on patients' engagement with treatment. Interaction effects were examined in order to establish whether significant effects of the app applied to all participants or varied across the clinical and healthy comparison group (Pallant, 2007). Specific research questions and hypotheses for each outcome are presented in Table 12.

Table 12: Research questions and hypothesis for the quantitative digital mood-monitoring study

Research questions	Hypotheses
1. Are there group (clinical and healthy) differences in momentary affective instability? [1]	1. The clinical group would report significantly higher levels of momentary affective instability (reflected by higher MSSDs) compared to the healthy comparison group.
2. Does use of the 'Catch It' app impact on clinical symptoms across all participants, including: • Momentary positive and negative mood intensity ratings; • Retrospectively assessed emotion regulation difficulties [2]; emotional awareness [3]; emotional clarity [4]; impulsivity [5]; and affective shifts. [6]	2. Use of the 'Catch It' app would have a significant impact on clinical symptoms across all participants, including: • Increased momentary positive mood intensity ratings; • Reduced momentary negative moods intensity ratings; • Improved retrospectively assessed emotion regulation difficulties; emotional awareness; emotional clarity; impulsivity; and affective shifts.
3. Does use of the 'Catch It' app improve (retrospectively assessed) engagement in patients accessing services? [7]	3. Use of the 'Catch It' app would significantly improve retrospectively assessed engagement.

Notes: 1) Momentary affective instability was calculated using MSSDs; 2) measured using the Difficulties with Emotion Regulation Scale (DERS-SF: Kaufman et al., 2016); 3) measures an individual's lack of attention to their emotional reactions; 4) measures an individual's lack of clarity about their emotional experience; 5) measures an individual's difficulty with controlling their behaviours when feeling distressed; 6) measured using the Affective Lability Scale (ALS-SF: Oliver & Simons, 2004); 7) measured using the Engagement Scale (Cunningham et al., 2009). See 'Method' for further information.

6.2 Method

6.2.1 Study design

This study employed a quasi-experimental pre-test – post-test design (Salkind, 2010). This frequently used design can help determine the impacts of an intervention, when a randomised controlled trial is not feasible or ethical (Schweizer et al., 2016, Harris et al., 2006). As seen in Figure 7, the study was completed in three distinct stages over a six-week period, in which participants completed baseline assessments (time 1), pre mood-monitoring study assessments (time 2), and post mood-monitoring study assessments (time 3).

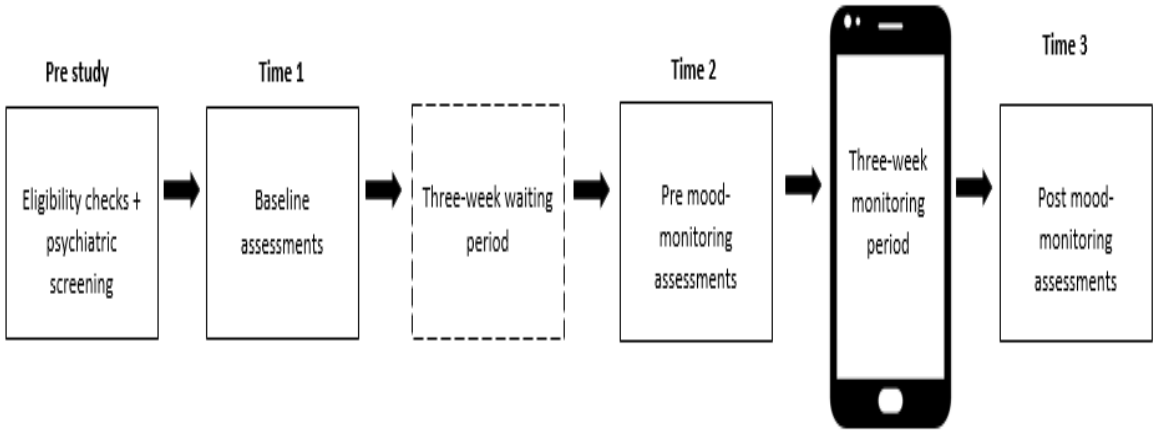

Figure 7: An overview of the study design. Assessments across time points included: 1) pre-study eligibility checks (non-NHS and healthy comparison group only); 2) demographic records & GP information (Non-NHS and healthy comparison group only); 3) DERS-SF; 4) ALS-SF; and 5) Engagement scale (clinical group only). See section 6.2.4 and 6.2.5 for further information.

6.2.2 Participants

A sample of young people with (n=23) and without affective instability (n=24) was recruited for the quantitative study. The eligibility criteria for the clinical group and healthy comparison group are listed in Box 1a and 1b, respectively. A sample size calculation was performed with support from a statistician at the University of Warwick. Using G*Power (2007), a statistical power analysis program, a test of difference between two independent means (t-test) was conducted using the following parameters: tails=2; effect size=1, alpha probability= .05; power=.9. This

resulted in a (minimum) sample size estimation of n=23 per group (i.e., the clinical group and healthy comparison group).

1. Has capacity to consent (as assessed by the clinician and verified by MD);
2. Currently receives mental health care (i.e., not discharged);
3. Aged 16 to 24;
4. Has a psychiatric diagnosis;
5. Currently experiences affective, mood, or emotional instability or dysregulation, irrespective of diagnosis;
6. No current need for inpatient or crisis team input;
7. No diagnosed learning disability;
8. Not currently involved in other research;
9. Access to an iOS or Android (4.0 and up) smartphone;
10. Understands/speaks English (at a level sufficient enough to understand and complete questionnaires/mood. diaries).

Box 1: Eligibility criteria for the clinical group

1. Aged 16-24;
2. Absence of current diagnosed mental disorder;
3. No previous diagnosis of borderline personality disorder, bipolar disorder, psychosis, or Attention deficit hyperactivity disorder (ADHD);
4. No diagnosed learning disability;
5. No involvement in other research at the time of the study;
6. Access to an iOS or Android (4.0 and up) smartphone;
7. Understands/speaks English (at a level sufficient enough to understand and complete questionnaires/mood diaries).

Box 2: Eligibility criteria for the healthy comparison group

Ethical approval was obtained from East Midlands Leicester Central Research Ethics Committee (reference: 17/EM/0146). An honorary contract, letter of access, and an authorisation email was also issued for research in Coventry and Warwickshire Partnership NHS Trust (CWPT), Forward Thinking Birmingham (FTB), and Coventry Mind, respectively.

Copies of the CWPT participant information sheet and consent form are listed in Appendix 3 and 4 for illustrative purposes. Materials slightly varied for other participants (e.g., FTB logos on FTB documents).

6.2.3 Setting

Child and Adolescent Mental Health Services and Adult Mental Health Services across CWPT, FTB, and Coventry Mind were chosen as the study settings for the recruitment of participants with affective instability. CWPT was chosen because it provided access to patients with affective instability across their youth and adult mental health services. FTB and Coventry Mind were chosen in order to expand the scope of potential participants, due to their close proximity to the University, and their willingness to support the study. Participants from the healthy comparison group were recruited via posters and social media (see section 6.2.5 for further details).

6.2.4 Materials

Mood-monitoring app

The 'Catch It' app was the selected mood-monitoring app for the study (full discussion Chapter 5). Figure 8 contains a screenshot of the app menu and 'record mood' section of the mood diary. Instructions for use of the app were given verbally when consent was obtained. Visual instructions (see Appendix 5) were also provided which participants could refer to throughout.

Participants were provided with MD's contact details, in case they encountered difficulties with the app or other aspects of the study.

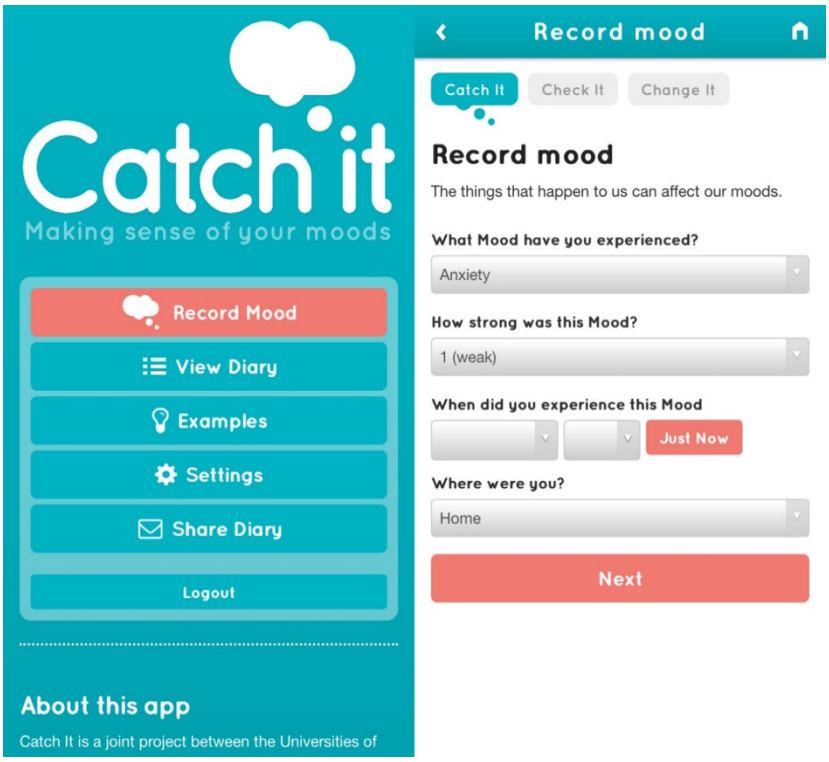

Figure 8: A screenshot of the 'Catch It' app's main menu and mood-recording screen

In summary, the 'Catch It' app consists of a multi-stage process (Kinderman et al., 2016). At the 'Catch it' stage, app users are asked to rate their initial mood on a scale of 1 to 5 and describe the circumstances and thoughts associated with their mood or change in mood. At the 'Check it' stage, the app helps users to reflect on what they are thinking. Finally, in the 'Change it' stage, users are encouraged to consider different, and potentially more helpful approaches. Following this consideration, users were asked to rate their mood a second time on a scale of 1 to 5 and were provided with brief, general feedback (see Figure 9 for an example).

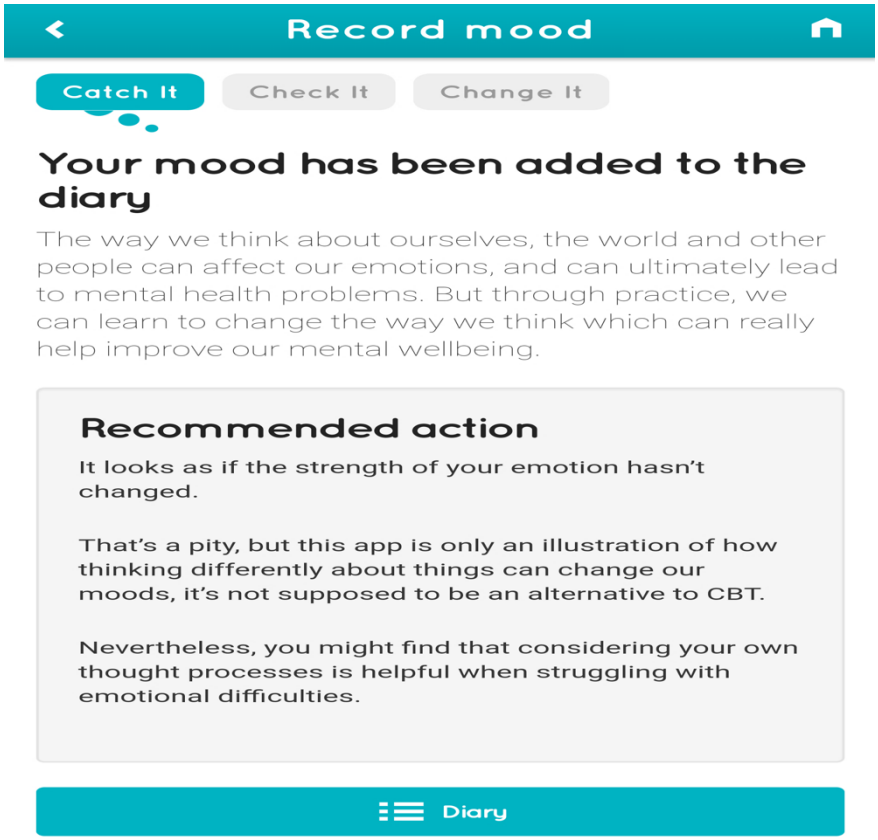

Figure 9: Example of feedback generated by the 'Catch It' app

Reminder apps

In order to address the absence of a reminder feature in the 'Catch It' app, participants were also asked to download a reminder app ('Randomly RemindMe' for Android users (James Morris Studios, 2016) and 'Mind Jogger' (Fata, 2014) for iPhone users), which prompted them to complete a mood diary at two random times during the day. This helped establish how participants' moods fluctuated throughout the day across the study period. The Android app was available at no cost. The iPhone app, which costs £0.79, was shared using a voucher code at no cost to the participant.

Participants decided between what times these two notifications were sent, ensuring the app did not intrude their daily lives. A time window of 10-12 hours was typically chosen. The reminder apps also enabled users to set up a notification title to their preference (e.g., a discreet notification, an encouraging notification). Figures 10 and 11 contain screenshots of the 'Randomly RemindMe' and 'Mind Jogger' app, respectively.

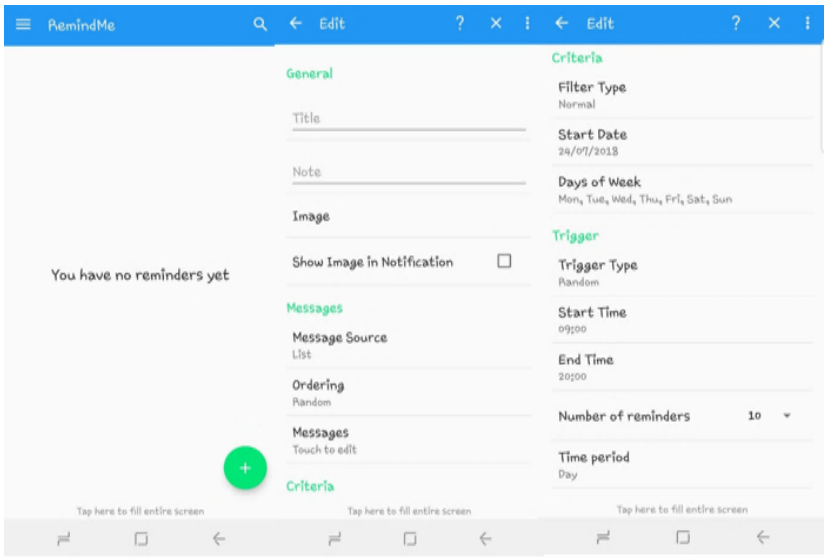

Figure 10: Screenshots of the 'Randomly RemindMe' app

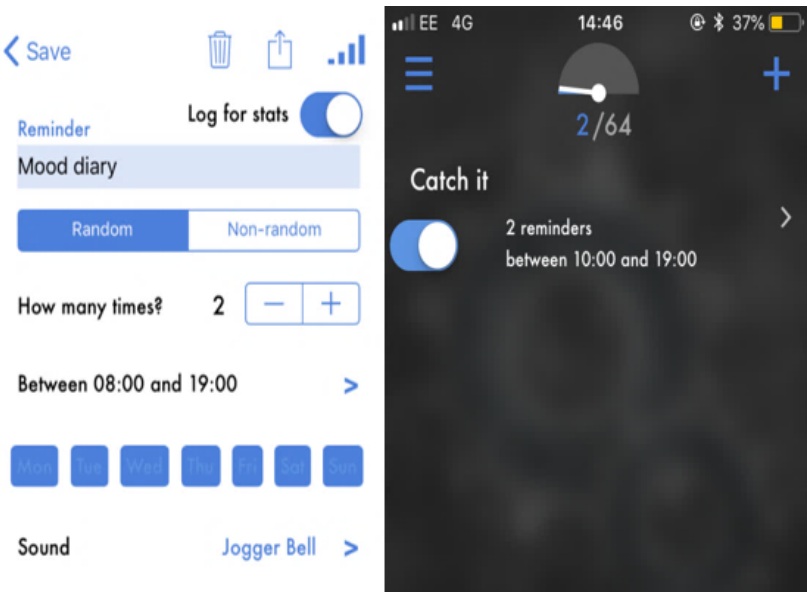

Figure 11: Screenshots of the 'Mind Jogger' app

Measures

The primary outcome measures was the Difficulties in Emotion Regulation Scale -Short Form (DERS-SF Kaufman et al., 2016), presented in Appendix 6. The secondary outcome measures were the Engagement Scale (Cunningham et al., 2009) and the Affective Lability Scale (ALS-SF Oliver and Simons, 2004), presented in Appendix 7 and 8, respectively.

DERS-SF

The DERS-SF measured the ability to regulate emotions. The 18-item scale consisted of six subscales including: 'strategies' (i.e., an individual's lack of belief in their effective emotion regulation skills), 'non-acceptance' (i.e., an individual's propensity towards negative secondary reactions to either negative emotions and/or denial of distress), 'impulse' (i.e., an individual's difficulty with controlling their behaviours when feeling distressed), 'goals' (i.e., an individual's difficulty with focusing and completing tasks when feeling distressed), 'awareness' (i.e., an individual's lack of attention to their emotional reactions), and 'clarity' (i.e., an individual's lack of clarity about their emotional experiences). Respondents chose between five options (coded 1-5), ranging from 'almost never' to 'almost always'. Higher scores on the DERS-SF (i.e., total scores of all items within and across sub-scales) indicated more difficulties with affect regulation. The DERS-SF has been tested in both adult and adolescent populations and has evidence of excellent psychometric properties (Kaufman et al., 2016).

Engagement scale

The Engagement Scale consisted of seventeen questions and included three subscales: 'readiness to change' (five items), 'bond with staff' (seven items), and 'collaboration on goals

and tasks' (five items). Respondents had the option to choose between seven response options (coded 1-7), which ranged from 'strongly agree' to 'strongly' disagree'. Mean total scores for overall engagement were computed, in which higher scores reflected higher levels of engagement. The scale has acceptable levels of reliability and strong content validity (Cunningham et al., 2009). Participants from the healthy comparison group were not asked to complete the Engagement scale as this questionnaire was only applicable to the clinical group.

ALS-SF

The ALS-SF was used as a secondary outcome measure. This scale consisted of eighteen items measured on a four-point Likert scale. Response options were coded 0-3 and varied from 'very undescriptive' to 'very descriptive'. Participants could obtain a total mean score and mean scores for three sub measures, including 'anxiety/depression' (5 items), 'depression/elation' (8 items), and 'anger' (5 items).[3]

General Health Questionnaire (GHQ-12)

Participants in the healthy comparison group were asked to complete the GHQ-12 screening measure (Goldberg and Williams, 1988) to determine their eligibility for the study (see Appendix 9). The GHQ-12 is a self-report questionnaire that detects the presence of psychopathology in community and non-psychiatric clinical settings. It does not enable diagnoses of psychiatric disorders (Goldberg and Williams, 1988, Morris and Earl, 2017). The scale consists of 12 items

[3] Despite some of the overlap between the affective instability scales, the DERS-SF was used to investigate the behavioural manifestation of affective instability (e.g., 'When I'm upset, I have difficulty getting work done.'), whereas the ALS-SF was used to investigate the lability component of affective instability and assessed shifts in affective states (e.g., 'There are times when I feel perfectly calm one minute and then the next minute the least little thing makes me furious.').

and is rated on a 4-point scale (Goldberg and Williams, 1988, Payne, 1998). Response options varied across items, ranging from 'not at all' to 'much more than usual' (negative items) and 'better/more so than usual' to 'much less than usual/much less capable/much less able' (positive items).

The GHQ-12 was scored using the original GHQ or binary method, in which the negative items were scored as 0 and the positive items were scored as 1 (Goldberg and Williams, 1988). Criteria for caseness (i.e., the probability that an individual has a minor psychiatric problem) were determined by threshold scores. The threshold for caseness in this study was 4, meaning that individuals obtaining a score of 4 or more were not eligible to partake in the study. This threshold has been used in UK studies on similar aged populations (Biddle et al., 2004, Beardsmore and Siegler, 2014).

Demographic information and GP information form

Demographic information and GP details for NHS participants were accessible via CareNotes (an electronic patient database). Non-NHS participants (from Coventry Mind) and participants from the healthy comparison group, whose records were not electronically accessible, were asked to complete a form asking for demographic information and GP details (e.g., Appendix 10).

Confirmation of diagnosis

Potential non-NHS participants whose mental health records were not available were asked to confirm:

1. Whether they had a psychiatric diagnosis;

2. Who gave them this diagnosis (a psychiatrist or GP);
3. Whether they were taking medication for their mental health condition.

If they answered positively to question 1 *and* question 2 and/or question 3, it was assumed they had a diagnosable mental health condition and met this specific eligibility criterion.

6.2.5 Procedures

Recruitment strategies

Affective instability appears more prevalent in females compared to males (Marwaha et al., 2013, Patel et al., 2015). To control for potential gender effects, a frequency matching strategy was employed to achieve a similar proportion of males to females across the clinical and healthy comparison group. Frequency matching is typically used in case control and cohort studies, in order to ensure the same distribution across sub groups defined by known or matching (risk) factors (Gail, 2014).

Clinical group

The study was advertised on posters in buildings across CWPT, FTB, and Coventry Mind, and through social media (Twitter and Facebook) where information about the study and contact information was provided (e.g., Appendix 11). In CWPT and FTB, mental health practitioners (e.g., psychiatrists, nurses, psychologists) were asked to identify eligible patients and tell them about the study. Eligible patients who expressed an interest were asked for their consent to release their contact details in order to receive further information. Potential involvement in the study could be discussed either in a face-to-face meeting after their appointment (with consent from the patient and mental health practitioner) or at a later date, depending on the patient's preferences. As detailed above, non-NHS patients were required to confirm their diagnosis prior

to commencing the study. Patients were given at least 24 hours to decide whether or not they wanted to take part in the study.

Healthy comparison group

Non-probability sampling strategies were also used for the healthy comparison group, which included a convenience sampling strategy (where potential participants were identified based on their availability and proximity) and snowball sampling strategy (where participants helped identify other potential participants to sample). The study was advertised on different social media (Facebook, Twitter, and Instagram) and posters across the University of Warwick. Prior to commencing the study, potential participants for the healthy comparison group were first required to confirm they met the eligibility criteria (e.g., 'absence of current diagnosed mental disorder'). Those who met the inclusion criteria subsequently completed the GHQ-12 to exclude potential psychopathology. These checks were completed in-person, via telephone, or email prior to their commencement of the study. Individuals who obtained a GHQ-12 score between 0 and 3 were deemed fully eligible and could commence the mood-monitoring study.

Study procedures

Once eligible participants gave their consent:

- The different steps of the study were reiterated;
- Instructions for the study questionnaires (DERS-SF, ALS-SF, Engagement scale) were provided and demographic/GP information forms (if applicable) were distributed;
- Participants were supported with downloading the study apps;
- Participants were provided with instructions on the study apps (e.g., how to complete the mood diary, how to email the data from the app).

The mood-monitoring study was conducted in distinct stages:

1. Participants were asked to complete the questionnaires (DERS-SF, ALS-SF, Engagement scale) and demographic/GP information form (where applicable) either in a face-to-face meeting or in their own time prior to which they were prompted via text-message or email.
2. After a three-week waiting period, participants were prompted to complete the same questionnaires for a second time. Once these questionnaires were completed, participants were required to start the three-week monitoring period during which they electronically monitored their mood using the mood-monitoring app twice per day.
3. After the three-week monitoring period, participants were asked to send the mood-monitoring data via email using the in-app export function, following which they completed the questionnaires for the final time.
4. Upon study completion, the first five participants received a £20 Amazon or Love2Shop gift voucher and reimbursement for travel expenses (maximum £5). Due to stipulations set by the Finance department on the reimbursement of travel expenses, subsequent participants received a £25 gift voucher, which included reimbursement for any travel expenses.

Participants had the option to complete questionnaires electronically (e.g., via a link on their smartphone) or on paper at all assessment points. A maximum of two additional prompts were sent to participants at each assessment point (time 1: baseline assessments, time 2: pre mood-monitoring study assessments, time 3: post mood-monitoring study assessments).

6.2.6 Data analysis

Statistical thresholds

Results are typically considered statistically significant if alpha levels are below .05. However, when multiple tests are carried out on the same data, this may increase the risk of a Type 1 error, in which a significant result is detected where there is none in reality (Pallant, 2007). One way to reduce the risk of a Type 1 error is by using a Bonferroni adjustment. The Bonferroni adjustment involves dividing the normal alpha level (i.e., .05) by the number of tests that are performed. A total of 16 tests, excluding descriptive statistics tests for sample characteristics, were performed in this study, which resulted in an adjusted alpha level of .003 to determine statistical significance.

Descriptive statistics

Sample characteristics

Demographic information was analysed using *'Statistical Package for the Social Sciences' (SPSS) version 25* software. Group comparisons in age were calculated using independent-sample t-tests. Gender and ethnicity variables were compared using Chi-Square tests. Ethnicities were categorised into white and non-white categories for the purpose of the Chi-Square test.

Type and frequency of moods

First, a single valence index was created (Santangelo et al., 2014). Negative moods were multiplied by -1, positive moods were multiplied by +1, and a valence score of 0 was given if a participant did not identify a mood. Thus, a participant who rated their happiness as 5, would

receive a valence score of +5, whereas a depression rating of 2, would result in a score of -2. Valence scores subsequently ranged from -5 to +5. To better understand the type and frequency of participants' affective experiences, diary entries were subsequently categorised into positive (valence range= 1 to 5) or negative moods (valence range= -1 to -5). Frequencies were calculated using *Microsoft Excel*.

Response rates

Participants were asked to record their mood twice per day over a 21-day monitoring period. This resulted in 42 possible mood recordings per participant. Similar to Trull et al. (2008), response rates were measured as the number of completed recordings by a participant divided by the total number of prompts in the monitoring period (i.e., 42). Response rates were calculated using *Microsoft Excel*. An independent samples t-test was conducted to compare group (clinical and healthy) response rates using *SPSS.*

Research question 1: Are there group (clinical and healthy) differences in momentary affective instability?

Outcome: MSSDs

Jahng et al.'s (2008) syntax was adapted to calculate within and between-day MSSDs in valence (see above for calculation) using the *Statistical Analysis Software (SAS)* version 9.4 program. Independent samples t-tests (and non-parametric equivalents, where applicable) were performed to compare individual MSSDs using SPSS. Findings were then confirmed using multilevel models in which SSDs (level 1) were nested within participants (level 2) (Santangelo et al., 2014, Jahng et al., 2008).

Hypothesis:

- The clinical group would report significantly higher levels of momentary affective instability (reflected by higher MSSDs) compared to the healthy comparison group.

Research question 2: Does use of the 'Catch It' app impact on clinical symptoms across all participants?

Momentary outcomes:

1) Positive mood intensity ratings
2) Negative mood intensity ratings.

Positive and negative mood intensity ratings were analysed separately (Kinderman et al., 2016). Average mood intensity scores were first calculated for each individual in *Microsoft Excel*. A mixed analysis of variance (ANOVA) was subsequently conducted using *SPSS.* This analysis assessed whether there was a significant main effect for time (i.e., within group differences in average moods over time across all participants), and whether there was a significant interaction effect between the group (clinical and healthy) and time variable. Findings were then confirmed using a repeated measured mixed model (Kinderman et al., 2016). This model accounts for the multiple assessments per participants by adding a random effect for the ID variable. This helps illustrate the unique variations in mood intensity that can be attributed to individual differences (Winter, 2013).

Of note, the severity of mood ratings in the 'Catch It' app was automatically set to 1 (Kinderman et al., 2016). If users selected a different mood intensity rating on the first entry but did not actively rate their mood on the second entry (i.e., leaving it at '1'), this could lead to false conclusions about the direction of results (see 'Discussion' for further information). Consistent

with Kinderman et al. (2016), a second, more conservative, analysis was performed to account for this issue, which excluded data in which the second mood rating post-reflection was 1.

Hypotheses:

- Use of the 'Catch It' app would have a significant impact on clinical symptoms across all participants, including:
    - Increased positive mood intensity ratings;
    - Reduced negative moods intensity ratings.

Retrospective outcomes:

1) Emotion regulation difficulties;
2) Emotional awareness;
3) Emotional clarity;
4) Impulsivity;
5) Affective shifts.

Mixed ANOVAs were conducted to assess the impact of the 'Catch It' app on retrospective outcomes across three time points (time 1: baseline assessments, time 2: pre mood-monitoring study assessments, time 3: post mood-monitoring study assessments). Emotion regulation was measured as the total DERS-SF score, containing the sum of all items. Emotional awareness, emotional clarity, and impulsivity scores were derived from their respective DERS-SF sub-scales, containing the sum of three items per sub-scale. Shifts in affective states were measured as the ALS-SF total mean score. Further paired-sampled post-hoc t-tests were conducted if significant main effects were found. Interaction effects were examined in order to establish whether significant effects of the app applied to all participants or varied across the clinical and healthy comparison group.

Hypotheses:

- Use of the 'Catch It' app would have a significant impact on clinical (or affective) symptoms across all participants, including improved retrospectively assessed:
    1) Emotion regulation difficulties;
    2) Emotional awareness;
    3) Emotional clarity;
    4) Impulsivity;
    5) Affective shifts.

Research question 3: Does use of the 'Catch It' app improve (retrospectively assessed) engagement in patients accessing services?

Outcome: Engagement

A one-way repeated measures ANOVA was conducted to assess differences in patients' engagement. Engagement was measured as the mean total Engagement scale scores across three time points (time 1: baseline assessments, time 2: pre mood-monitoring study assessments, time 3: post mood-monitoring study assessments). Further paired-sampled post-hoc t-tests were conducted if a significant main effect was found.

Hypothesis:

- Use of the 'Catch It' app would significantly improve retrospectively assessed engagement.

6.3 Results

6.3.1 Descriptive statistics

Sample characteristics

A total of 101 people were invited to the quantitative mood-monitoring study. They were allocated to the clinical (n=55) or healthy comparison group (n=46). In the clinical group, 24 participants consented to take part in the study, of which one participant withdrew due to personal circumstances and competing demands at school. In the healthy comparison group, 27 eligible people consented to take part in the study, of which one participant withdrew due to competing demands at work and two were lost-to-follow up for unknown reasons. The final sample consisted of 47 participants, including 23 people with mental health problems and 24 people without current mental health problems. The consent rate (i.e., the proportion of people who completed the study out of the total number of people who were invited to the study) for the clinical and healthy comparison groups was 41.8% and 51.1%, respectively. There was no data available to statistically compare those who did and those who did not consent. An overview of the recruitment process is described in Figure 12.

There was a similar proportion of males to females across the clinical (males= 12, females= 11) and healthy comparison (males= 12, females= 12) groups. There was no significant association between gender and groups; χ^2 (1, n=47) = .00, p = 1.00, phi = .02, demonstrating that frequency matching had been effective.

Participants' ages ranged from 16 to 26 years, with a mean age of 20.70 years (standard deviation (SD) = 3.17). One participant, aged 26 years, was mistakenly referred to the study by their care coordinator. This was despite the clear instructions given to the care coordinators regarding the study's eligibility criteria (i.e., the referral of participants between the ages of 16

to 24 years) and information provided on the participant information sheet. There was no significant difference in age between groups; t (45) = -1.23, p = .22.

Participants identified as White British (48.9%), other White Background (2.1%), Black African (8.5%), other Black Background (2.1%), Indian (2.1%), Pakistani (8.5%), other Asian Background (8.5%), Black and White Heritage (4.3%), other Ethnic Background (2.1%). Information on participants' ethnicity was not reported or available for 12.8% of all participants. There was no significant association between ethnicity and groups; χ^2 (1, n=41) = 2.69, p = .10, phi = .31. In the healthy comparison group, 29.2% of participants were employed, 66.7% were in education or learning, and one person (4.2%) was neither in education nor in employment. Information on the employment status of participants in the clinical group was not available in the patient record system.

The majority of participants in the clinical group (82.6%) were on medication. Given *that "a current diagnosed mental disorder"* and *"previous diagnosis of borderline personality disorder, bipolar disorder, psychosis, or ADHD"* were two of the exclusion criteria for potential participants of the healthy comparison group, information on psychiatric medication intake was not requested for this group. Diagnoses varied considerably across participants in the clinical group, with a substantial amount of comorbidity. Participants with psychotic disorders (with/without comorbidity) comprised 26.1% of the sample; (emergent) personality disorders (with/without comorbidity) accounted for 26.1%, and the remainder (47.8%) consisted of people with mood, panic, eating, and/or anxiety disorders (with/without comorbidity). A breakdown of the sample characteristics across both groups is provided in Table 13.

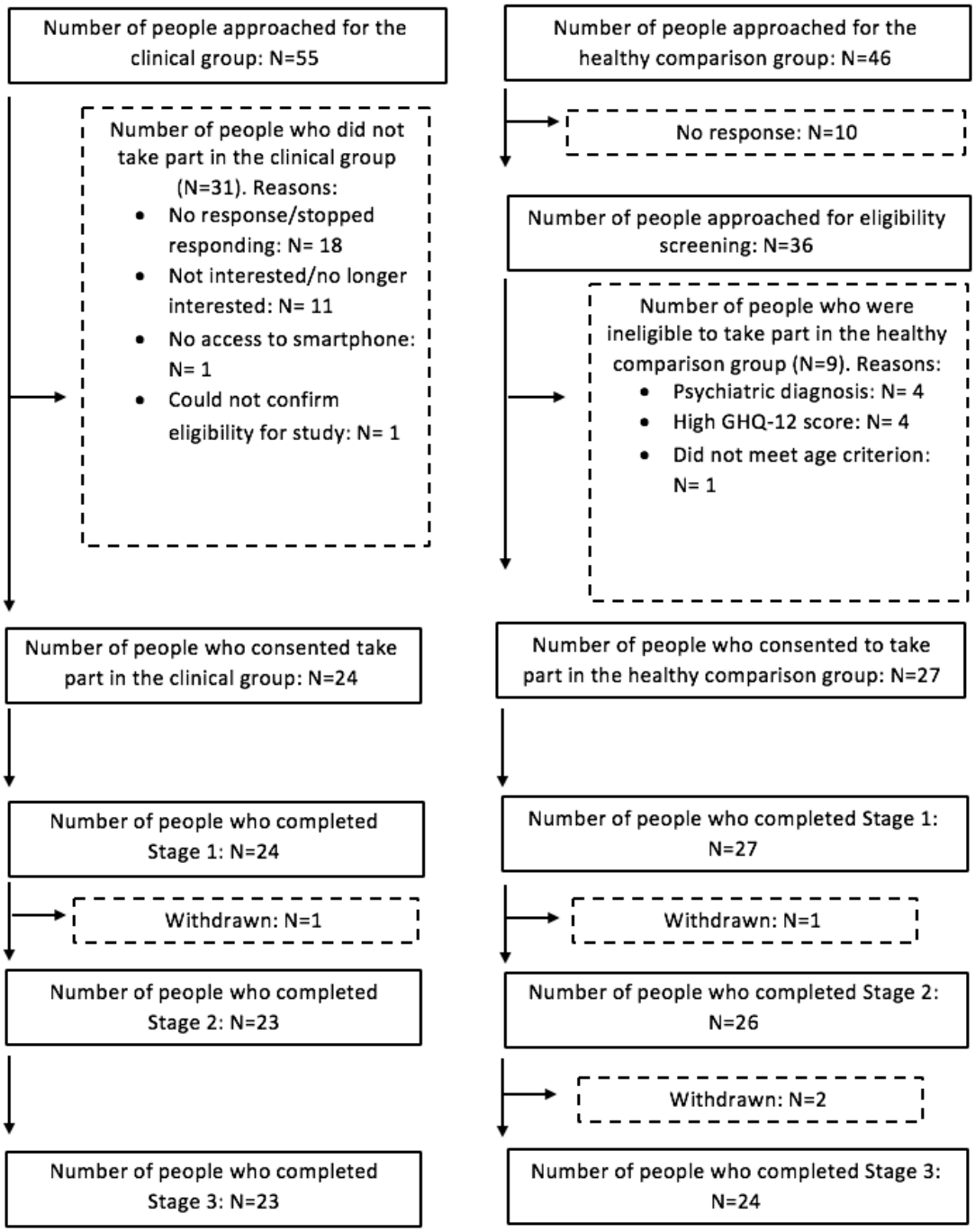

Figure 12: Overview of the study's recruitment process

Table 13: Characteristics of the clinical and healthy comparison group

Characteristics	Clinical group	Healthy comparison group	p
Age in years, mean (SD)	20.13 (2.9)	21.23 (3.4)	.22
Gender, n (%)			1.00
Female	11 (47.8)	12 (50.0)	
Male	12 (52.2)	12 (50.0)	
Ethnicity, n (%)			.10
White British	12 (52.2)	11 (45.8)	
Other White Background	1 (4.3)		
Black African		4 (16.7)	
Other Black Background	1 (4.3)		
Indian		1 (4.2)	
Pakistani		4 (16.7)	
Other Asian Background	1 (4.3)	3 (12.5)	
Black and White Heritage	2 (8.7)		
Other Ethnic Background		1 (4.2)	
Not recorded/available	6 (26.1)		
Employment status			
Employed		7 (29.2)	
Not in education, employment, or training		1 (4.2)	
In education/learning		16 (66.7)	
Not recorded	23 (100.0)		
Medication, n (%)			
On medication	19 (82.6)		
Not on medication	4 (17.4)		
Not applicable/not requested		24 (100.0)	
Diagnoses, n (%)			
Psychotic disorders with/without comorbidity	6 (26.1)		
Mood, panic, eating, and/or anxiety disorders with/without comorbidity	11 (47.8)		

Characteristics	Clinical group	Healthy comparison group	p
(Emerging) personality disorders with/without comorbidity	6 (26.1)		

Mood recordings (type and frequency)

Figure 13 displays participants colour-coded diary entries based on their valence scores. In total, participants across both groups reported 667 negative mood recordings and 734 positive mood recordings. This figure does not include blank recordings (n=10), which were uninterpretable, and a neutral recording (n=1), where the participant did not identify an emotion.

Figure 13: Matrix of colour-coded valence scores organised by group and gender.
Notes: Colours range from red (negative valence) to green (positive valence). White boxes reflect missing recordings. HCP= Healthy Comparison Participants.

Response rates

A total of 1412 recordings were completed across the monitoring period, of which 698 recordings were completed by the clinical group (M= 30.35, SD= 13.42), and 714 recordings were completed by the healthy comparison group (M= 29.75, SD = 12.42). There was no

significant difference in response rates between the clinical (M= .72, SD= .32) and healthy comparison group (M= .71, SD= .30); t (45) = .16, p = .88.

6.3.2 Momentary and retrospective outcome data

Research question 1: Are there group (clinical and healthy) differences in momentary affective instability?

There was no significant difference in within-day affective instability between the clinical group (M= 20.83, SD= 9.86) and the healthy comparison group (*M*= 19.04, *SD*= 12.11). Similarly, the results also showed no significant difference in between-day affective instability between the clinical group (M= 11.97, SD= 9.87) and the healthy comparison group (M= 11.72, SD=7.53). As the between-day MSSD variable was slightly skewed (kurtosis=2.66), this difference was checked through the non-parametric Mann-Whitney U test, which similarly revealed no significant difference (p= .72). Multilevel analyses confirmed these results, which demonstrated no significant group differences (demonstrated by the γ_{01} parameter) in within-day affective instability, γ_{01} = .08, t (45) = .41, p=.69, and between-day affective instability, γ_{01} = -.17, t (40) = -.93, p=.36.

Research question 2: Does use of the 'Catch It' app impact on clinical symptoms across all participants?

Momentary clinical outcomes

To reiterate, the 'Catch It' app consists of a multi-stage process (Kinderman et al., 2016), including stage: 1) initial mood intensity entry; 2) reflection and reappraisal of mood and related thoughts; 3) second mood intensity entry post-reflection.

Positive mood intensity

The first analysis, which included all valid recordings (i.e., recordings which were interpretable and had both pre- and post-values), showed a non-significant (p= .02; Bonferroni corrected threshold: p= .003) reduction in the strength of positive mood from the initial entry (M= 3.18, SD= .84) to the second entry (M=2.83, SD= .91) for all participants. The linear mixed model with random effects confirmed the non-significant main effect for 'time'; F (1, 46) = 2.55, p= .12. There was no significant interaction effect between 'time' and 'group'; F (1, 46) = .06, p= .81.

After the removal of recordings for which the post-assessment was 1 (see 'Method' and 'Discussion' for further information), results showed a non-significant (p= .02; Bonferroni corrected threshold: p= .003) increase in the strength of positive mood from the initial diary entry (M= 3.32, SD= .60) to the second entry (M= 3.50, SD= .62) for all participants. The linear mixed model with random effects confirmed the non-significant result; F (1, 43) = 2.53, p = .12. There was no significant interaction between 'time' and 'group'; F (1, 43) = .07, p = .79.

Negative mood intensity

The first analysis showed a significant (p<.003) reduction in the strength of negative mood from the initial entry (M= 2.97, SD= .81) to the second entry (M= 2.32, SD= .85) for all participants. A linear mixed model with random effects was subsequently carried out, which confirmed the significant main effect for 'time'; F (1, 45) = 41.83, p < .003. There was no significant interaction between 'time' and 'group'; F (1, 45) = .05, p = .82, indicating that the significant effect did not vary across the clinical and healthy comparison group.

After the removal of recordings for which the post-assessment was 1, results showed a significant (p<.003) reduction in the intensity of negative mood from the initial diary entry (M= 3.42, SD= .62) to the second entry (M= 2.95, SD= .68) for all participants. The linear mixed model with random effects confirmed the significant main effect for 'time'; F (1, 41) = 14.82, p < .003. There was no significant interaction between 'time' and 'group'; F (1, 41) = .31, p = .58, indicating that the significant effect did not vary across the clinical and healthy comparison group.

Retrospective clinical outcomes

There was a significant main effect for time for the 'Impulse' subscale, Wilks Lambda = .74, F (2, 44) = 7.69, p < .003 partial eta squared = .26. This suggests there was a significant decrease in impulsivity over time across all participants. There was no significant interaction between 'time' and 'group'; Wilks Lambda = .98, F (2, 44) = .55, p = .58, indicating that the significant effect did not vary across the clinical and healthy comparison group. A post-hoc test revealed no significant difference between time 1 and time 2 (p = .69). The reduction between time 2 and time 3 reached statistical significance using traditional thresholds but was not significant using the adjusted alpha threshold (p= .02; Bonferroni corrected threshold: p= .003). There was a significant reduction between time 1 and time 3 (p <.003).

There was no significant main effect for time for any of the other DERS-SF retrospective clinical outcomes, including: total emotion regulation difficulties (p = .11), emotional awareness (p = .82), and emotional clarity (p = .68). All interaction effects were non-significant (range: p= .42 - .77) Mean scores for the total and DERS-SF subscales are presented in Table 14.

Finally, there was no significant main effect for time for the ALS-SF mean total score, indicating no significant difference in affective shifts over time 1 (M=1.24, SD= .72), time 2 (M=1.21, SD=.73), and time 3 (M=1.24; SD=.76); Wilks Lambda = .98, F (2, 44) = .49, p = .62.

Table 14: Overview of DERS-SF total and sub-scale scores

	Total	Sub-scales		
Time	Emotion regulation	Clarity	Awareness	Impulse
1	46.77 (14.19)	7.47 (2.70)	7.68 (3.20)	6.64 (3.38) ↔ *
2	46.70 (16.39)	7.17 (3.12)	7.85 (3.03)	6.51 (3.62)
3	44.79 (15.92)	7.30 (3.19)	7.94 (2.79)	5.74 (2.94) ↔ *

Notes: DERS-SF total score (scale= 1-90) and subscales scores (scale= 1-15). Higher scores reflect more difficulty. ↔ Indicates time difference. * Significant at p < .003

Research question 3: Does use of the 'Catch It' app improve (retrospectively assessed) engagement in patients accessing services?

There was no significant main effect for time for mean total Engagement, suggesting no significant difference in patients' engagement across time 1 (Mean= 2.91, SD= .56), time 2 (Mean= 2.84, SD= .53), and time 3 (Mean= 2.89, SD= .74); Wilks Lambda = .97, F (2, 21) = .32, p = .73.

6.4 Discussion

The aim of this work package was to investigate affective instability using the 'Catch It' app in young patients with affective instability and a healthy comparison group. Specifically, this work package used EMA and retrospective assessments to examine: 1) differences in momentary affective instability between the clinical and healthy comparison group; 2) the impact of the

'Catch It' app on clinical symptoms across all participants; and 3) the impact of the 'Catch It' app on patients' engagement with treatment. A summary of the main findings relating to the momentary and retrospective outcomes is presented below.

6.4.1 Are there group (clinical and healthy) differences in momentary affective instability?

There was no significant difference in momentary affective instability between groups. The hypothesis predicting significantly higher levels of momentary affective instability in the clinical group compared to the healthy comparison group was therefore rejected. These findings may be attributed to the mood-monitoring schedule.

Previous studies that successfully measured affective instability (Santangelo et al., 2014, Santangelo et al., 2017), employed much higher sampling-frequencies (e.g., hourly recordings), compared to twice per day in the current study. In contrast to research such as Santangelo et al. (2017), however, this work package found no significant group difference in response rates, which supports the feasibility of the monitoring schedule for clinical and non-clinical populations. Thus, whilst low-frequency monitoring schedules may increase the feasibility of digital mood-monitoring tools (Dubad et al., 2018), they might not accurately capture statistical indices of affective instability such as MSSDs. As evidence-based guidelines for sampling frequencies are limited (Santangelo et al., 2017), this further highlights the need for research on optimal monitoring schedules, which effectively measure affective dynamic processes, whilst taking into consideration app users' workload (Bolger et al., 2003, Trull et al., 2015).

Although the current study did not detect significant group differences in overall momentary affective instability, as measured by the MSSDs, differences might be detected in specific subcomponents of affective instability (Santangelo et al., 2014). Houben et al. (2016) for example, investigated 'emotional switching' (i.e., strong moment-to-moment fluctuations between positive and negative emotions) in patients with borderline personality disorder and

healthy controls. The EMA study found no group differences in participants' overall tendency to switch between positive and negative emotions. However, results did show significant group differences in the magnitude of these affective shifts. Future studies should therefore further investigate the different subcomponents of affective instability in order to better determine the sensitivity and specificity of mood-monitoring apps.

6.4.2 Does use of the 'Catch It' app impact on clinical symptoms across all participants?

Contrary to Kinderman et al.'s (2016) findings and the research hypothesis, use of the 'Catch It' app did not significantly improve momentary positive moods across all participants in the current study, i.e., a (non-significant) reduction in positive moods was found when all ratings were included. However, the removal of potentially confounding ratings showed a (non-significant) increase in positive moods across groups. Notwithstanding this conflicting finding, momentary negative mood intensity scores significantly reduced for both the clinical and healthy comparison group, irrespective of the inclusion or exclusion of potentially confounding mood recordings. Given the link between negative affect and psychopathology (Kring and Bachorowski, 1999), future endeavours should further examine momentary affect in youth through apps. Additional studies, using appropriate in-app rating scales, are also needed to confirm the potential beneficial effects of mood-monitoring apps on improvements in mood.

The only retrospective outcome which showed a significant improvement over time was 'impulsivity'. Both groups showed a significant reduction in impulsivity from the start of the study compared to the end of the study. This indicates that clinical and non-clinical populations can successfully use cognitive reappraisal strategies to reduce impulsivity. Gruber et al. (2014) hypothesised that whilst people with mental health problems have the ability to efficiently regulate their emotions through cognitive reappraisal when prompted (e.g., via an app), they may struggle to apply these strategies in everyday life when unprompted. It is also suggested

that patients may not engage in cognitive reappraisal as frequently or as effectively as healthy individuals (Carthy et al., 2010, Gruber et al., 2014). As impulsivity is associated with adverse outcomes, such as suicidal behaviours (Bender et al., 2011), the importance of supporting young people in the use of cognitive reappraisal strategies is highlighted (Gruber et al., 2014).

Given that the 'Catch It' app had a self-monitoring feature and encouraged the use of cognitive reappraisal skills, both of which can positively influence behavioural or clinical outcomes (Frates et al., 2011, Runyan et al., 2013, Runyan and Steinke, 2015, Gruber et al., 2011), future studies should further dissect the individual and combined contributions of each skill on the study outcomes . For example, an experimental study may compare participants on clinical outcomes across three conditions: 1) a monitoring condition; 2) a cognitive reappraisal condition; 3) a combined condition using both monitoring and reappraisal skills. Although this work package indicated that use of these skills may decrease problems with impulsivity or negative mood intensity, it is also worth investigating whether they may aid the prevention or delay of affective difficulties (Gruber et al., 2014).

It is currently unclear how the digital placebo effect (i.e. positive impacts of a digital tool on clinical symptoms resulting from an individual's expectations about their benefits (Torous and Firth, 2016)) may have influenced some of the findings. Future research should investigate this effect further (e.g., by formally evaluating participants' beliefs about mood-monitoring apps before commencing the study). High-quality studies, with follow-up assessments, are also needed to establish whether the observed effects of the app can be sustained in the long-term.

6.4.3 Does use of the 'Catch It' app improve (retrospectively assessed) engagement in patients accessing services?

The hypothesis predicting significant improvements in self-reported engagement over time was not supported. Patients used the app for the purpose of the study as opposed to their standard treatment in the current work package (see Chapter 7 for further information). There was therefore a lack of direct clinician involvement in the study who monitored or reviewed the use of the app. As the therapeutic alliance is imperative for successful treatment outcomes (Karver et al., 2006), this could potentially explain the lack of change observed in this domain (Prentice and Dobson, 2014). It is also possible that the duration of the monitoring period (3 weeks) was too brief for a significant change across outcomes, such as engagement, to occur. Future studies may therefore need to employ longer monitoring periods.

6.4.4 Strengths and limitations

This appears to be the first study which investigated affective instability using a publicly accessible app in a multi-diagnostic and ethnic youth sample. In contrast with previous research which have employed publicly accessible apps (Mistler et al., 2017), this app was identified using a systematic strategy, using input from different stakeholders. Moreover, in contrast with previous studies that provided correlational evidence (Hill and Updegraff, 2012), this work package employed a quasi-experimental pre-test post-test design, which better determined potential causal effects of apps across a range of outcomes (Schweizer et al., 2016, Harris et al., 2006). Finally, digital mood-monitoring data was collected every day in the current study, as opposed to selected days (Santangelo et al., 2017), which increased the ecological validity of the study.

Despite this, the work package had a number of limitations. First, this work package used a low-frequency mood-monitoring schedule, had a relatively small sample size and short study

duration. This may have made it more difficult to capture meaningful differences or changes across outcomes. The study also did not control for potentially confounding variables (e.g., change in patients' medication during the study period) or potential sources of bias (e.g., non-blinding of outcome assessments. Future studies should therefore consider employing more robust study designs (e.g., RCTs), with larger sample sizes, increased monitoring frequencies, and longer monitoring periods. Future studies should also investigate whether the results can be replicated in patients with more acute levels of mental illness and sustained in the long-term.

Problems with the app should also be discussed. For example, the 'Catch It' app did not incorporate a built-in reminder and allowed for retrospective back-filling. As such, it was not possible to verify participants' compliance with the mood-monitoring schedule, including how promptly participants responded to prompts as well as average times between assessments. Future research therefore needs to consider some of the limitations of publicly accessible apps, which typically offer fewer advanced features compared to non-publicly accessible apps.

As previously mentioned, the app's default rating of '1' could have negatively affected the interpretation of findings. For example, if a participant rated their 'depression' as 5 on the first entry, but did not actively rate their mood on the second entry (i.e., leaving it at '1'), this would indicate that there was a substantial reduction in depression from 5 to 1 following their use of the app (even though there may have been no improvement in reality). As such, the default rating could result in misleading conclusions about the effects of the app. Informal feedback from participants and inconsistencies between participants' mood ratings and written diary entries strongly suggested that some participants did not actively rate their mood on the second entry across different occasions. Some of these default ratings were done accidentally but could not be deleted from the app. Moreover, some participants appeared to have their own interpretations of the second mood rating, despite the instructions provided at the beginning of the study (e.g., a post-rating of 1 suggesting no change in mood). Although a second analysis

was performed to account for this issue, this continues to reflect a limitation of the app (Kinderman et al., 2016).

Finally, due to time constraints, the current study did not examine participants' written mood-monitoring entries, which described the circumstances and thoughts surrounding their moods as well as their reflections on app entries. An investigation of this data might reveal group difference in mood related events or triggers of affective instability and participants' perceptions of these (Santangelo et al., 2014). Variations in participants' emotional processes should therefore be further investigated.

Of note, a brief inspection of participants' written app entries indicated more severe negative mood entries in patients (e.g., descriptions of hopelessness and suicidal thoughts) compared to negative entries recorded by the healthy comparison group. However, despite differences in the severity and context of negative mood recordings both between and within groups, all adverse recordings were classed as negative for the purpose of the analysis (i.e., negative moods, negative valence). For example, one participant who reported feeling *"grossed out"* due to seeing a *"bed bug"* and rated this as a "5", would be categorised in the same manner as a participant reporting feelings of extreme anxiety or depression. Although negative moods which appear less severe (e.g., boredom) may potentially trigger more severe emotional or behavioural responses at a later stage (e.g., Gudde et al., 2015), it is possible that the analytical approach in the current study potentially minimised differences in affective experiences within and across groups. Future studies should therefore investigate mood recordings and variations in their raw format.

Chapter summary

This chapter investigated momentary affective instability and retrospectively-assessed outcomes in a sample of young patients with affective instability and a healthy comparison group. The study found no significant differences in momentary affective instability between groups. There was a significant improvement in momentary negative mood intensity and retrospectively assessed impulsivity across all participants. However, there was no significant improvement in other clinical outcomes across participants and in patients' engagement with treatment. This work package highlighted a need for larger and longer-term trials, with robust designs, to confirm and further investigate the potential clinical impacts of apps. Further guidance is also needed on appropriate sampling strategies, which can better inform the assessment of momentary affective instability. Future studies should also take into consideration the limitations of apps without built-in reminders, given the increased difficulties of verifying compliance with the mood-monitoring schedule.

Chapter 7: Digital mood-monitoring technology - A qualitative investigation

Chapter overview

The previous chapter presented a quantitative investigation of affective instability using the 'Catch It' app, and examined the effects of using this app on clinical outcomes. This chapter further evaluates the mood-monitoring app through a qualitative investigation of the usability, clinical utility, and impacts from the perspective of young patients and clinicians in mental health services. First, a brief introduction into the study is provided, followed by a description of the study methods. The next section contains the results of the study, in which the themes that emerged from the analysis are described. The main findings are subsequently discussed followed by a chapter summary.

7.1 Introduction

It is often assumed that young people in particular will embrace smartphones for the management of their mental health. Whilst these pre-conceived ideas may drive changes in digital health services, they are rarely tested and may not correspond with how young people use, perceive, and engage with technology in practice (Grist et al., 2018, Hollis et al., 2017). An online survey of 11-16 year old girls revealed that despite their high rates of Internet and app usage, only 15-17% of respondents with mental health problems had used a mental health app (Grist et al., 2018). Moreover, 22 – 24% of these respondents expressed preference for face-to-face appointments over apps, and 26 – 31 % of respondents did not think an app would be helpful to them. Young people in this study reported various concerns about the use of mental health apps, such as apprehensions about the accuracy of information on the app, worries about privacy and unauthorised access, and a lack of trust in apps.

Although systematic review evidence suggests that apps are usable for young people, there is a need for qualitative studies to further examine young peoples' and clinicians' perceptions (Hollis et al., 2017), both of which have not been sufficiently considered in the literature (Dubad et al., 2018). Although studies (Pierce et al., 2016, Schueller et al., 2016) suggest that healthcare practitioners are very interested in the integration of smartphone technology in treatment, actual uptake of, and familiarity with, apps is low. Lack of confidence with technology, and little guidance regarding the selection of apps, are some of the barriers that may affect healthcare practitioners' use of apps in mental health services (Pierce et al., 2016).

A qualitative study by Terp et al. (2018) described how features of a smartphone app, such as a medication overview and action planning, allowed young people with a recent diagnosis of schizophrenia to keep track of their mental health and progress, and enabled them to receive help based on their needs. Through these processes, the app helped young people to be in control of their condition, therefore empowering them. However, the efficacy of the app strongly relied on the involvement of healthcare practitioners who helped alleviate some of the young people's concerns about the app. The successful implementation of smartphone technology in mental health services is therefore contingent upon the engagement of both service users and their healthcare providers.

Qualitative research methodology can be a powerful approach for exploring the experiences and attitudes of both clinicians and patients in mental health settings (Palinkas, 2014). Data collection methods vary in qualitative research (e.g., observations, focus groups). Individual interviews can increase awareness of lesser known, and potentially sensitive, areas (Crowe et al., 2015), such as mental health stigma (Dinos et al., 2004) and lived experiences of psychiatric hospitalisation (Gilburt et al., 2008). Within the field of digital mental health specifically, interviews can provide unique insights into how technologies are used and perceived by people with mental health problems (Mistler et al., 2017), which may further inform their implementation

in clinical settings (Terp et al., 2018). Qualitative studies in healthcare settings typically employ semi-structured interview schedules (Gill et al., 2008). Similar to structured interviews, this interview method contains key questions to guide participants, but offers a greater degree of flexibility or deviation from the interview schedule (e.g., through follow-up questions). This can help uncover new insights which may not have been sufficiently considered by the researchers when developing their interview questions.

The overall aim of this work package was to examine the usability, clinical utility, and impacts of the 'Catch It' app from the perspective of young patients and clinicians in mental health services. Specifically, it examined the following research questions:

1. What are young patients and clinicians' perceptions of the 'Catch It' app?
2. What are the clinical and treatment benefits of the 'Catch It' app from the perspective of young patients and clinicians?
3. What patient and clinician identified factors influence engagement and disengagement with the 'Catch It' app and how may its clinical utility be improved?

7.2 Method

7.2.1 Sample

The sample consisted of patients and clinicians from mental health services across Coventry and Warwickshire Partnership NHS Trust (CWPT) and Forward Thinking Birmingham. Further information about these services is provided in Chapter 5. Patients were recruited following their participation in the quantitative digital mood-monitoring study. Only those who previously agreed to be contacted to take part in the qualitative study were invited. Clinicians consisted of those who referred and were involved in the care of patients. As the study focused on clinicians' views of their patients' use of apps and mood-monitoring data, clinicians were only invited if

their patients had completed the mood-monitoring study and mood-monitoring data was available.

Ethical approval was obtained from East Midlands Leicester Central Research Ethics Committee (reference: 17/EM/0146) on 12 May 2017. For the initial research protocol, patients were invited to participate in a focus group only. The focus group proved impractical (e.g., conflicts in patients' schedules), and therefore individual interviews were undertaken instead. Participant information sheets and consent forms for CWPT participants are listed in Appendix 12-15 for illustrative purposes. Materials were slightly amended for other participants, as explained in the previous chapter.

7.2.2 Semi-structured interview schedule

Semi-structured interview schedules were derived from a topic guide (O'Hara et al., 2014), described in Table 15. Interview schedules were developed for patients (10 questions) and clinicians (8 questions) and are listed in Box 3 and 4 below. A combination of open- and closed-ended questions were employed. Closed-ended questions were followed up by prompt questions in order to probe for more in-depth responses (Singer and Couper, 2017).

Table 15: Topics for young patients and clinicians' interviews

Topics for young patient interviews	Topics for clinician interviews
Ease of use of the app	Usefulness of mood app data
Empowerment	Degree of correspondence between app output and clinicians' expectations of affective instability across borders
Self-management/self-regulation strategies	Benefits/problems of using technology to engage young patients
Communication with mental health professionals	Improvement in the app that could aid clinical utility

Engagement with process

Comparison and contrasts in experiences of seeing young patients with and without mood-monitoring app data during clinics

Comparison of communicating mental health symptoms with and without apps

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1. Was the app easy to use?
    - Prompt: if yes, why?
    - Prompt: if no, what made it difficult to use?
2. Did the app make you feel more in control of your mood?
    - Prompt: if yes, how?
    - Prompt: if no, what did you experience instead?
3. Did the app help you with using safe coping skills?
    - Prompt: if yes, how?
    - Prompt: if no, what did you experience instead?
4. Did the app help you become (more) aware of your mood?
    - Prompt: if yes, how?
    - Prompt: if no, what did you experience instead?
5. Did the app help you understand your mood better?
    - Prompt: if yes, how?
    - Prompt: if no, what did you experience instead?
6. Did the app help you to communicate better with mental health professionals?
    - Prompt: if yes, how?
    - Prompt: if no, what did you experience instead?
7. How did this experience compare to communicating without an app?
8. Did using the app help you feel more engaged with your treatment?
    - Prompt: if yes, how?
    - Prompt: if no, what did you experience instead?
9. What (other) benefits did you experience when using the app?
10. What (other) problems did you experience when using the app?

Box 3: Semi-structured interview schedules for patients

1. What is your professional role?
    - Prompt: how long have you been working as [insert professional role]?
2. How useful was the mood app data?
    - Prompt: why/why not?
3. How did the output of the app compare to your professional expectations of mood swings across diagnoses?
4. What were the benefits of using this technology (to engage young people)?
5. What were the problems with using this technology (to engage young people)?
6. Did use of the app have an impact on your therapeutic relationship with the patient?
    - If yes, how?
    - If no, what did you notice about your therapeutic relationship instead?
7. How could the app be improved to aid clinical utility?
8. How do your experiences of seeing young people with mood swings who have used the app compare to those who have not used the app?

Box 4: Semi-structured interview schedules for clinicians

7.2.3 Procedure

Patients and clinicians who expressed an interest in the qualitative study were provided with an information sheet and given the opportunity to ask questions. Written consent was obtained prior to each interview, which was conducted either face-to-face or via telephone by MD, depending on individual needs and preferences. Research has shown that both of these interview modes can be successfully used in qualitative studies without compromising on the nature or depth of responses (Sturges and Hanrahan, 2004).

All participants were reminded that a digital recording device would be used, and to not reveal identifiable information during interviews. Where needed, patients were given the opportunity to re-familiarise themselves with the app and their mood-monitoring data prior to their interview. This was to compensate for long durations between patients' participation in the quantitative and qualitative study (see Results and Discussion for further information). Similarly, clinicians were offered the chance to briefly use the app and familiarise themselves with their patients' mood-monitoring data before each interview.

As recommended, interviews were initiated with relatively simple questions before more sensitive topics (e.g., coping skills) were addressed, which can help put participants at ease (Gill et al., 2008). Questions were rephrased and adapted during the interview, where needed (e.g., if a question was unclear to a participant). Participants were invited to share additional comments or feedback at the end of the interviews. This gave them the opportunity to discuss issues that they had given further thought to, or address topics that had not been addressed in the interview schedule (Gill et al., 2008).

Following the interviews, patients were given a £10 gift voucher in recognition of their time spent participating in the study. Clinicians' contributions were acknowledged in personalised certificates and an accompanying letter. Audio recordings were stored on a password-protected

computer at the University of Warwick and professionally transcribed using Appen's (2018) secure, quality-controlled, and confidential transcription service.

7.2.4 Analysis

Qualitative data analyses are often influenced by their theoretical and philosophical underpinnings (Starks and Brown Trinidad, 2007, Harper, 2011). For example, discourse analysis is largely based on social constructionism, which assumes that knowledge and meaning are social constructs that are typically produced through language (Starks and Brown Trinidad, 2007, Harper, 2011, Carpenter, 2009). As such, discourse analysis focuses on how individuals use language to narrate their experience, with a lesser focus on the experience in itself. Phenomenology, however, is a philosophical discipline that aims to understand individual experiences and how they perceive the world (Starks and Brown Trinidad, 2007, Harper, 2011). In contrast with discourse analysis, the focus of phenomenological analysis is on the lived experience and what meanings are attached to these experiences (Starks and Brown Trinidad, 2007, Harper, 2011, Carpenter, 2009). Individual accounts are closely examined and interpreted with the aim of uncovering participants' inner thoughts and feelings.

Although this work package investigated participants' perceptions and experiences, it did not focus on potential latent or underlying meanings of participants' accounts (Brockwell, 2013, Braun and Clarke, 2006). Rather, it primarily aimed to present and organise their accounts semantically, describing the data as they were narrated. Moreover, the analysis aimed to be data driven (inductive analysis) as opposed to theory driven (deductive analysis), which may help minimise biases (e.g., influences from existing frameworks) and better ensure themes are closely related to participants' accounts (Brockwell, 2013, Braun and Clarke, 2006). As such, data was analysed using Braun and Clarke's (2006) thematic analysis method. This approach

is not restricted to a particular framework, and therefore offers a greater degree of flexibility compared to other analytical approaches (Crowe et al., 2015, Braun and Clarke, 2006). Moreover, it enables researchers to systematically identify key themes, including semantic themes, in large amounts of data acquired from multiple participants (Brockwell, 2013, Braun and Clarke, 2006).

The analysis for this work package was informed by Braun and Clarke's (2006). On receipt, MD familiarised herself with the data by listening back to the interview recordings. Transcripts were read and re-read and corrected for transcription errors where necessary. MD subsequently recorded initial thoughts and codes on paper transcripts and entered these electronically using *NVivo version 12* software. The next stages involved organising the codes into possible themes, reviewing the themes, and defining those themes. Farah Elahi (FE), a PhD candidate at the University of Warwick, separately coded approximately 50% of the anonymous transcripts (three clinician and four patient transcripts), which were randomly selected using *Microsoft Excel's* random generator function. MD individually assessed FE's codes against her codes to assess their validity (Guion et al., 2011) and to further develop and adapt the themes. The final themes are reported in the Results section below.

7.3 Results

7.3.1 Participants

Out of the 23 young people who took part in the quantitative mood-monitoring study, 5 declined to be contacted for the qualitative study and 12 initially expressed an interest, but subsequently declined (n=1) or did not respond to interview invitations (n=10). The final patient sample therefore consisted of 7 participants (3 females and 4 males), aged 17- 24 years (Mean age= 20.71, SD= 2.56). The average length of time between patients' completion of the quantitative

and qualitative study was 215 days (SD= 164.29, range= 2 – 380). The mean interview time for patients was 13.20 minutes (SD= 5.93, range= 8.17 – 21.55). This does not include the time spent reviewing the app and mood-monitoring data prior to the interview.

Thirteen clinicians were approached for the qualitative study, of which six responded to interview invitations and participated in the interviews. The clinician sample comprised 2 consultant psychiatrists, 3 community psychiatric nurses, and an assistant practitioner in mental health. On average, clinicians worked in their respective roles for 8.5 years (SD= 7.4, range= 1.5 – 21 years). The mean duration of clinician interviews was 8.46 minutes (SD= 2.70, range= 5.05 – 12.47) not including the time spent reviewing the app and mood-monitoring data prior to the interview.

7.3.2 Themes

Nine themes were identified from the analysis of data. There were four themes from the patient interviews (Table 16), two themes from the clinician interviews (Table 17) and three cross-cutting themes from patient and clinician interviews (Table 18). Quotes were reported verbatim in quotation marks and italics.

Table 16: Overview of young patients' themes, sub-themes, and exemplar quotes

Theme	Sub-theme	Exemplar quotes
1. Positive perceptions about the usability of the mood-monitoring app	1.1 Positive impressions and future use of apps	*"I'm glad it was introduced to myself"*
	1.2 Ease of use	*"It's just a lot easier 'cause you don't have to think about the letters and stuff and it will autocorrect and things like that."*
2. Negative perceptions about the usability of the mood-monitoring app	2.1 Technical difficulties	*"And I tried to delete it and I don't think it let me so I had to, like, redo the mood."*

	Theme	Sub-theme	Exemplar quotes
		2.2 Perceived expectations of the app	*"...and then it expects you to feel better after documenting it."*
3.	Communication, memory, and engagement with treatment	3.1 Communication	*"It, kind of, made it easier to talk to, like, friends and family, which obviously helps."*
		3.2 Memory	*"… I was able to just look back at my mood diary and I'd remember things basically that I would have otherwise forgotten."*
		3.3 Engagement with treatment	*"It helped me keep a track on what was, what I was feeling at the time"*
4.	Reflection, self-awareness, and affect regulation	4.1 Reflection	*"Like, it just let me just, like, reflect on, like, how I was feeling and then just, like, deal with it better."*
		4.2 Self-awareness	*"...sometimes I don't actually realise that I'm anxious until I actually, like, sit down and think about it, I guess"*
		4.3 Affect regulation	*"... it would always make me think about something I could be doing to get, like, like to improve my mood."*

Table 17: Overview of clinicians' themes, sub-themes, and exemplar quotes

	Theme	Sub-theme	Exemplar quotes
5.	Clinicians' perceptions of the app usability and output	5.1 Clinicians' perceptions of the app's usability	*"...I think it is a useful tool, yeah."*
		5.2 Clinicians' perceptions of the accuracy of the app output	*"I think the mood reflects on how they're feeling."*
		5.3 Threats to validity	*"The only thing might be that they, when they do lose their phone or they forget and then maybe the results might not be as consistent."*
6.	Increased information, understanding, and implications for the therapeutic relationship	6.1 Increased information	*"...looking at the data you showed me, it sounds like I would get more information."*
		6.2 Increased understanding	*"...it's good to see what their mood's doing when they're not with us and how they problem solve."*
		6.3 Implications for the therapeutic relationship	*"...because you understand patients better, your, you know, your, your therapeutic relationship with patients also improves."*

Table 18: Overview of cross-cutting themes from patient and clinician interviews

Theme	Sub-theme	Exemplar quotes
7. Comparability to other monitoring methods		*"No one writes anything down for me anymore. It's like pens don't exist."*
8. Barriers to compliance and engagement		*"If we get people who are very poorly, they, they might not find it as, as a priority to do, I guess."*
9. Aiding the clinical utility of apps	9.1 Mood recording system and personalisation	*"I think, I think maybe it can be more friendly with visuals."*
	9.2 Coping strategies and the medical integration of apps	*"…it's almost like it want, when you're at that stage, it, it felt like I wanted, wanted it to give me more, more of a, of, of like a, you know, like more, more of an answer sort of thing..."*

Patient themes

Theme 1 – Positive perceptions about the usability of the mood-monitoring app

Sub-theme 1.1 Positive impressions and future use of apps

Views on the mood-monitoring app itself were largely positive. One patient was "*glad it was introduced to myself"* [Participant ID 7, male aged 24], whereas another described the app as *"beneficial"* and believed that *"it helped me'* [Participant ID 16, male aged 22]. Two patients also contemplated using the app outside of the study, either "*in the future if I needed to"* [Participant ID 7, male aged 24] or at the present time:

"I think that might help with, like, around, like, exam time and, like, around about now, because I am quite run down and stuff. [...] So, like, it might help just to kind of, like, think about things, I guess. [...] I might do that, to be honest, 'cause I think it would help me." [Participant ID 1, female aged 18]

Sub-theme 1.2 Ease of use

The app was perceived as convenient in terms of the relative ease and speed with which it could be used. For example, one patient explained that when using your phone:

"It's just a lot easier 'cause you don't have to think about the letters and stuff and it will autocorrect and things like that." [Participant ID 4, male aged 17].

The app's ease of use was strengthened by the design of the app and the supportive features it offers, such as the *"step-by-step guide for every entry you enter"* [Participant ID 7, male aged 24] and the app's provision of examples:

"…if I needed anything taught to me, I could just click on the example tab or just [...] sort of read a little bit, and then it'd tell me exactly what to do." [Participant ID 4, male aged 17]

One other patient, who shared her mood-monitoring data with her clinician after the study, valued the ease to *"go back and scroll up and see the dates and everything"* [Participant ID 12, female aged 21]. She also appreciated having *"documented evidence"* of her feelings, and concluded that the data was useful for health care professionals to see.

Theme 2 – Negative perceptions about the usability of the mood-monitoring app

Sub-theme 2.1 Technical difficulties

Despite the positive feedback, not all patients expressed a preference for app-based diaries over non app-based methods and some reported negative experiences. For example, one patient was not able to locate one of his diary entries, despite saving it on the app [Participant ID 22, male aged 20]. Another patient experienced difficulty with exporting the diary entries from the app using the sharing feature [Participant ID 12, female aged 21]. Moreover, this patient expressed frustrations with being unable to delete an erroneous recording as she *"tried*

to delete it and I don't think it let me so I had to, like, redo the mood" and the repeated requests to enter a PIN when using the app, both of which this patient described as *"annoying"*. It should be noted that no other patient reported problems with the PIN, with one patient perceiving the PIN as an important feature which adds security against potential data breaches [Participant ID 4, male aged 17].

Sub-theme 2.2 Perceived expectations of the app

One patient wanted the app to include positive examples and felt as if the app *"wants you to be upset sort of thing"* [Participant ID 22, male aged 20]. Three patients also reported apprehensions about the reflective 'Change It' feature of the app. To summarise, the app encourages users to consider different perspectives on their diary entry (e.g., *"Look at it a different way: 'In two days' time, how would you look at things?'"*), following which they rate their mood again post-reflection. Although this appears to have not been specified within the app, the 'Change It' feature is applied if the currently experienced emotional state is not helpful, proportionate or considered in full (Kinderman et al., 2016). One patient believed that the app *"expects you to feel better after documenting it"*, despite experiencing no changes in mood, which the patient perceived as *"kind of annoying"* and also wished for this expectation to be removed [Participant ID 12, female aged 21]. One other patient felt that the app was *"too urgent"* and wished the app was *"more delicate in the terms of like the, the way it conveys things"* [Participant ID 22, male aged 20]. He explained:

"… '*cause it seems like it wants you to change, change your mood within the next five seconds, if that makes sense. [...] Whereas obviously, you know, anyone will tell you who has like anxiety that it's not going to happen in five seconds. But there is obviously techniques to*

help calm you down."

Moreover, the app increased this participants's negative emotion on one occasion:

"There was one occasion where I've, I've, I felt quite upset about something, and basically wrote on the app, and then it obviously said, like, 'What were you, how were you feeling at the time?' So I wrote how I was feeling at the time, and it's, 'Go about it a different way.' And, and it just made me more angry for some reason, and I put an even more negative response than the first time."

Theme 3 – Communication, memory, and engagement with treatment

Sub-theme 3.1 – Communication

There was some indication that apps may positively influence communication with clinicians in the clinic. The app appeared to encourage one patient to communicate more honestly with his clinician:

"…she sort of was able to read what I thought rather than me pretending to feel something, or, like ... because people can lie. Whereas, when you're in those sort of moods and you say the, you write down the thing that you're, you're thinking necessarily you can't lie in that situation. Especially for me." [Participant ID 4, male aged 17]

Another patient, who did not recall discussing his mood entries with a clinician, felt positively about the potential effect of apps in communicating information about his moods, stating:

"…it would give them [mental health professionals] a, a basis to work from. Like, they would know how I was feeling, what I was doing to combat my feelings, and then they can offer, well, not, well, advice and other coping mechanisms-slash-support to go along with what I have in place already." [Participant ID 7, male aged 24]

One patient did not find that the app helped her communicate better with her mental health professional at the time, but attributed this to herself (*"I'm not a very open book"*) and her

relationship with technology (*"I'm not a very app, app-y person"*) [Participant ID 2, female aged 23].

Some patients also shared how the app facilitated their communication with friends, family, and significant others, despite not necessarily experiencing benefits in their communication with their clinician. For example:

"It, kind of, made it easier to talk to, like, friends and family, which obviously helps", because, *"rather than just trying to explain to them how I'm feeling, I could just show them and then we'll talk about it, rather than just, well, attempting to explain."* [Participant ID 2, female aged 23].

For one other patient, who noticed a slight change in his interactions with his significant other, the app offered him more time to think about his wording:

"Sometimes I find it hard to put things into words, so writing it down on the app, I do get a bit more time. And it, as much as it doesn't really help me emotionally change, it can, it can help me word things better, if that makes sense. […] Or you know, I'll, I'll be wording things a lot better because I'll have more time to think about it." [Participant ID 22, male aged 20]

Sub-theme 3.2 Memory

Several of the patients described difficulties with recalling their emotions during their appointments, and the way in which the app could have or had helped during these times:

"… I was able to just look back at my mood diary and I'd remember things basically that I would have otherwise forgotten." [Participant ID 2, female aged 23]

"'Cause sometimes, like, I forget, like, what I get anxious about [...] and it's just easier just to show them. So they can, like, kind of, like, understand it a bit better." [Participant ID 1, female aged 18]

One patient also reflected on the impact of the long gaps between appointments. When using the app, she would *"have a way to show, like, 'This is how I felt this day ... and this is how I felt this day, and ... they can just quickly, like, scroll through. So I think that's pretty helpful."* [Participant ID 12, female aged 21]. However, when she did not use the app, she would experience a form of memory bias. That is:

"… if I wasn't using the app I kind of would just pick up on the main, the main mood that I would be having. So, like, if at that time I felt fine then I would just kind of reflect back to that time [...] how I'm feeling instead of, like, thinking back three months or two months, one month [...] or even, like, the last week. It would be, kind of be, like, 'Well I feel fine now so ...'"

Sub-theme 3.3 Engagement with treatment

Patients expressed reservations about the utility of apps in terms of their impact on care and engagement with treatment. Only one patient felt as if the app helped him feel more engaged with his treatment as "*it helped me keep a track on what was, what I was feeling at the time*" [Participant ID 7, male aged 24], whereas one other patient felt the app had potential to improve engagement, depending how it is applied [Participant ID 22, male aged 20]. Although one patient highlighted how the mood-monitoring data can potentially help narrow down the focus of treatment, she did not feel more engaged as a result of using the app [Participant ID 12, female aged 21]. Three other patients reported no differences in engagement but attributed this to limited discussions about the app during appointments [Participant ID 1, female aged 18], generally negative experiences with their treatment [Participant ID 2, female aged 23], and the lack of relevance of their treatment (this treatment was reportedly focused on his "*REM sleep")* to the app [Participant ID 4, male aged 17].

Theme 4: Reflection, self-awareness, and affect regulation

Sub-theme 4.1 Reflection

Several patients fed back how the app aided reflections on their mood. One patient reported that the app helped her *"reflect on, like, how I was feeling and then just, like, deal with it better"* [Participant ID 1, female aged 18]. The mood-monitoring app also *"helps you think about your emotions a lot more"* [Participant ID 4, male aged 17]. One patient thought it was *"really useful to, to, sort of put a, a label on how you're feeling"* [Participant ID 16, male aged 22]. When feeling angry for example, this patient felt it was *"nice to sort of just like think about it, write it down, which I definitely did, did, it did help."*

However, one patient did not perceive the app as *"useful as it could have been"* in its current format, and did not feel that the reflection feature was applied properly [Participant ID 22, male aged 20]. Sub-theme 9.2 describes his suggestion for this limitation.

Sub-theme 4.2 Self-awareness

The app also appeared to help some of the patients develop an increased understanding and awareness of their mood. One patient considered the app helpful because *"sometimes I don't actually realise that I'm anxious until I actually, like, sit down and think about it, I guess"* [Participant ID 1, female aged 18], whereas another patient acquired an increased understanding as he was *"able to identify what's making me angry or, or depressed"* [Participant ID 7, male aged 24]. One patient reported a greater sense of awareness and understanding as use of the app means you *"have to acknowledge it"* and are *"constantly having to, like, document it"* [Participant ID 12, female aged 21].

Using the mood-monitoring app helped some patients also develop a different perspective on their moods. One patient felt that the app *"let me kind of know that, like, some stuff I've been getting anxious about it's not really worth it"* and helped her realise that *"not everything was, like, as bad as it was 'cause I was mostly happy most of the time"* [Participant ID 1, female aged 18]. Similarly, another patient appreciated being able to record his *"positive moods when I felt positive, which seemed to be more often than not"*, and said to have been surprised by the number of positive moods he was experiencing [Participant ID 7, male aged 24].

In contrast, for one patient the diary data contributed to obtaining an increased awareness of her negative moods but did not help her understand her moods better [Participant ID 2, female aged 23]. Other patients similarly reported mixed feedback. One patient for example, felt that the app was *"useful for identifying, sort of, patterns in, in emotion and sort of mood […] but maybe not necessarily like what the actual cause of that pattern is"* [Participant ID 16, male aged 22].

Another patient similarly did not experience a greater understanding of his moods but did acknowledge some changes in awareness, which depended on the intensity of his moods, and let him *"consider just things more and think about it"* [Participant ID 22, male aged 20]. One patient said his awareness *"hasn't really changed much"*, explaining that he was *"not very good at that anyway"* [Participant ID 4, male aged 17]. The only difference he experienced was *"the fact that I could, I could visually see, like, what emotions I was feeling"*. This experience was shared by other patients who appreciated being able to *"observe, like, what I was feeling"* [Participant ID 7, male aged 24], *"looking retrospectively […] seeing how you felt"* [Participant ID 16, male aged 22], and being able to see *"how far I came when I, like, read through all the things"* [Participant ID 1, female aged 18].

Sub-theme 4.3 Affect regulation

One of the key benefits of using the mood-monitoring app for some patients was that it provided a form of emotional outlet and reduced the "emotional burden". For example:

"When I didn't [use the app], it was almost like I had the world on my shoulders. A heavy weight and stuff like that. Like, the, the, the proper cliché sort of metaphors of having a lot of things on your mind. But then, like, when I was using the app, there was a lot of those ones that were going down onto the, the page. And so it was lifting quite a heavy weight off. And then you can sort of carry on." [Participant ID 4, male aged 17]

Similar to the patient who reported to 'consider things more' (see above), two patients reported reductions in their impulsive or reactive behaviours as a result of using the app:

"... like, I used to not really think about it, but then it actually let me, like, sit down and think, like, 'What can I do to,' like, 'make it a bit better?' than just act upon it, I guess." [Participant ID 1, female aged 18]

"It stopped me cutting, which was good because I managed to circumvent it by taking the five minutes out and doing, and doing an entry before or, yeah, just before I even felt like I needed to. So it stopped me." [Participant ID 4, male aged 17]

Whilst one patient described how writing mood-entries *would "always make me think about something I could be doing to get, like, like to improve my mood"* [Participant ID 16, male aged 22], another patient reflected on how he could learn from his previous app entries *"if I was angry and depressed in the future"*, and could then review *"what coping mechanisms I used back then to calm my anger and depression when I was writing future entries"* [Participant ID 7, male aged 24]. Although the app did encourage this patient to utilise safe coping skills, he acknowledged that this was done alongside the skills he had learnt in therapy.

Some patients also felt the app helped them take control of their mood. One patient felt that the app did help him take control of his mood and said that it helped him think more positively [Participant ID 7, male aged 24], whereas one other patient found that the process of labelling his mood was helpful, and explained *"it was good to sort of, me, make me think about, put it in my brain, like what I could be doing to just sort of just like control my mood, and stuff"* [Participant ID 16, male aged 22]. One patient expressed feeling better after writing things down, as it is *"nice to think about it in your head, but actually getting it on paper lets you actually know, like, how to deal with things and, like, how you can make it better and stuff"* [Participant ID 1, female aged 18]. She later spoke about feeling more independent as a result of the app:

"…when I was, like, talking to, like, I forgot what her name is, like, I guess I couldn't, like, remember it all, like, the emotions I have. […] And then afterwards, like, like, with the app, like, I kind of, like, knew them, and I kind of could deal with it myself, like. I feel like I was, like, relying on, like, other people more than, like […] myself. And when I used the app like I was relying on myself a bit more. […] I mean, obviously it's nice to have people to help, but, like […] in, like, like, you know ... to be honest with you, like, most of the time you've only really got yourself."

For some patients, however, there was little to no change in their ability to regulate or take control of their mood and mental health. One patient explained that she *"went on about things like I usually would" but would be writing about it as well* [Participant ID 2, female aged 23]. For another patient, *"there was two or three occasions where it reminded me to actually kind of calm myself down a little bit"*, but generally speaking found that the app did not have an effect [Participant ID 22, male aged 20]. Moreover, he expressed it *was "a lot better to use like an actual person to vent to rather than the app."*

Clinicians' themes

Theme 5: Clinicians' perceptions of the app usability and output

Sub-theme 5.1 Clinicians' perceptions of the app usability

Clinicians seemed positive about the use of mood-monitoring apps in clinics. Clinicians described the app as "*a useful tool*" [Clinician ID 3, Psychiatric Nurse], "*brilliant*" [Clinician ID 2, Assistant Practitioner], and "*accessible*" [Clinician ID 1, Psychiatric Nurse]. Whilst some clinicians reported to have already been promoting the use of apps in clinics, others were now keen to recommend the 'Catch It' app to young people. Although the app was considered as easy to use by some, one clinician highlighted the importance of staff practice:

"…it would be good for us to play with it as well, with obviously without that information going anywhere just so we can demonstrate, 'This is how you do it [...] this is how it works'". [Clinician ID 3, Psychiatric Nurse]

Sub-theme 5.2 Clinicians' perceptions of the app output

Clinicians' evaluations of the app output suggested that the mood-monitoring data accurately presented their patient's mood. One clinician noted that the app *"reflects on how they're feeling"* and that, without the app, young people might experience more difficulty with accurately rating their mood, because:

"…people tend to sort of judge their mood when they are, when they're quite intense and not necessarily retrospectively. So when it's happening there and then, it can be quite intense for them. But it might not be reflected in what their actual presentation is." [Clinician ID 2, Assistant Practitioner]

One clinician, who observed that the *'mood dysregulation is apparent in their, the data entry'*, also reflected on the diagnostic validity of the data for one of her patients with Autism [Clinician

ID 5, Consultant Psychiatrist]. She noted that the *"concreteness in, in the, in her responses is, is also quite evident. So it truly is reflective of, of this patient's, you know, difficulties in, in reality as well."*

Although the data seemed to correspond with young people's mental states, it was difficult to ascertain problems with affective instability for some of the clinicians. One clinician for example, felt that her patient's *"mood seems relatively settled"* and that for *"different conditions, I'd expect more of a variation"* [Clinician ID 1, Psychiatric Nurse]. Another clinician noted an improvement in her patient's mood. That is, whilst her patient's current mood-monitoring data *"would probably be as I would expect it"*, in the previous year *"there probably would have been a lot of, a lot more [...] kind of, negative stuff such as anger [...] annoyed, frustration."* [Clinician ID 6, Psychiatric Nurse]. It should finally be noted that for one clinician, there was a contrast between the mood-monitoring data and a patient's presentation in clinics. She explained:

"I mean, one of the ones that you showed me, the girl that you showed me [...] I would expect, but knowing her, she would present very differently in clinic. [...] She would either present to me as, 'Everything is fine,' or she would present to me, 'Everything is very bad.' But this kind of gave me a good fluctuation [...] (inaudible) that it's in between actually. [...] So it kind of brings everything in the middle, gives me a more average account of things." [Clinician ID 4, Consultant Psychiatrist]

Clinicians also discussed opportunities for reflection on the mood-monitoring data with the young person which can *'help us build, like, a relapse prevention plan'* [Clinician ID 6, Psychiatric Nurse] and help set future goals, by saying *'"You've done this and …" which is a positive. "How can we use that again if we're faced with this in the future?"'* [Clinician ID 2, Assistant Practitioner].

Sub-theme 5.3 – Threats to validity

Clinicians identified several circumstances in which the accuracy and consistency of mood-monitoring data could be compromised, such as when they *"lose their phone or they forget"* [Clinician ID 6, Psychiatric Nurse]. Two clinicians discussed potential issues with the app's default rating of '1', which may lead to some app users not scoring their mood accurately and choosing this default rating automatically. Making young people aware of this, can help obtain a *"truer reading"* [Clinician ID 3, Psychiatric Nurse]. According to one clinician, young people may also be cautious of the potential interpretations of their mood ratings and what effect this may have on their treatment. Young people might think:

"'Oh, Dr [name doctor] gonna see this,' and, 'Let me just make sure that I put everything on five, because I don't want that antidepressant.' [...] That's the only worry that I have, that, you know [...] would the data get skewed because they feel that it's going to be, you know, interpreted in, in clinical situations, and would they be, would that change as a result." [Clinician ID 5, Consultant Psychiatrist]

There is also a possibility that service users *"might hide things"* or if *"somebody is, is extremely suicidal, they, they may input things differently"* [Clinician ID 5, Consultant Psychiatrist]. As this can affect the accuracy of information, this clinician noted she *"would have to base it on not necessarily the data that I see, but also the, my clinical observation [...] and assessment of the patient."*

Theme 6: Increased information, understanding, and implications for the therapeutic relationship

Sub-theme 6.1 Increased information

Clinicians discussed the various ways in which mood-monitoring apps may be beneficial in clinics. Upon reviewing the data from the mood-monitoring app, several clinicians asserted that the app provides a greater quantity of information. Not only does it give *"you extra information"* [Clinician ID 1, Psychiatric Nurse], it also gives *"a very indepth knowledge when it's used correctly"* [Clinician ID 4, Consultant Psychiatrist].

Several clinicians discussed the difficulties in obtaining information from young patients in clinics. These difficulties were partly attributed to difficulties in remembering details during appointments, and thus could potentially be ameliorated by means of apps. For example:

"…when someone's away from you, you know, they're thinking and they're feeling and they're having all these emotions, and then when you see them a week later, they've often forgot about what they've been feeling. So, for me diaries are brilliant, on the whole". [Clinician ID 1, Psychiatric Nurse]

"...sometimes we, or the, the service users struggle to remember what happened last week or two days ago. So this would be a good way of monitoring, having it on there. And it's a, I think for them it would be a nice, cool way to do that." [Clinician ID 6, Psychiatric Nurse]

Sub-theme 6.2 Increased understanding

It was suggested that the use of apps, particularly in young people who ordinarily struggle with communication, *"might be the first sort of building block to them to understand their emotions."* [Clinician ID 5, Consultant Psychiatrist]. In addition, it may help strengthen clinicians' own understanding of young people. Given the limited time available in appointments, one clinician appreciated being able to *"see what their mood's doing when they're not with us and how they problem solve"* [Clinician ID 2, Assistant Practitioner]. Clinicians also valued being able to know *"exactly how often our service users experience mood swings or exactly how it works, and how*

they can reflect on it afterwards" [Clinician ID 6, Psychiatric Nurse] and gaining a better understanding of their lifestyle, such as *"his activities and what time he's up, where he's been"* [Clinician ID 1, Psychiatric Nurse]. The mood-monitoring data offered one clinician a new perspective on one of her patients' mental health. She explained how:

"…you can make links between his eating problems and his moods. So, for example, he felt anxious, that's when he started eating, and then that reflects on his depression. So that's a circle that, you know, the cycle of emotions that he goes through. And if we can tackle his anxiety, perhaps we can tackle his eating a bit better and his moods a bit better. But this is the first time I've sort of seen it and connected the dots, and I wonder if he connected the dots for him whether he'd benefit from this as well. So, I think it's very, very useful from so many aspects." [Clinician ID 5, Consultant Psychiatrist]

Sub-theme 6.3 Implications for the therapeutic relationship

Clinicians agreed on the potential positive influence of apps on the therapeutic alliance. It was felt that *"...because you understand patients better, your, you know, your, your therapeutic relationship with patients also improves"* [Clinician ID 5, Consultant Psychiatrist]. One clinician felt she could use the data to build on young people's strengths as a way of improving the therapeutic relationship, as she would be able to say *"you've achieved something really well, you've been able to do this, you've shown that you managed and utilised coping strategies"* [Clinician ID 2, Assistant Practitioner]. Another clinician also appreciated potential opportunities for collaboration, and explained how:

"it builds my relationship with them because I could turn around and say, 'Let's look at it together,' kind of a thing. So, and we are not just going by their word. [...] And I'm not just showing my interpretation. [...] So some, somebody else's random analysis or list is there. [...]

So it might actually, they might actually feel that this person is not saying it, it's me who's done it actually.' [Clinician ID 4, Consultant Psychiatrist]

One clinician felt that the app data *"would give us that conversation to be able to build on"* [Clinician ID 2, Assistant Practitioner]. Two other clinicians commented on the sense of comfort and safety mood-monitoring apps could offer. Apps can provide young people with the space to be open and remove any fear of judgement [Clinician ID 5, Consultant Psychiatrist]. On a similar note, it was felt that:

"…sometimes it might be easier for them to, to use the app [...] monitor how they're feeling there [...] rather than telling me. So they might feel more, what is it, comfortable [...] doing that. And then [...] maybe just show me afterwards [...] rather than them being scared, 'Oh, this is how I felt.'" [Clinician ID 6, Psychiatric Nurse]

Patient and clinician themes

Theme 7 - Comparability to other monitoring methods

Several comparisons were drawn between the use of paper-based diaries and app-based diaries. Interviewees commented on the appeal of this technology for youth:

"…I think a lot of, like, people my age, our phones are normally next to us or near us. So we prefer using that rather than writing almost. So it's, it's, it was a lot more innovative I'd say. A lot more appealing for, for young people." [Participant ID 4, male aged 17]

Clinicians also perceived it as *"more cool when a, when a clinician says, 'Oh, there's an app,' [...] rather than a [inaudible] old style pen and paper, with this generation"* [Clinician ID 4, Consultant Psychiatrist] and believed that *"it really suits young people"* [Clinician ID 1, Psychiatric Nurse].

Some patients, who previously used paper-based diaries, reported that this method was *"more difficult to maintain"* [Participant ID 16, male aged 22] and that they'd *"always forget"* [Participant ID 2, female aged 23]. Clinicians similarly addressed how apps may help overcome issues with compliance. One clinician described instances where she would *"send someone with a sheet to complete, and that gets lost"* [Clinician ID 1, Psychiatric Nurse]. Moreover, in her experience *"no one writes anything down for me anymore. It's like pens don't exist"*, whereas phones and apps *are "really accessible"*. One other clinician experienced similar difficulties with paper-based diaries. Through apps, she believed:

"I would get more compliance in getting the mood diaries. [...] And I would get any data at all. [..] Because normally, at the moment, in the last three years I've not had anyone actually complete a mood diary for me. [...] With almost a couple of days maybe, but not consistently. So if I've got a week or two weeks good data. [...] So I know people (inaudible) kids will actually do it.[...] And because when they're stressed they'll have their phone on them." [Clinician ID 4, Consultant Psychiatrist]

Finally, one patient valued the increased privacy afforded by apps in comparison with paper-based methods, and expressed:

"…it's almost like more subtle to go on your phone. [...] no one like knows you enough to look at your phone for something. [...] Everybody respects your privacy, whereas if I was, I don't know, writing in a book, they'd be like, "Oh, what are you writing?" they're more, more curious." [Participant ID 16, male aged 22]

This patient also perceived the phone itself as a visual reinforcer compared to other monitoring methods:

"… I reckon just like having an app in your phone you're more likely just to remember to like pop in. 'Cause you see it when you like open up your, like your, like your, like the, your, your

homepage on your, on your phone. […] And you see the app there, you're like, 'Oh yeah,' I, I, I, I will, I will constantly like reinforce. That's the power of like sort of phones nowadays is you're constantly reinforced about, like, looking at it and stuff. Whereas a, a little book that you, you struggle to find, your, almost like your mood goes, you get so frustrated with finding, you're like, 'Oh, I can't be bothered anymore,' so ..." [Participant ID 16, male aged 22]

Theme 8 – Barriers to compliance and engagement

Although the app was perceived as useful, some clinicians questioned its utility for certain young patients. One clinician reflected on the impact of a patient's mental state on the usability of apps, stating:

"…if I look at another patient who I've got in my head, he doesn't charge his phone, he's quite chaotic, he's has other priorities, you know, so I think it could be problematic, yeah. For a more chaotic person, it's just not going to happen, you know, they don't even charge the phone." [Clinician ID 1, Psychiatric Nurse]

One other clinician similarly reflected on the impact of patients' mental state and at what stage they are at their recovery, because *"if we get people who are very poorly, they, they might not find it as, as a priority to do, I guess"* [Clinician ID 6, Psychiatric Nurse]. Young people's ability to engage with the app may be an indicator of their reflective ability, said one other clinician [Clinician ID 5, Consultant Psychiatrist]. However, f*or "some of the patients that reflective ability isn't there"*, which puts into the question the utility of the app for some of those patients.

Similarly, one patient identified the frequency of mood changes as a potential barrier to using the app, stating that:

"… if I was to just use that app whenever I had, like, a mood change I think it would be more annoying because, like, it would be every time that I have something happen I would feel like I need to put it in. And it would be, like, extra effort, if that makes sense." [Participant ID 12, female aged 21]

This patient also believed that the app is more useful for people whose moods are elicited by specific triggers, which makes it easier to reflect, compared to people who experience no antecedent or immediate trigger.

Finally, although compliance was generally perceived to be better for apps, some patients' compliance was negatively affected either due to "*forgetting to record on some days"* [Participant ID 7, male aged 24], or due to perceiving themselves as *"very lazy"* [Participant ID 4, male aged 17]. This meant that *"even if it was just really easy to use, I would, just wouldn't use it"*.

Theme 9 - Aiding the clinical utility of apps

Sub-theme 9.1 Mood recording system and personalisation

Several suggestions were made for the improvement of the mood recording system. Some patients wished the app had the option to record multiple emotions at once, expressing that *"I feel like sometimes you can be feeling two different things at once"* [Participant ID 22, male aged 20] and that *"there's probably loads of people out there like me that have multiple emotions at once"* [Participant ID 2, female aged 23]. It was suggested that such a feature would reduce the time it takes to describe the multiple moods and might make the recording process more structured.

Upon evaluating the mood recording process, two clinicians also questioned whether the app could have been *"more friendly with visuals"* [Clinician ID 4, Consultant Psychiatrist]. The use of *"some symbols"* [Clinician ID 4, Consultant Psychiatrist], *"smiley faces"*, or *"any other sort of visual method of communication"* were suggested, instead of *"people quantifying their emotions"* [Clinician ID 5, Consultant Psychiatrist]. The implementation of calendars was also proposed, which could provide *a "good visual graphical understanding"* [Clinician ID 4, Consultant Psychiatrist]. For example:

"…they might come along, 'I'm having such a crap day.' [...] And then they can look at their phone [...] and say, 'Actually my week has been okay.' [...] 'It's mostly been ambers and greens.' [...] 'And one red doesn't [...] go, or doesn't harm that much.'"

Similarly, one patient commented on the availability of *"graphs and stuff for people with mood disorder"* and expressed that in order *"to make it more diverse and more, have more variety it would be better, like, to have different options for different people"*, as opposed to *"it being expected and required"* [Participant ID 12, female aged 21]. Other examples included the *"option to add comments"* and being able to keep recordings private, because:

"…if you are using this for a healthcare professional and you don't want to show them everything […] you're going to be more likely to not document when you're feeling, like, 'I don't want anyone to know I feel this way.' So if you could just, like, pick or choose maybe at a later date you could go back and just show them, like, "Oh I felt embarrassed about this but now I'm feeling more ..." […] "... willing to show." So I think that's, like, that would be good.'

One patient believed the app would have been more useful if it was able to automatically identify key words used by the app users when describing their feelings and mental health, and help users reflect on these person-specific diary entries [Participant ID 22, male aged 20].

Other suggestions included the option to record overall moods which ask, *'How was the day generally?'* [Clinician ID 4, Consultant Psychiatrist] and an audio recording feature to help simplify the recording process:

"Cause I wonder with him, my patient, he didn't write a lot. [...] It was all well and good scoring and pressing a button, so to make it easier, to just dictate, I suppose, that's the only thing.' [Clinician ID 1, Psychiatric Nurse]

Sub-theme 9.2 Coping strategies and the medical integration of apps

Some clinicians believed it would have been useful if the app had been more closely integrated into mental health services as opposed to being delivered on its own. At the clinic level, discussion around the use of apps could be included as a standard part of the appointment, where young people can be asked *"How are you getting on with your app"* [Clinician ID 2, Assistant Practitioner].

At the Trust level, some interviewees wished the app data was available, and regularly transferred, to clinicians. One patient, for example, expressed how the treatment process could be improved if the app was integrated with their medical account, explaining:

"If they can view the diaries to see exactly how you're feeling and, and then they can kind of figure out trends, as you know, if you, say for instance I was, if I was to mention certain things again and again, they keep on making me upset, then they'd know instantly, by the next appointment, about it. And it would mean, you know, every appointment that people go to, as well, they'd have, they'd have sort of would have more context without them even saying, say, without them saying, 'Okay, what's been happening recently?' […] You know, they'll already know some, some things already." [Participant ID 22, male aged 20]

The availability of mood-monitoring data before appointments may help with clinicians' preparation, as *'before clinic I can actually look at it [...] and be ready for them'* [Clinician ID 4, Consultant Psychiatrist]. One clinician also felt it would be *'useful to have this data before I see my patients for new assessments, and as an ongoing sort of report as well for people with affective disorders, as well as emotional, you know, dysregulation problems too'* [Clinician ID 5, Consultant Psychiatrist].

This clinician also raised concerns regarding young people's safety *"when documenting extreme scenarios"* and the lack of availability of this data to clinicians. She gave the example of a young person who may be feeling suicidal and records an entry about that. The young person may:

"…feel like actually they've done something about it, but actually they haven't really talked to a professional [...] and that data is sitting somewhere [...]. That's the dangerous side of things, I feel. That if the data was available to a clinician, for example, you can see a trend actually there. The suicidal reports are increasing now, they have more unhappy days, or they have started, stopped inputting the entries, and you would be thinking, 'Okay, what's really going on?' So I think the fact that I don't get to see it or a clinician is not really look, monitoring it makes me feel a bit concerned as to the safety of patients."

Patients commented on the need for in-app coping skills suggestions such as *"...just distract yourself from redoing, like ..."* or *"just listen to this"* [Participant ID 16, male aged 22], and considered the app as too generalised and found it lacked a *"real input"*:

"…it's almost like it want, when you're at that stage, it, it felt like I wanted, wanted it to give me more, more of a, of, of like a, you know, like more, more of an answer sort of thing. Whereas it just said, 'Oh, you, you feel negative, just change it.' Sort of thing, know what I mean? But again I think generalisation, especially for people who have anger, anxiety, or feel, or loneliness,

or anything like that. That it's not, it's not going to work when it's generalised." [Participant ID 22, male aged 20]

Similarly, one clinician suggested the addition of help-seeking or coping skills features as well as the importance of documenting risk behaviours and care plans into the app:

"…so that when the patients are having their really down days or down moments then they have a plan, because at the moment they're just inputting the data, and that's it. No help there. So what can they do about it is something that if the app also had would be fantastic. Other things, for example, we, we advocate applications like, is it Headspace, and CALM, and those sort of things help patients. If that, again, was a part of something like this ... […] then the application is not just for monitoring the mood, but it's also to seek help as well."

Other suggestions to improve the clinical utility of the app was to link the app data with young people's medication intake with the aim to improve compliance (e.g., *"If I take this medication then I've had these good days"*), the provision of emergency numbers such as the *"crisis team"* within the app [Clinician ID 5, Consultant Psychiatrist], and the availability of a Trust directory of apps [Clinician ID 1, Psychiatric Nurse].

Sub-theme 9.3 Reminders

The use of the separate reminder app was an important factor in maintaining compliance with the app for some patients:

"… if I wasn't, like, having alerts I wouldn't really use it [...] unless I was actually, like, going out and wanted to reflect on if I did have a mood change". [Participant ID 12, female aged 21]

It was suggested by some that the app could be improved by building in the reminder feature, which removed the need to download and use a separate app. Moreover, a built-in random

reminder could "*lead to more accuracy and emotions rather than picking and choosing when you do it*" [Participant ID 22, male aged 20] and help prevent the over inclusion of *"extreme"* positive or negative moods. [Clinician ID 4, Consultant Psychiatrist]

7.4. Discussion

The aim of the study was to qualitatively investigate the usability, clinical utility, and impacts of the 'Catch It' app from the perspective of young patients and clinicians in mental health services. Key findings in relation to each research question are discussed below.

7.4.1 What are young patients and clinicians' perceptions of the 'Catch It' app?

Perceptions of the 'Catch It' app were largely positive across the patient and clinician samples. Patients considered 'Catch It' to be an innovative, straightforward, and convenient mood-monitoring tool, which may provide users with *"documented evidence"* of their moods. This is particularly useful for patients with affective instability who can feel as if they need to prove the validity of their symptoms to their clinicians (Bilderbeck et al., 2014). Although the mood-monitoring app can offer a greater degree of privacy and accessibility to young people compared to paper-based methods, not all young people expressed a preference for digital mood-monitoring methods or preferred a combination of in-person and digital methods. Consistent with previous studies (Grist et al., 2018), this suggests that mental health apps, including mood-monitoring technologies, are not universally acceptable to young people and should be considered as an adjunct to standard care.

Similar to previous research (Schueller et al., 2016), clinicians expressed favourable attitudes towards the utility of apps in clinical practice. Clinicians valued being able to better understand their patients' use of coping strategies, activities, and lifestyles. Some clinicians in this study

had already been promoting mental health apps in clinics. Others intended to recommend the 'Catch It' app to their patients after they had reviewed the information obtained through the app. This is encouraging, as patients are more likely to use mental health apps if these have been 'prescribed' or recommended by their healthcare providers (Schueller et al., 2016). Although a small number of studies have researched clinicians' perspectives on factors that may potentially improve or reduce their adoption of apps in mental health settings (Pierce et al., 2016, Schueller et al., 2016), very few clinicians in studies actually use apps in their current practice. Factors that predict the real-life uptake and maintained use of apps by mental health providers therefore remain underexplored and require further investigation.

7.4.2 What are the clinical and treatment benefits of the 'Catch It' app from the perspective of young patients and clinicians?

Use of the 'Catch It' app may have important clinical and treatment benefits for young patients and clinicians. The act of self-monitoring and labelling emotions, for example, helped some patients develop a greater understanding and awareness of their mood. As observed in previous studies, this increase in emotional self-awareness may consequently improve mental health outcomes (Kauer et al., 2012). Moreover, use of these app-based technologies may also encourage patients to use effective self-regulation strategies to effectively manage their mental health (Terp et al., 2018). Indeed, some patients reported an improved ability to safely and independently cope with their moods as a result of using the app. This supports that smartphone apps can promote patient empowerment, which in turn may help improve patient outcomes and experiences (De Santis et al., 2018).

The mood-monitoring process also provided patients with a platform to express their emotions. While the inhibition of emotions can be detrimental to physical and emotional health, the expression of emotions can increase control over depressed mood and release accumulated

emotional energy or tension (Ullrich and Lutgendorf, 2002, Graham et al., 2008). Although initial qualitative evidence was found suggesting that app-based methods may have similar effects (e.g., one patient felt that a heavy weight was lifted of his shoulder when using the app), further research is needed.

Consistent with findings from the quantitative mood-monitoring study, the qualitative feedback indicated that young patients experienced a reduction in their impulsive or reactive behaviours as a result of using the app. This may be attributed to the aforementioned 'Change It' feature of the app, which encouraged users to consider other perspectives or ways of thinking (Kinderman et al., 2016). This finding further stresses the importance of supporting young people in the use of cognitive reappraisal strategies, which could help them better manage their affective experiences (Gruber et al., 2014). Nevertheless, some young people negatively appraised this feature and the expectation to feel changes. Although participants were offered reassurance during the quantitative study if they did not experience a difference in mood (e.g., see Appendix 5), further guidance might be needed to reduce potential pressures.

Feedback from both patients and clinicians highlighted the difficulties that patients with affective instability can have in discussing, recalling, and estimating their moods over time (Bilderbeck et al., 2014). It was believed that the mood-monitoring app, through its capacity for ecological momentary assessment, could help patients overcome some of these difficulties by enabling moods to be recorded in real-time (Shiffman et al., 2008, Trull and Ebner-Priemer, 2009). This helped patients to more easily, accurately, and potentially more honestly, communicate information about their moods by showing clinicians their diary data. Moreover, the recording of moods in real time was reported to facilitate patients' communication within their day-to-day lives. Research suggests that the use of multiple informants may produce discrepancies in findings (Larsen et al., 2018, De Los Reyes et al., 2013). Thus, whilst patients reported improvements in outcomes, such as communication, it is unclear how this may have been

perceived by those who regularly interact with patients (e.g., partners, relatives). This warrants the need for multiple-informant designs (Larsen et al., 2018, De Los Reyes et al., 2013).

Finally, qualitative feedback supported the potential of mood-monitoring apps to better prepare clinicians for appointments, assist clinicians with new assessments, and support the development of care or treatment plans. This work package therefore adds more insight into the possible treatment benefits of mood-monitoring apps. However, further research is needed to confirm the beneficial effect on treatment outcomes. For example, one clinician's feedback showed how mood-monitoring data helped her make links between her patient's moods and eating problems. Future studies could further examine this link by exploring the way in which mood-monitoring data may impact the quality of functional behavioural analyses (a type of analysis which helps determine the functions of behaviours (Psychology Tools, 2019)).

Clinicians' feedback also suggested that this technology can help clinicians obtain a greater quantity and quality of mood-monitoring data compared to paper-based diaries. In turn, this information can also improve clinicians' understanding of their patients which may improve the therapeutic relationship. Future endeavours could employ an experimental design in clinical settings comparing an app condition to a non-app condition (e.g., paper-based diaries). Analyses could then assess the impact of the app on outcomes such as 'number of completed mood diaries' (Matthews et al., 2008b), as an index of quantity, and employ measures such as the 'Working Alliance Inventory', as an index of the therapeutic rapport (Horvath and Greenberg, 1989).

7.4.3 What patient and clinician identified factors influence engagement and disengagement with the 'Catch It' app and how may its clinical utility be improved?

Technical difficulties and perceived expectations of the app, including the way in which suggestions were conveyed, negatively affected young people's experiences with the app. Feedback from the Young Person's Steering Group (see Chapter 5) and the patient interviews, therefore stressed the potential impact of language use in apps, which may affect patients' understanding and engagement (Bakker et al., 2016, Williams and Morrison, 2010). This highlights the need for simple, accessible, and concise language.

Apps were considered a feasible mood-monitoring tool by both patients and clinicians. However, given that the feasibility of maintaining the mood diary strongly relied on the use of reminders, it is surprising that a substantial number of apps, such as the 'Catch It' app, either do not offer this feature or do not notify users as intended (Nicholas et al., 2015). Studies focusing on self-help interventions, including technology-based treatment, have demonstrated the impact of reminders on sustaining user engagement (e.g., Christensen et al., 2004), improving adherence, and reducing attrition (Cavanagh, 2010), which highlights the importance of reminders (Bakker et al., 2016). A need for built-in reminders, particularly those that allow prompts to be delivered at random times, was therefore highlighted. Feedback suggested these may better represent how mood fluctuates throughout the day and offer a more accurate and balanced overview of patients' moods – an outcome that was considered important by interviewees.

Patients and clinicians shared a number of other suggestions to improve the clinical utility of apps, some of which may improve app engagement. Examples include the suggestion of coping skills or built-in coping skill exercises, which may help improve patients' mental wellbeing (Anthes, 2016). Whilst promising, caution should be applied regarding the advice offered by some of these apps. Nicholas et al. (2015), for example, carried out a review on smartphone

apps for bipolar disorder and found that some apps offered users inaccurate advice (advising app users to consume strong alcohol to aid sleep during an episode of mania) and information (stating that bipolar disorder can be contagious).

An additional point to consider is the availability of mood-monitoring data to mental health providers. During the study, the 'Catch It' app was used in isolation and therefore not integrated into any medical record or clinical system. Interview feedback suggested this could affect not only the quality of treatment but may also have safety implications. Although the app does contain a disclaimer to seek appropriate professional support if app users are concerned about aspects of their mental health, any risk related information (e.g., suicidal ideation) recorded on the app would remain unreported unless the patient voluntarily chooses to share this data. It should also be noted that there are currently no existing standards for the response to in-app self-injurious behaviours or suicidal intent (Chan et al., 2018). Hence, if mood-monitoring data is not automatically monitored and responded to by the clinical team, this should be made clear to the patient (Armontrout et al., 2016).

Interviewees recommended the full integration and regular transfer of mood-monitoring data, which could help alleviate some of the clinicians' apprehensions about the app. Moreover, with the importance of integrated care increasing, the sharing of data may also help prevent the fragmentation and obstruction of care (Torous et al., 2018b, Torous et al., 2016). The suggestion to include in-app emergency numbers may similarly relieve clinicians' concerns. Fortunately, such features are increasingly offered across apps (Chan et al., 2018).

Other reported recommendations to improve the clinical utility of apps included the incorporation of care plans, a medication intake feature, and the option to record multiple simultaneous moods using alternative methods (e.g., the selection of smiley faces, dictated voice recordings), which may help improve the usability of the app for certain clinical groups.

7.4.4 Strengths and limitations

This appears to be the first study to qualitatively explore young people's and clinicians' perspectives on the usability, clinical utility, and impacts of a publicly available mood-monitoring app. Although the study produced clinically important findings and discussed potential implications for practice, there are a number of limitations which need to be acknowledged.

First, the majority of patients invited to interviews either declined to participate or did not respond to study invitations. Out of these, several individuals experienced difficulties in the quantitative mood-monitoring study either due to problems with the app itself or problems with their mental health which could have negatively affected their experiences. Furthermore, clinicians who took part in the study were already promoting apps or expressed interest in recommending apps. Clinicians who did not take part may not have shared these views or experiences. Given that much of the feedback in this study was positive, it is possible that the final sample may have been biased towards people with more favourable attitudes or experiences. As suggested by Terp et al. (2018), a larger study using a purposive maximum variation sampling strategy, can help diversify the group of participants, and help uncover this issue.

The second limitation pertains to the issue of data saturation. This concept, which was originally linked to grounded theory (O'Reilly and Parker, 2013), is used as a threshold to discontinue the collection or analysis of data, typically when no new data, patterns, or themes emerge (O'Reilly and Parker, 2013, Saunders et al., 2018). There are currently limited and inconsistent guidelines available to help researchers determine whether data saturation has been reached (Guest et al., 2006). Nevertheless, some studies (Guest et al., 2006, Morgan et al., 2002) have suggested that a sample size of 6 to 12 interviews may be sufficient to reach saturation. The current sample

size fell within this range, and no new themes appeared to emerge from the final interviews. However, ideally (e.g., if there were more resources) a larger sample would have been used.

Issues with the interview duration should also be highlighted. Qualitative interviews typically last between 20 and 60 minutes and are affected by variables such as the study topic, the researcher, and the participant (Gill et al., 2008). However, although the work package collected a large amount of clinically relevant data, many of the interviews in the current study were much shorter in duration. One explanation for this is the study design, which was amended due to extenuating circumstances. In brief, the qualitative study was initially designed as a focus group. Therefore, data collection was delayed until a sufficient number of participants were available to partake. As previously mentioned, the focus group had to be cancelled and individual interviews were eventually offered instead. The delay however, meant that some participants' interviews took place long after the quantitative study had completed. For patient interviews, it was noted that participants who recently completed the quantitative study tended to speak for somewhat longer lengths of time than participants who completed the study earlier. Although most participants did not seem to have difficulties with recalling information and participants were given the opportunity to re-acquaint themselves with the data, this delay may nevertheless have affected the quantity and quality of the data.

Several patients also highlighted that their mental health appointments did not overlap with the study period in which they used the app. This meant that some participants did not discuss their data with clinicians and could not evaluate some of the study outcomes (e.g., the impact on the therapeutic relationship). Some patients did share their data but did so with other mental health professionals as opposed to the clinicians who had referred them to the study. Accordingly, clinicians in this study did not get the opportunity to review the data with patients before the study and shared some of their hypothetical insights as opposed to their actual experiences. The inability to reflect on those experiences may subsequently have negatively affected the

length of interviews for both patients and clinicians. Future research should therefore more consciously integrate apps in healthcare services in order to better evaluate study outcomes.

It should finally be mentioned that MD was responsible for data collection in both the quantitative and qualitative study. Although MD's involvement helped establish initial rapport with participants, at an unconscious level, this may have introduced either researcher and/or participant bias into the study. Findings should therefore be interpreted with these considerations in mind.

Chapter summary

This chapter qualitatively investigated the usability, clinical utility, and impacts of the 'Catch It' app from the perspective of young patients and clinicians in mental health services. Individual interviews were carried out, following which thematic analysis was used to uncover patterns within the data. Patient and clinician feedback on the app was generally positive. Apps were considered to be a straightforward, accessible, and feasible mood-monitoring tool, which may improve clinical outcomes (e.g., emotional awareness) and promote patient empowerment. The mood-monitoring app also aided communication within clinical settings and in patients' everyday lives and has the potential to improve assessments, care planning and delivery. App features, such as reminders, emergency numbers, and coping skills suggestions, may help improve the usability and clinical utility of mood-monitoring apps. The chapter also discussed a number of limitations (e.g., possible sampling bias), which could have biased some of the findings.

Chapter 8: Thesis summary

Chapter overview

The aim of this chapter is to integrate and summarise the findings from the four work packages. First, the chapter provides a summary and synthesis of the main findings in relation to the research aim. Then it describes the strengths and limitations of the PhD, through a reflection on the different methodologies and contributions to research. The final part of the chapter compares and contrasts findings across work packages, highlighting the potential implications, including recommendations for future research.

8.1 Summary of main findings

The overall aim of this PhD was to gain an understanding of how digital mood-monitoring technology can be used to support the assessment, engagement, and empowerment of young people presenting to mental health services with affective instability. A combination of quantitative and qualitative methods was used to achieve this aim. Whilst findings from the systematic review demonstrated the potential of apps to improve engagement, this was not supported by the qualitative and quantitative digital mood-monitoring study. The mood-monitoring study duration may have been too brief for a substantial change to occur. This finding may also be attributed to the lack of integration of the app within mental health services. This is further discussed in the 'limitations' section below. Findings from both the systematic review and qualitative study suggested apps can aid assessment in clinical settings. However, evidence in the quantitative work package was less clear, which showed no significant group difference in momentary affective instability. This may be attributable to the relatively small sample size as well as the low-monitoring frequency. Finally, qualitative findings suggested apps have the potential to empower young people, by increasing their ability to control or

manage their moods. Findings across studies indicated that apps can potentially improve clinical outcomes (e.g., impulsivity, awareness) and may have important treatment benefits for both patients and clinicians (e.g., overcoming issues with memory or compliance). The PhD therefore supports the utility of apps in clinical settings, which may be a powerful self-help tool and adjunct to treatment.

8.2 Strengths and limitations

8.2.1 Strengths of the PhD

At the start of the PhD, several reviews had already examined mood-monitoring apps, and described the evidence for their usability, psychometric properties, and potential clinical utility. However, included studies predominantly investigated adult populations or provided scoping review evidence based on findings from a small number of trials and apps (Dubad et al., 2018). This PhD therefore identified and addressed the need for a systematic review specifically focusing on young people. The review highlighted factors that can potentially affect the usability of mood-monitoring apps (e.g., less intensive mood-monitoring schedules) and identified important gaps in the literature. This subsequently helped narrow down the focus for the next stages of the PhD, ensuring the work packages addressed the research areas where evidence was lacking.

For example, as most of the studies in the systematic review used apps that were not publicly accessible, the PhD specifically searched for apps that were available across commercial platforms. In contrast with previous studies that used public apps (Mistler et al., 2017) , this PhD adopted a unique approach for the identification of the optimal mood-monitoring app. This involved a comprehensive two-stage decision-making process, involving a systematic search of apps across large platforms, and the consultation of different stakeholders. This process

better ensured the chosen mood-monitoring app ('Catch It') was suitable for use by young people with mental health problems. Moreover, it provided unique insights into young people's perspectives on mood-monitoring apps, which further informed the design of the quantitative study. For example, as a result of feedback from the young person's steering group, a reminder app was selected that allowed for a greater degree of flexibility (e.g., personalised reminders) to potentially improve participants' experiences.

Studies included in the systematic review also under-investigated the clinical impacts of mood-monitoring apps, particularly their potential negative effects, and typically recruited non-clinical samples or those with less severe psychopathologies. Furthermore, the review highlighted the paucity of qualitative studies that examined the perspectives of both young patients and clinicians. In light of these findings, the final two phases of the PhD employed a combination of quantitative and qualitative methods to investigate the clinical impacts and utility of the 'Catch It' app using data from patients, healthy participants, and clinicians. This mixed methods approach helped triangulate the findings (Torrance, 2012). For example, use of the app improved impulsivity in both the quantitative and qualitative study. Similarly, qualitative data from clinicians and patients suggested that apps can improve experiences with mental health services (e.g., overcoming issues with compliance and memory difficulties). The use of qualitative and quantitative methodologies therefore strengthened the credibility of the findings.

8.2.2 Limitations of the PhD

Notwithstanding this, the PhD also had a number of limitations. For example, whilst the use of a publicly accessible app was a strength of the PhD, the lack of control over the design and functioning of the app presented problems during data collection and analysis. For example, approximately halfway during recruitment, the 'Catch It' app experienced difficulties with

exporting data for some participants with iPhones. Although the app developer attempted to resolve this issue, researchers who use public apps are reliant on the availability of developers and their willingness to address these issues. Moreover, during the analysis phase of the quantitative study, it was not possible to verify participants' compliance with the monitoring app. This was due to the use of a separate reminder app, as the 'Catch It' app did not contain this feature. As such, there was no data linking mood recordings from the reminder app in relation to prompts sent by the reminder app. Studies which use non-publicly accessible apps, however, may have greater control over such features and are potentially less likely to experience these problems.

The lack of integration of the 'Catch It' app within mental health services was another limitation. That is, patients used the app for the purpose of the study rather than as part of their standard care. As a result, most patients appeared to use the app independently without input from their clinicians, whereas some discussed their recordings with other mental health professionals who were not involved in the study. This made it difficult to explore outcomes such as 'impacts on the therapeutic relationship' during the qualitative patient and clinician interviews. Moreover, as the therapeutic relationship is important for successful treatment outcomes (Karver et al., 2006), the lack of clinician input could also explain the non-significant change in retrospectively assessed engagement during the quantitative study (Prentice and Dobson, 2014).

It should finally be noted that there were limited resources available during the PhD, which affected the quality of some of the studies. For example, although the use of a quasi-experimental design in the quantitative study enabled the investigation of app impacts, it was not feasible to conduct a larger randomised controlled trial, which would have increased methodological rigour and quality (e.g., through the random selection of participants, random allocation to conditions, blinding of conditions). Similarly, the use of a single researcher during the app search in the second work package could have potentially increased the risk of errors.

Thus, whilst the PhD produced important findings, findings need to be replicated in larger scale trials which address these shortcomings. Table 19 provides an overview of the main PhD findings, strengths and limitations.

8.3 Implications

8.3.1 Clinical and research implications

As seen in Figure 14, findings from three studies (including the systematic review, quantitative, and qualitative study) indicated that apps are acceptable to patients and clinicians, can potentially increase compliance, may improve clinical symptoms, and potentially increase patient empowerment. This suggests that apps may potentially be an interventional tool, or at a minimum, could be considered as an adjunct to existing treatments. Future studies should investigate: 1) at what stage apps are most effective (e.g., prevention); 2) whether findings can be replicated in patients with more severe psychopathologies; 3) whether benefits can be sustained in the long-term; 4) what specific features of the app contribute to psychological changes; and 4) whether improvements can be attributed to individuals' expectations of apps.

The studies also demonstrated the potential utility of apps for clinical practice. For example, apps may help overcome patients' difficulties with memory recall and facilitate clinical communication. Findings from the systematic review and qualitative study also supported its utility for clinical assessments. In light of the non-significant group difference in momentary affective instability, possibly due to the monitoring schedule, future studies should consider increasing monitoring frequencies, whilst taking into consideration respondent load, to increase the richness of data and better capture affective instability.

Table 19: Main findings, strengths, and limitation of the PhD

Key findings	Evidence obtained from:	Main strengths	Main limitations
1. Apps may support engagement.	Systematic review.	1. The PhD identified and addressed gaps in the literature following a thorough systematic review.	1. Use of a publicly accessible app presented problems during the data collection and analysis phase of the quantitative study.
2. Apps may increase patient empowerment.	Qualitative study.	2. The PhD used a publicly accessible app which was identified through a comprehensive two-stage selection strategy, including a systematic app search and consultation from key stake holders.	2. The 'Catch It' app was used without the direct involvement of clinicians, making it difficult to assess some of the impacts of the app.
3. Apps may aid assessment.	Systematic review, qualitative study.	3. The PhD employed a combination of qualitative and quantitative methods, and included data from both patients and clinicians, which helped triangulate and increase the credibility of findings.	3. Limited resources affected the scope and methodological quality of the PhD.
4. Apps may reduce impulsivity.	Quantitative study, Qualitative study.		
5. Apps may reduce negative mood intensity.	Quantitative study.		
6. Apps may improve emotional awareness.	Systematic review, qualitative study.		

8.3.2 Design implications

Findings across studies also had implications for app developers. To improve the clinical utility and safe usage of mood-monitoring apps, respondents from the qualitative and 'app identification' studies' recommended that apps should have: 1) the capacity to be integrated into patients' medical accounts; 2) offer coping skills and additional safety features (e.g., emergency numbers); 3) provide sufficient security and transparent data access guidelines to protect users' mood-monitoring information; and 4) have a built-in reminder feature in order to verify patients' engagement with the app and improve the quality of information. Apps which have the capacity to tailor or personalise features and offer different mood recording options (e.g., dictation) may improve their usability as well as user experience. App developers should finally be mindful of the potential adverse impact of app costs, non-discrete icons and titles, negative language, and the targeting of apps to specific populations.

8.4 Conclusions

Young people are disproportionately affected by mental health problems and affective instability. Despite this higher prevalence, they often do not receive suitable treatment at this time of need. Findings from this PhD show that smartphone technology, specifically a mood-monitoring app, has potential to improve clinical outcomes for young people. Their use may benefit young people and clinicians alike and are in line with government health policies. If findings are replicated on a larger scale (e.g., RCTs), mood-monitoring apps could positively influence young patients and clinicians' experiences of mental health services.

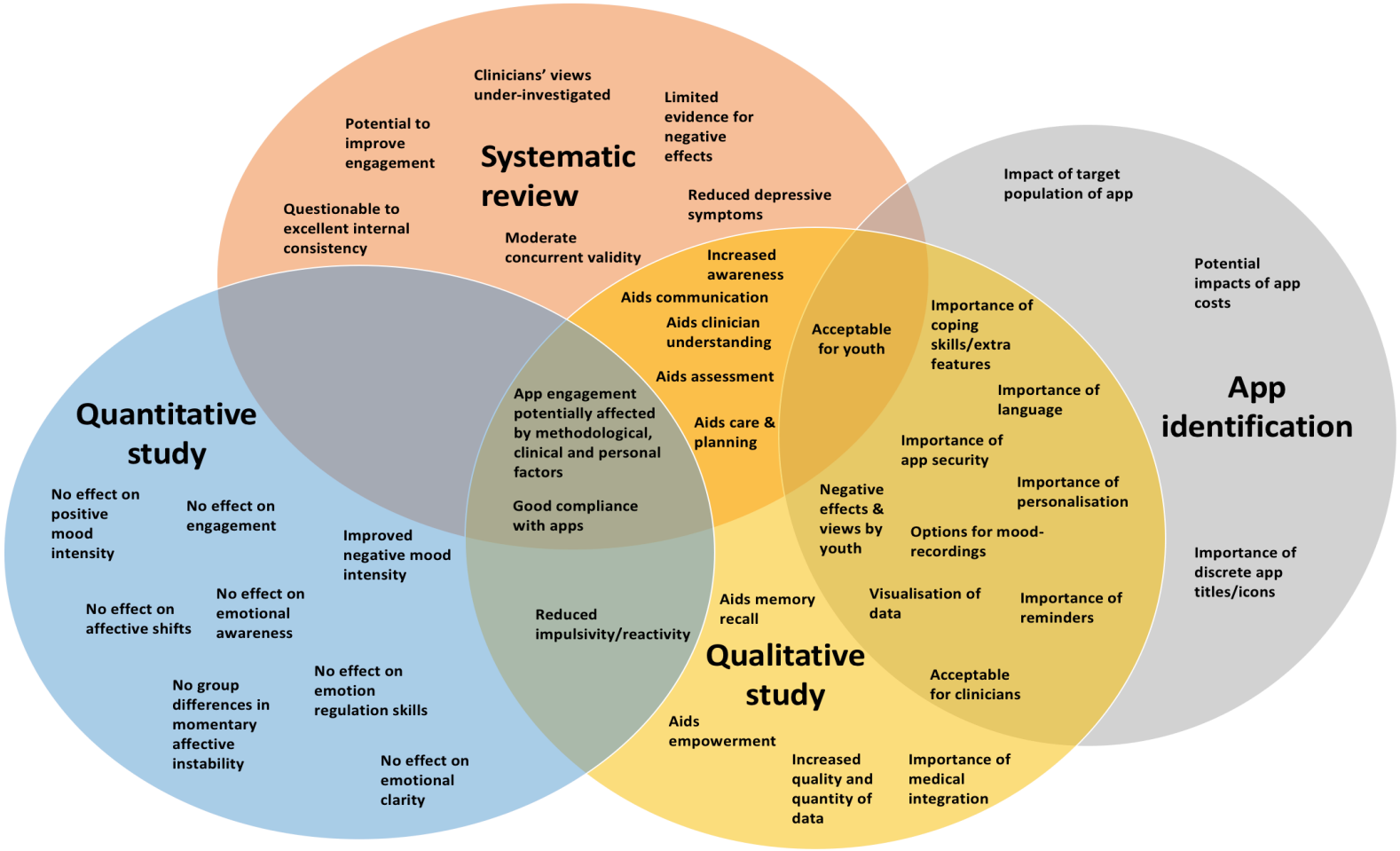

Figure 14: Overview of study findings including similarities and differences

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Appendices

The appendices are presented in the order they are mentioned in the thesis.

Appendix 1: Systematic review

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REVIEW ARTICLE

A systematic review of the psychometric properties, usability and clinical impacts of mobile mood-monitoring applications in young people

M. Dubad[1]*, C. Winsper[1], C. Meyer[1,2], M. Livanou[1] and S. Marwaha[1,3]

[1] Mental Health and Wellbeing, Division of Health Sciences, Warwick Medical School, University of Warwick, Coventry, UK
[2] Warwick Manufacturing Group, University of Warwick, Coventry, UK
[3] Affective Disorders Service, Caludon Centre, Coventry, UK

Background. Mobile mood-monitoring applications are increasingly used by mental health providers, widely advocated within research, and a potentially effective method to engage young people. However, little is known about their efficacy and usability in young populations.

Method. A systematic review addressing three research questions focused on young people: (1) what are the psychomet-ric properties of mobile mood-monitoring applications; (2) what is their usability; and (3) what are their positive and negative clinical impacts? Findings were synthesised narratively, study quality assessed and compared with evidence from adult studies.

Results. We reviewed 25 articles. Studies on the psychometric properties of mobile mood-monitoring applications were sparse, but indicate questionable to excellent internal consistency, moderate concurrent validity and good usability. Participation rates ranged from 30% to 99% across studies, and appeared to be affected by methodological factors (e.g. payments) and individual characteristics (e.g. IQ score). Mobile mood-monitoring applications are positively per-ceived by youth, may reduce depressive symptoms by increasing emotional awareness, and could aid in the detection of mental health and substance use problems. There was very limited evidence on potential negative impacts.

Conclusions. Evidence for the use of mood-monitoring applications in youth is promising but limited due to a lack of high-quality studies. Future work should explicate the effects of mobile mood-monitoring applications on effective self-regulation, clinical outcomes across disorders and young people's engagement with mental health services. Potential negative impacts in this population should also be investigated, as the adult literature suggests that application use could potentially increase negativity and depression symptoms.

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Key words: Ecological momentary assessment, mental health, mhealth, mobile application, mood, mood monitoring, young people.

Introduction

Mood is an affective dynamic, which naturally varies across time and contexts (Trull et al. 2015). Problems with regulating mood can play a key role in the devel-opment and trajectory of a range of psychopathologies (Paris, 2004; Crowell et al. 2009; Marwaha et al. 2015). Traditionally, mood has been assessed with retrospect-ive measures (Trull et al. 2015). This can increase the risk of recall bias subsequently reducing accuracy (Schwartz et al. 1999; Reid et al. 2009). The relatively recent use of ecological momentary assessment (EMA) facilitates the real-time assessment of mood by collecting data on multiple occasions throughout the day (Wenze & Miller, 2010). Thus, it may be more suitable for understanding daily mood changes (Cristobal-Narvaez et al. 2016; Myin-Germeys et al. 2016; van Knippenberg et al. 2016).

Various EMA techniques exist, ranging from paper-and-pencil to physiological assessment (Wenze & Miller, 2010) to digital data collection. A number of UK governmental reports (HM Government, 2011; Department of Health, 2013) highlight the benefits of digital tools and Information and Communications Technology (ICT) in aiding the objective, reliable assessment and care of mental health problems. With demand for mental health services outgrowing avail-able resources (Department of Health, 2013), technol-ogy might relieve some of this pressure by providing

* Address for correspondence: M. Dubad, BSc, MRes, Mental Health and Wellbeing, Division of Health Sciences, Warwick Medical School, University of Warwick, Gibbet Hill Road, Coventry CV4 7AL, UK.

(Email: m.dubad@warwick.ac.uk)

remote resources that increase access to effective treat-ment while reducing clinician load.

Applications ('apps') offer great promise to young people who are disproportionately affected by mental illness or may struggle to engage with mental health services (Seko et al. 2014). Apps are delivered in a medium young people are familiar with. Figures from Ofcom (2015) indicate that 90% of youth between the ages of 16 and 24 own a smartphone, regardless of sociodemographic domain. Given this widespread ownership and apparent attachment to mobile technol-ogy (Ofcom, 2015), youths might feel more comfortable with assessments and treatments utilising mobile apps.

Mental health services increasingly use apps (Olff, 2015), many of which have the capacity for EMA to monitor mood (e.g. Sandstrom et al. 2016b). Several reviews with mainly adult studies (e.g. Donker et al. 2013; Naslund et al. 2015; Nicholas et al. 2015; Torous & Powell, 2015; Bakker et al. 2016; Faurholt-Jepsen et al. 2016; Walsh et al. 2016) have appraised evidence for the use of mood-monitoring apps.

Studies included in these reviews provide some evi-dence for the psychometric properties, e.g. internal consistency (Palmier-Claus et al. 2012) and concurrent validity (Faurholt-Jepsen et al. 2014) of these apps. There is also evidence for usability (Bardram et al. 2013). Participation rates are generally high across studies sampling adults, ranging from 65% (Depp et al. 2015) to 88% (Ainsworth et al. 2013), though Depp et al. (2012) reported much higher completion rates for paper and pencil compared with app mea-sures (82.9% v. 42.1%). Evidence also suggests that apps may help people with mental health problems to monitor triggers (Bardram et al. 2013), that the cap-acity to convey experience can be therapeutic, and that apps could be a useful tool for improving patient–clinician communication (Palmier-Claus et al. 2013).

Less is known about the use of mental health apps, particularly mood-monitoring apps, in youth (10–24 years). A scoping review by Seko et al. (2014) suggested that mood-monitoring apps are positively perceived by youth (Matthews et al. 2008a), may improve treatment adherence (Matthews et al. 2008b) and possibly improve mental wellbeing (Kauer et al. 2012). While intriguing, findings were preliminary due to the low quality of available evidence (NCCMH, 2014), the small number of studies on mood-monitoring apps specifically and the limited number of apps studied (n = 2) (NCCMH, 2014; Seko et al. 2014).

In summary, mood-monitoring apps offer a poten-tially important step change in the assessment of mood and delivery of youth mental health services. Despite this potential and the widespread advocacy for their use (e.g. Firth et al. 2016; Sandstrom et al. 2016a), there are no extant reviews examining the psychometric properties, usability and clinical impacts of mood-monitoring apps in young populations. Therefore, a systematic review was completed to address the following research questions: (1) what are the psychometric properties of mobile mood-monitoring apps; (2) what is their usability; (3) and what are their positive and negative clinical impacts among clinical and non-clinical youth populations? Our secondary aims were to frame our findings within the adult literature, and conduct a quality assessment to examine potential sources of bias.

Method

Following a scoping review, the authors developed the protocol delineating the planned methodology. The review was conducted in adherence to this protocol, and in line with the PRISMA statement (Moher et al. 2009).

Information sources and search strategy

The following sources were searched: Medline, EMBASE, PsycINFO, ProQuest Dissertations & Theses, ProQuest SciTech Collection, the Association for Computing Machinery (ACM) Guide to Computing Literature and Web of Science for articles published from 2008 [the year when the first app was launched (Donker et al. 2013)]. Search terms were informed by pre-vious reviews (Seko et al. 2014), and modified following advice from a medical librarian and field experts. The search was conducted by combining five groups of terms (see online Supplementary Table S1) relating to: type of technology (e.g. 'mhealth'), type of assessment (e.g. 'ambulatory assessment'), mood-related outcome or problem (e.g. 'bipolar disorder'), youth population (e.g. 'youth'), usability/treatment-related outcomes and psychometric properties (e.g. 'reliability', 'validity'). We were interested in all forms of validity potentially exam-ined in the app literature, e.g. concurrent, face or predict-ive (Faurholt-Jepsen et al. 2016), though we anticipated a paucity of studies due to the novelty of the field. We defined the 'usability' of mood-monitoring apps in accordance with the International Organisation for Standardisation (2001) definition of usability, i.e. 'the capability of the software product to be understood, learned, used and attractive to the user, when used under specified conditions'. Consistent with previous systematic reviews (Donker et al. 2013), we included young people's participation rates (i.e. compliance, response and completion) and how apps were perceived by youths (including their acceptability – how satisfied they were with the app, whether it could be used with ease) as markers of usability.

MD conducted a hand search of articles published in Cyberpsychology, Behavior and Social Network, the Journal of Medical Internet Research (JMIR), the JMIR Mental Health, and the JMIR mHealth and uHealth over the last 5 years. An additional search of the first 15 pages of Google Scholar was conducted (search terms 'mood', 'phone', 'app' and 'monitoring'). Reference lists and in-text citations of relevant articles were inspected. Finally, subject experts were approached to identify additional articles.

Study selection

Inclusion criteria were:

(1) Apps must have been developed for, and delivered through, mobile phones or smartphones;
(2) Participants aged 10–24 years (consistent with the World Health Organisation's definition of young people; World Health Organisation, 1986);
(3) Studies included published and unpublished research reported in the grey literature;
(4) Studies must have been published in the English language;
(5) Studies must have been published in 2008 or later;
(6) Studies must have included community or clinical populations (to ensure the inclusion of sub-clinical youth, who may subsequently access care).

Screening procedure

Following removal of duplicates, MD and ML independently screened 100% of titles and abstracts for full-text retrieval. MD assessed full-text articles against the inclusion criteria and extracted relevant data.

Quality assessment

MD evaluated the quality of included studies for potential risk of bias using Cochrane's risk of bias tool, in which studies are allocated a rating of high, low or unclear risk of bias (Higgins et al. 2011).

Data synthesis

Quantitative and qualitative data were synthesised narratively.

Results

Study selection

A total of 1747 articles were identified in the initial search, and 19 from the hand search (Fig. 1). Following removal of duplicates, 1176 abstracts were screened, 86 of which were selected for full-text retrieval. There was a high level of agreement between raters ($\kappa = 0.90$). In total, 64 articles were excluded following full-text review. Three additional articles were identified following inspection of included studies. Twenty-five articles were included in the final review.

Study characteristics

Table 1 outlines study methodology, the characteristics and features assessed in the studies, and main findings. Three studies reported on a randomised con-trolled trial (RCT): one was the primary RCT (Reid et al. 2011), and two reported secondary analyses with the same dataset (Kauer et al. 2012; Reid et al. 2013). The remaining studies were non-experimental or quasi-experimental. The search identified 19 pub-lished studies and six unpublished studies (four con-ference proceedings; two theses). The majority of studies (n = 16) were quantitative; the remaining nine employed mixed methods.

Sample size ranged from 6 to 1 08 996 participants. Eight studies recruited healthy participants. Eleven studies recruited participants from clinical populations including youth with a range of mental health, emo-tional or behavioural problems, such as depression (n = 8), high-functioning autism/Asperger's disorder (n = 2) and substance or alcohol use (n = 1). The remain-ing six studies recruited participants from mixed popu-lations comprising healthy, mentally ill or substance-using individuals. Mean ages across studies ranged from 10.95 to 23.7 years.

Methods across studies varied greatly. For example, some studies lent participants a phone, whereas others let participants use their own device. Please see Table 1 for a description of the different data collection meth-ods used in each study. As observed in the adult litera-ture, terminology also varied greatly across studies (please see Usability section for more details).

Various apps were used, the most frequent of which was the 'Mobiletype' programme (Reid et al. 2009). Mood outcomes were either direct mood assessments, or described mood-related constructs or behaviours (e.g. stress, hostility). Outcomes were monitored over variable time periods. The shortest period was 24 h (Bossmann et al. 2013), the longest 326 days (Matthews & Doherty, 2011). Monitoring schedules also varied, and could comprise hourly, daily or weekly monitoring, or requirements to complete mea-sures a fixed number of times per day (with or without pre-specified time intervals). Reimbursements or incentives were available in 18 studies (e.g. payments, gift vouchers).

Psychometric properties of mood-monitoring apps

Nine studies reported on the reliability or validity of mood-monitoring apps.

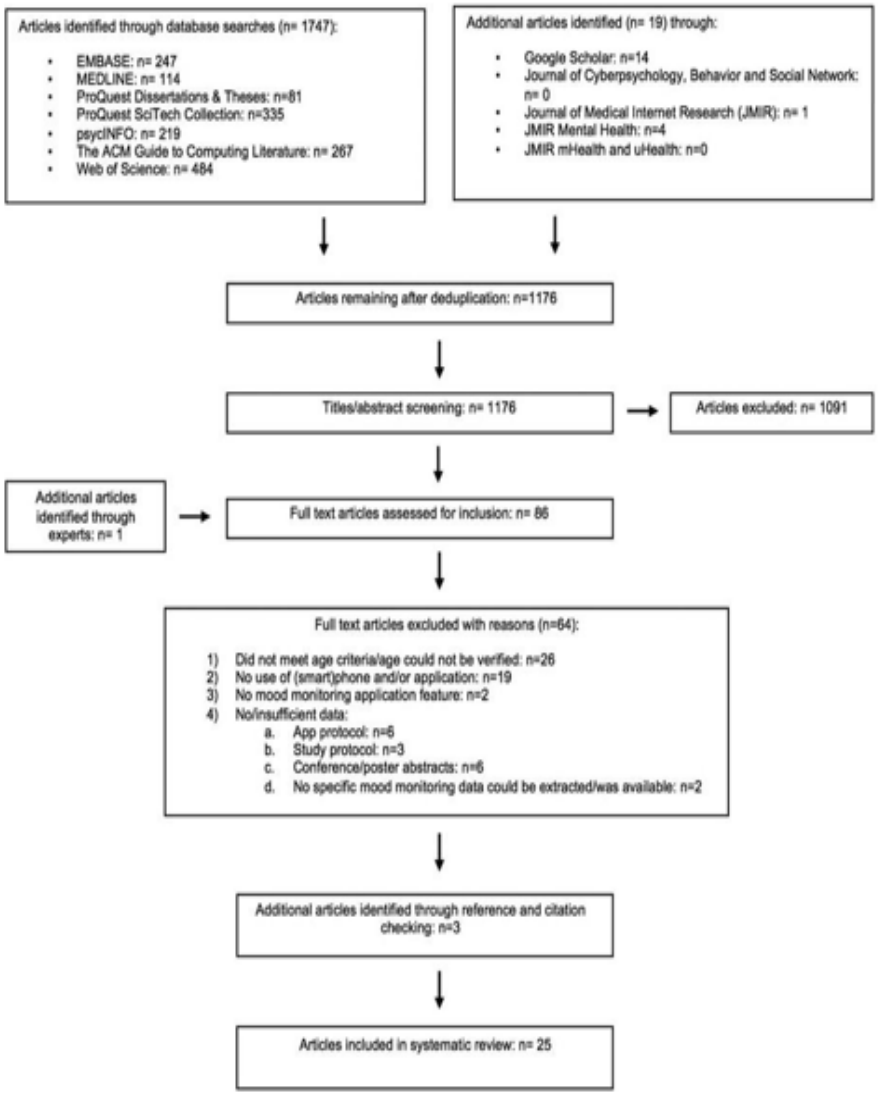

Fig. 1. Flowchart of literature search results and selection of studies.

Reliability

The internal consistency (correlation between items within a scale) was assessed in four studies (Dunton et al. 2011, 2014; Huh et al. 2014; Ansell et al. 2015). As demonstrated in Table 2, levels ranged from ques-tionable to excellent (George & Mallery, 2003).

Validity

Concurrent validity. Three studies examined concurrent validity (the correlation between an assessment and a previously validated assessment of the same construct). Concurrent validity was mostly moderate across studies (see Table 1). Khor et al. (2014a) compared relationships between participant and parent-reported data from the retrospective Responses to Stress Questionnaire (Connor-Smith et al. 2000) and mobile app data record-ing participants' responses to stress. In two studies of university students, Ben-Zeev et al. (2015) and Wang et al. (2014) compared momentary app and retrospective questionnaire data on perceived stress.

Face validity. Two studies described participants' views on the face validity of the 'Mobiletype' app (see Table 1 for numerical details). Reid et al. (2012), using a sample with various mental health problems, found that the app was relatively successful in capturing participants' feelings and current situation. Khor et al. (2014a), using

Table 1. Study details including the author (year,) study purpose, sample characteristics, intervention details and a summary of the main findings

Author (year)	Study purpose	Sample characteristics	Intervention[a]	Main findings
Ansell et al. (2015)	To explore the effects of marijuana use on impulsivity and hostility in everyday life using smartphone-based EMA	• Sample size: N = 43 (M = 23.7 years) • Population type: young recreational substance users • Comparison/control: none • Location: USA • Data collection: in-person research	• App name: not specified • Operation system: not specified • Accessibility: no web/general/app store access • Device: not specified • Measurements: daily alcohol, tobacco and marijuana use; daily impulsivity and daily interpersonal hostility • Monitoring period: 14 days, monitoring schedule varied. Compliance monitored for irregularities by research staff • Incentive/reimbursement: payments + bonus payment for 95% survey response rate	Psychometric properties: • Reliability: acceptable to excellent internal consistency[b] Usability: • Participation rate: impulsivity: 96% completed data; interpersonal interactions: >99% completed data Clinical impacts: • Potential implications for problems with (perceived) interpersonal hostility
Bachmann et al. (2015)	To examine the usability and unobtrusiveness of the Mobile Ambulatory Mood Assessment (MoA^2) app	• Sample size: N = 9 (M = 23.4 years) • Population type: healthy/ non-clinical participants • Comparison/control: none • Location: Germany • Data collection: in-person research	• App name: MoA^2 • Operation system: Android • Accessibility: no web/general/app store access • Device: participants used study phones (Google Nexus 4) or personal Android smartphone • Measurements: mood, tiredness and stress level • Monitoring period: 12 prompts p/day for 4 days • Incentive/reimbursement: no payment	Psychometric properties: not studied Usability: • Participants' perception: app perceived as user-friendly and convenient Clinical impacts: not studied/reported
Ben-Zeev et al. (2015)[c]	To examine if smartphone sensor data can be used to measure behaviour and mental health	• Sample size: N = 47 (M = 22.5 years) • Population type: students reporting varying levels of depression symptoms • Comparison/control: none • Location: USA • Data collection: in-person research	• App name: StudentLife • Operation system: Android • Accessibility: no web/general/app store access • Device: participants were offered an Android study smartphone – type not specified • Measurements: momentary stress and automated sensor data • Monitoring period: 10 weeks (sensor data gathered automatically; stress ratings completed daily, 5 days per week) • Incentive/reimbursement: (Raffle) prizes	Psychometric properties: • Concurrent validity: significant moderate relationship between averaged app-assessed stress ratings and retrospective post-study questionnaire scores on a measure of perceived stress ($r = 0.41$, $p < 0.01$) Usability: • Participation rate: average weekly response rate was 4.92 days a week (98.4%) Clinical impacts: not studied/reported

Bossmann et al. (2013)	To clarify the relationship between everyday physical activity and affective states over a 1-day period	• Sample size: N = 62 (M = 21.4 years) • Population type: healthy/ non-clinical students • Comparison/control: none • Location: Germany • Data collection: in-person research	• App name: MyExperience movisens Edition version 594 • Operation system: Android • Accessibility: web/general access only • Device: participants were provided with an HTC Touch 2 smartphone • Measurements: valence, calmness and energetic arousal • Monitoring period: 1 day – affect measurements every hour after waking up • Incentive/reimbursement: no payment	Psychometric properties: not studied Usability: • Participation rate: ○ Mean completion rate was 10.5 electronic diaries per participant ○ Please note that 15 participants were excluded for missing data Clinical impacts: not studied/reported
Crooke et al. (2013)	To examine the relationship between varying rates of alcohol use and positive and negative mood through EMA	• Sample size: N = 41 (M = 15.4 years) • Population type: young people with varying levels of alcohol intake • Comparison/control: none • Location: Australia • Data collection: in-person research	• App name: Mobiletype • Operation system: not specified • Accessibility: no web/general/app store access • Device: participants were lent a Nokia 6630 • Measurements: activities, company, location, mood, responses to stressful events and coping, and questions on participants' previous evening's alcohol and cannabis use • Monitoring period: 4× p/day on 20 randomised days over the 31-day study period • Incentive/reimbursement: Partial reimbursement/ gift voucher (value: $25)	Psychometric properties: not studied Usability: • Participation rate: 58.3% (AM diaries) and 43.8% (PM diaries) completed mood assessments Clinical impacts: • Potential implications for youth alcohol interventions
Dennis et al. (2015)	To assess the feasibility of smartphone-based EMA and recovery support ecological momentary interventions (EMI) via smartphones. The study also assessed the feasibility of using EMA and EMI to predict substance use in the following week	• Sample size: N = 29 (M = 16.6 years) • Population type: adolescents with different clinical problems • Comparison/control: none • Location: USA • Data collection: in-person research	• App name: Addiction Comprehensive Health Enhancement Support System (ACHESS) • Operation system: Android • Accessibility: web/general access only • Device: participants provided with a smartphone – type not specified • Measurements: feelings, activities, location and social context, and drug and alcohol related measurements • Monitoring period: 6× p/day for 6 weeks. Compliance monitored for irregularities by research staff • Incentive/reimbursement: payment –up to $50 per week for adherence to all study requirements	Psychometric properties: not studied Usability: • Participation rate: 89% of assessments completed • Participants' perception: ○ App-based EMA perceived as 'not too long' (95%), 'very easy' or 'easy to learn how to do' (100%), and 'very easy' or 'easy to complete six EMAs per day' (94%) ○ Of note, one participant withdrew early from the study due to frustrations with software problems Clinical impacts: • Potential implications for relapse prevention
Dunton et al. (2014)[a]	Using EMA to bi-directionally explore how affective and physical feeling states are associated with physical activity	• Sample size: N = 119 (M = 10.95 years) • Population type: children with varying body mass index (BMI) levels	• App name: MyExperience • Operation system: Windows • Accessibility: web/general access only • Device: participants were lent an HTC Shadow.	Psychometric properties: • Reliability: acceptable to good internal consistency[b]

Table 1 (cont.)

Author (year)	Study purpose	Sample characteristics	Intervention[a]	Main findings
		• Comparison/control: none • Location: USA • Data collection: in-person research	• Measurements: main activity type, social context, physical location, mood and enjoyment • Monitoring period: monitoring period: 3–7 random prompts p/day within pre-specified times over two data collection waves (duration: 4 days per wave), separated by 6 months • Incentive/reimbursement: up to $40 (compensatory) payment	Usability: • Participation rate: 76% of assessments completed on average Clinical impacts: not studied/reported
Dunton et al. (2011)[a]	To assess if the level and experience of children's leisure-time physical activity vary with social and physical contexts by means of EMA	• Sample size: N = 121 (M = 11.02 years) • Population type: children with varying BMI levels • Comparison/control: none • Location: USA • Data collection: in-person research	• App name: MyExperience • Operation system: Windows • Accessibility: web/general access only • Device: participants were lent an HTC Shadow. • Measurements: main activity type, social context, physical location, mood and enjoyment • Monitoring period: 3–7 random prompts p/day within pre-specified times over 4 days • Incentive/reimbursement: up to $40 (compensatory) payment	Psychometric properties: • Reliability: acceptable to good internal consistency[b] Usability: • Participation rate: 80.3% of assessments completed on average Clinical impacts: not studied/reported
Huh et al. (2014)	To examine the contextual antecedents to smoking in a sample of Korean American young adult smokers through EMA	• Sample size: N = 22 (M = 21.23 years) • Population type: young adult smokers • Comparison/control: none • Location: USA • Data collection: in-person research	• App name: ActiPal (MEI Ltd.) • Operation system: Android • Accessibility: web/general access only (demo app) • Measurements: affect, perceived stress, cigarette craving, and other contextual and environmental measures • Device: Android enabled phones (study phones provided if participants owned iPhones) • Monitoring period: random non-smoking signal contingent (5× p/day for 7 days) + event-contingent prompts over a 7 day period. Compliance closely monitored by research staff • Incentive/reimbursement: not reported	Psychometric properties: • Reliability: questionable to acceptable internal consistency[b] Usability: • Participation rate: 92.4% of assessments completed on average • Participants' perception: it should be noted that one participant withdrew from the study due to technical difficulties with the EMA app Clinical impacts: not studied/reported

Kauer et al. (2012)[c]	A secondary analysis that investigated the relationships between self-monitoring, emotional self-awareness, and depression through EMA	• Sample size: N = 69 (M = 18.5 years) • Population type: young people with mild or more severe mental health/emotional problems • Comparison/control: attention comparison (n = 49, M = 17.4 years). • Location: Australia • Data collection: In-person research	See Reid et al. (2011)	Psychometric properties: not studied Usability: • Participation rate: completion rates were 52.9% for the intervention group and 59.6% for the comparison group Clinical impacts: implications for depression symptoms
Kauer et al. (2009)[c]	To assess the feasibility and usefulness of a mobile phone-based EMA app to gather information on alcohol use and related behaviours	• Sample size: N = 18 [mean ages 15.9 years (females) and 15.8 years (males)] in study 1; n = 6 [mean ages 18.3 years (females) and 19.5 years (males)] in study 2 • Population type: healthy/ non-clinical students in study 1 and high-risk drinkers in study 2 • Comparison/control: none • Location: Australia • Data collection: in-person research	• App name: Mobiletype • Operation system: not specified • Accessibility: no web/general/app store access • Device: participants were lent a Nokia 6630 • Measurements: activity, mood, stress, alcohol and cannabis use • Monitoring period: 4× p/day for 1 week • Incentive/reimbursement: partial reimbursement/gift voucher (value: $25)	Psychometric properties: not studied Usability: • Participation rate: better compliance for school-based adolescents than older adolescent high-risk drinkers Clinical impacts: not studied /reported
Kenny et al. (2015)	To assess the feasibility of the CopeSmart app	• Sample size: N = 43 (M = 16.0 years) • Population type: healthy/ non-clinical adolescents • Comparison/control: none • Location: Ireland • Data collection: in-person research	• App name: CopeSmart • Operation system: Android + iOS • Accessibility: no web/general/app store access • Device: app was downloaded on participants' Android or iOS phones • Measurements: happiness, anger, sadness, stress and worries • Monitoring period: 1 week • Incentive/reimbursement: no monetary incentive	Psychometric properties: not studied Usability: • Participation rate: participants engaged with the app on 4 out of 7 days (57.1%) • Participants' perception: the app's interface layout was liked by 79% of participants. Furthermore, the app was perceived as easy to use (93%); minor technical difficulties with logging on were experienced by 7% of participants; 70% of participants would use the app in the future; 74% believed the app would be used by other young people; and 70% would recommend the app to a friend Clinical impacts: • Implications for self-awareness
Khor et al. (2014a)[g]	To assess the utility of the Mobiletype programme to examine adolescents with High-Functioning Autism/Asperger's Disorder's (HFASD) stressors and coping	• Sample size: N = 31 (M = 14.46 years) + parents • Population type: adolescents with HFASD • Comparison/control: none • Location: Australia • Data collection: in-person research	• App name: Mobiletype (adapted) • Operation system: not specified • Accessibility: no web/general/app store access • Device: participants were lent a Sony Ericson T501i • Measurements: mood, stress, last time and daily stress • Monitoring period: 4× p/day for 2 weeks	Psychometric properties: • Concurrent validity: ○ Mostly poor to moderate correlations between data from the retrospective Responses to Stress Questionnaire (Connor-Smith et al. 2000) and mobile app data recording participants' responses to stress

Table 1 (cont.)

Author (year)	Study purpose	Sample characteristics	Intervention[a]	Main findings
			• Incentive/reimbursement: partial reimbursement (value: $20)	○ A significant moderate to strong correlation for the 'involuntary engagement' factor: r = 0.70, p < 0.01; parent report: r = 0.48, p < 0.01 ○ A significant strong correlation for the 'primary control engagement coping' factor: r = 0.53, p < 0.05 • Face validity: ○ The face validity was measured by assessing how well the app captured participants' current situation, thoughts and feelings ○ The highest ratings were reported for the app's ability to capture participants' feelings (67%); followed by its ability to capture participants' current situation (63%); and finally its ability to measure participants' thoughts (50%) Usability: • Participation rate: participants responded to 61.8% of prompts ○ Note that a substantial proportion of participants gradually stopped responding throughout the study; while every participant completed at least one entry on the first day, completion rates reduced to 45% on day 14 ○ Also note that there was a significant positive correlation between full scale IQ and compliance rates (r = 0.46, p < 0.01) Clinical impacts: not studied/reported
Khor et al. (2014b)[g]	To investigate how daily hassles, coping, and behaviour and emotional problems are related in adolescents with HFASD	See Khor et al. (2014a)	See Khor et al. (2014a)	Psychometric properties: not studied Usability: not studied/reported Clinical impacts: • Implications for emotional and behavioural problems
Loventoft et al. (2012)	To find out whether people treated for depression would be interested in using a smartphone app for support in their daily lives	• Sample size: N = 6 (ages 17–24, no means reported) • Population type: young people with recent depression treatment • Comparison/control: none • Location: Denmark	• App name: Daybuilder • Operation system: Android • Accessibility: no web/general/app store access • Device: participants provided with Android device with app installed	Psychometric properties: not studied Usability: • Participation rate: different compliance rates across app features –no obvious pattern. Mean normalised compliance for daily registrations of approximately 30%; mean

		• Data collection: in-person research	• Measurements: Weekly Major Depression Inventory; daily mood, appetite and sleep • Monitoring period: 4 weeks • Incentive/reimbursement: payment of 500 DKK ($95 or 2 h salary)	normalised compliance for weekly registrations of approximately 50% • Participants' perception: user experience negatively affected by technological difficulties; clinicians highlighted the usefulness of self-monitoring when combined with therapy. Clinical impacts: • Implications for treatment
Matthews & Doherty (2011)	To assess the issues around the use of mobile phones for mood charting with the aim to improve adolescent engagement	• Sample size: N = 9 (M = 13.78 years) • Population type: young people with depression, mood disorders, self-harm and anger management • Comparison/control: none • Location: Ireland • Data collection: in-person research	• App name: Mobile Mood Diary (MMD) • Operation system: not specified • Accessibility: no web/general/app store access • Device: app downloaded on clients' phones • Measurements: energy, sleep and mood + free area for thought entries • Monitoring period: min. 1× p/day for two sessions • Incentive/reimbursement: reimbursement where necessary	Psychometric properties: not studied Usability: • Participation rate: 65% response on average Clinical impacts: • Implications for treatment
Matthews et al. (2008b)	To explore the effectiveness of mobile phone v. pen-and-paper for mood tracking	• Sample size: N = 73 (M = 14.87 years) • Population type: healthy/ non-clinical students • Comparison/control: paper-based diary condition (n = 52) • Location: Ireland • Data collection: in-person research	• App name: MMD • Operation system: not specified • Accessibility: no web/general/app store access • Device: app downloaded on students' phones • Measurements: energy, sleep and mood + free area for thought entries • Monitoring period: 1× p/day for 2 weeks • Incentive/reimbursement: none	Psychometric properties: not studied Usability: • Participation rate: mobile group significantly more responsive than paper-diary group ($t = -2.324$, $p < 0.05$) • Participants' perception: participants preferred mobile technology Clinical impacts: not studied/reported
Reid et al. (2009)[f]	A study aimed at developing, piloting and reviewing a youth focused mobile phone programme to track young people's experiences in real time	• Sample size: focus group (n = 11, mean age not reported) and pilot study [males (n = 5, M = 15.8 years) and females (n = 13, M = 15.9 years)] • Population type: students • Comparison/control: none • Location: Australia • Data collection: in-person research	See Kauer et al. (2009)	Psychometric properties: not studied Usability: • Participation rate: ○ Participants' completed 76% of diaries ○ However, response rates decreased from 91% on day 1 to 67% on day 7 ○ Of note, one-third of the sample stated that they did not always respond honestly to items if a specific response would result in further questioning • Participants' perception: the study's initial response rate suggested mobile technology may not be preferred or adopted by all young people. Nevertheless, the app was

Table 1 (cont.)

Author (year)	Study purpose	Sample characteristics	Intervention[a]	Main findings
				overall viewed as youth-friendly and non-invasive Clinical impacts: not studied/reported Psychometric properties: not studied Usability: • Participation rate: response rates for the intervention group: 52.9%; comparison group: 60.9% Clinical impacts: • No significant effects on mental health outcomes; potential implications for self-awareness
Reid et al. (2011)[c]	A randomised controlled trial to investigate some of the mental health benefits of the Mobiletype programme	• Sample size: N = 68 (M = 18.5 years) • Population type: mild/more mental health or emotional problems • Comparison/control: comparison programme (n = 46, M = 17.4 years) • Location: Australia • Data collection: in-person research	• App name: Mobiletype • Operation system: not specified • Accessibility: no web/general/app store access • Device: participants were lent a Sony Ericsson Z750i mobile phone • Measurements: current activities, company, location, mood, recent stressful events, responses to stressful events, alcohol consumption, cannabis use, and sleep, exercise and diet-related questions • Monitoring period: min. 2×/day for 2–4 weeks • Incentive/reimbursement: partial reimbursement (A$30) and gift cards (A$20) for post-questionnaires completion (maximum A$60)	
Reid et al. (2013)[c]	To assess the utility of Mobiletype in a primary care setting (secondary analysis)	See Reid et al. (2011)	See Reid et al. (2011)	Psychometric properties: not studied Usability: not studied/reported Clinical impacts: • Potential implications for treatment and clinicians' understanding of patients
Reid et al. (2012)	To review Mobiletype in clinical settings	• Sample size: n = 47 (M = 15.59 years) • Mental health/clinical status: adolescents with varied (medical) disorders. • Comparison/control: none • Location: Australia • Data collection: in-person research	• App name: Mobiletype • Operation system: not specified • Accessibility: no web/general/app store access • Device: participants were lent a ZTE F851 JAVA MIDP 2.0 phone with $50 credit • Measurements: location, activity, company, mood, stressful events, responses to stressful events, alcohol and cannabis use, sleep, exercise and diet-related questions • Monitoring period: four random prompts p/day for 2–4 weeks (min. completion: 1× p/day)	Psychometric properties: • Face validity: ○ The face validity was measured by assessing how well the app captured participants' current situation, thoughts and feelings ○ The highest ratings were reported for the app's ability to capture participants' feelings (86%); followed by its ability to capture participants' current situation (83%); and finally its ability to measure participants' thoughts (57%)

			• Incentive/reimbursement: none	Usability: • Participation rate: Participants completed 91% of entries in week 1 Clinical impacts: • Potential implications for assessment and management
Sacco (2015)	To examine the feasibility and utility of a smartphone app developed to assess five areas of functioning associated with depression	• Sample size: N = 114 (M = 19.36 years) • Population type: students with varying levels of depression symptoms • Comparison/control: none • Location: USA • Data collection: in-person research	• App name: Android Health and Wellness UDTracker App • Operation system: Android • Accessibility: no web/general/app store access • Device: app installed on participants' own Android enabled phones • Measurements: depression, mood, social functioning, cognitive and lifestyle factors, coping/emotion regulation (daily or weekly) • Monitoring period: 14 days. Assessment times varied across measures: 1× p/evening [e.g. Positive and Negative Affect Scale (Watson et al. 1988)], 1× p/morning [sleep questionnaire, adapted from Pittsburgh Sleep Quality Index (Buysse et al. 1989)], and 1× p/week [e.g. items from the COPE scale (Carver et al. 1989)] • Incentive/reimbursement: extra/research participation course credit	Psychometric properties: not studied Usability: • Participation rate: 85–93% response rate across different measures • Participants' perception: ○ App perceived as 'easy to use' (95.6%); 'a little' to 'not at all' irritating (90.3%) ○ The monotony of responding to the same survey questions (15%); the high frequency of the pop-up notifications (9%), and the drain on the phone's battery life (8%) were perceived as irritating. Participants suggested more varied survey questions (23%), fewer crashes, bugs or freezes (9%) and provided suggestions for novel technical features (13%) ○ Some participants also enjoyed the user-friendliness of the app (40%) and the pop-up-reminder feature (17%) Clinical impacts: • Potential implications for self-reflection on emotions or behaviours
Scotti (2015)	To assess the efficacy, acceptability and feasibility of the school-based Dialectical Behaviour Therapy skills group for the treatment of adolescent eating disorders and sub-diagnostic problematic eating behaviours	• Sample size: High school students (N = 4, M = 16.75 years) and middle school students (N = 3, M = 13.67 years) • Population type: students with eating disorder symptoms or body image concerns • Comparison/control: two high school students who had withdrawn (M = 16.5 years) • Location: USA • Data collection: in-person research	• App name: not specified • Operation system: not specified • Accessibility: unknown web/general access, no app store access • Device: participants own smartphones – type not specified • Measurements: individual eating disorder-related behaviours and cognitions/feelings • Study/monitoring period: 12 weeks • Incentive/reimbursement: academic credit and/or prize draw	Psychometric properties: not studied Usability: • Participants' perception: preference for paper-and-pencil tracking by some participants Clinical impacts: not studied/reported
Tregarthen et al. (2015)	To describe a smartphone app for the self-monitoring of eating disorder symptoms, evaluate characteristics of app	• Sample size: N = 1 08 996 [M = 22 years (reported by 48 830 users)]	• App name: Recovery Record • Operation system: Android + iOs	Psychometric properties: not studied

Table 1 (cont.)

Author (year)	Study purpose	Sample characteristics	Intervention[a]	Main findings
	users and assess the feasibility and utilisation of the app for self-monitoring purposes	• Population type: people with varying levels of ED severity • Comparison/control: none • Study Location: USA • Data collection: crowd-sourcing	• Accessibility: general/web and app store access • Device: own (iOS or Android) smartphone – type not specified • Measurements: meals and eating disorder-related behaviours/cognitions/feelings/urges • Monitoring period: overall usage data not available – six monitoring prompts p/day • Incentive: none	Usability: • Participation rate: 89% of participants monitored 53 meals; 67% continued to monitor at 30 days • Participants' response: app received high user ratings Clinical impacts: not studied/reported
Wang et al. (2014)[c]	To measure university students' mental health, academic performance and behavioural trends using the StudentLife app	• Sample size: N = 48 (M = 22.8 years) • Population type: university students with varying depression scores. • Comparison/control: none • Location: USA • Data collection: in-person research	• App name: StudentLife • Operation system: Android • Accessibility: no web/general/app store access • Device: participants either used their own Android phones (primary users) or were offered an Android Nexus 4a (secondary users) • Measurements: momentary mood, sleep, social, physical exercise, activity, and behaviour; automated sensor data. • Monitoring period: 10 weeks • Incentive: (Raffle) prizes	Psychometric properties: • Concurrent validity: significant moderate relationship between averaged app-assessed stress ratings and retrospective post-study questionnaire scores on a measure of perceived stress ($r = 0.41$, $p < 0.01$) Usability: • Participation rate: response rates for participants who used own phones: 65%; response rates for participants who used study phones: 72% Clinical impacts: not studied/reported

[a] The accessibility of mood-monitoring apps was assessed through a search of Google and three app stores (iTunes, Google Play and Microsoft store) in June 2016.
[b] Please refer to Table 2 for coefficient values.
[c] These studies utilised the same data.
[d] These studies utilised the same data.
[e] These studies utilised the same data.
[f] These studies partly utilised the same data.
[g] These studies utilised the same data.

Table 2. Internal consistency coefficients across studies and domains

	α Coefficients									Ω Coefficients		
	Positive affect			Negative affect			Perceived stress			Impulsivity		
Authors	O	WS	BS	O	WS	BS	O	WS	BS	O	WS	BS
Ansell et al. (2015)	–	–	–	–	–	–	–	–	–	–	0.78	0.96
Dunton et al. (2011)	0.88	–	–	0.75	–	–	–	–	–	–	–	–
Dunton et al. (2014)	0.87	–	–	0.74	–	–	–	–	–	–	–	–
Huh et al. (2014)	0.65	–	–	0.78	–	–	0.73	–	–	–	–	–

Note: O, Overall, WS, within-subject level, BS, between-subject level. Internal consistency coefficients values interpretation: '>0.9 – excellent, >0.8 – good, >0.7 – acceptable, >0.6 – questionable, >0.5 – poor and <0.5 – unacceptable' (George & Mallery, 2003, pp. 231).

a sample with high-functioning autism and Asperger's found that the app was not quite as successful in these domains. In both studies, the apps were less successful in capturing participants' thoughts.

Usability of mood-monitoring apps

Participation rates

Twenty-one studies examined participation rates, which ranged from 30% to 99%. Average percentages were not computed in four studies. Instead, these stud-ies described the mean number of diary entries per participant (Bossmann et al. 2013), between-group dif-ferences (Matthews et al. 2008b; Kauer et al. 2009), or evidence of ongoing compliance (Tregarthen et al. 2015). There was some indication that response rates were higher in studies with incentives. For example, Dennis et al. (2015) offered an incentive of $50 per week, and had a participation rate of 89% (see Table 1 for comparative rates and incentive details). Participation rates also appeared to be affected by response fatigue. In Reid et al. (2009), for instance, response rates decreased from 91% on day 1 to 67% on day 7. Finally, participation rates were potentially affected by sample-specific characteristics. In a study with high-functioning autistic participants, Khor et al. (2014a) found a significant positive correlation between full-scale IQ and compliance rates ($r = 0.46$, $p < 0.01$).

Participants' perceptions

Nine studies considered participants' perceptions of the apps. Three of these studies specifically referred to the 'acceptability' of apps. In Dennis et al. (2015), 95% of adolescents felt that the EMA app 'was not too long'. Tregarthen et al. (2015) measured app utilisa-tion data as a proxy for acceptability. There were over 100 000 users over a 2-year period (with 89% using the application at least three times), which the authors interpreted as a demonstration of broad acceptability. While they did not define acceptability specifically, Reid et al. (2009) concluded that their app was 'accept-able' based on the data they captured (e.g. completion rates, participants' feedback).

Across studies, 93–100% of respondents found apps easy to learn or use (Dennis et al. 2015; Kenny et al. 2015; Sacco, 2015). In addition, participants rated apps as useful (Kenny et al. 2015), convenient, user-friendly (Bachmann et al. 2015), youth-friendly and non-invasive (Reid et al. 2009). Despite these positive experiences, technological difficulties (e.g. software crashes, reduced battery life) were reported to nega-tively affect user experience and participation (Loventoft et al. 2012; Huh et al. 2014; Dennis et al. 2015; Sacco, 2015). Although most young people reported a preference for mobile phone mood charting in comparison to paper diaries (Matthews et al. 2008b), not all young people preferred mobile technology (Reid et al. 2009; Scotti, 2015). Scotti (2015), e.g. found that several participants from a sub-diagnostic eating disorder sample favoured paper-and-pencil to track their data.

Positive and negative clinical impacts of mood-monitoring apps

Mental health and awareness

Five (two were from the same RCT) studies examined potential clinical impacts of the apps. Reid et al. (2011) found a significant improvement in emotional self-awareness, but no significant improvements in depres-sion, anxiety or stress scores in youth with mental health or emotional problems. In a secondary analysis of the same RCT, Kauer et al. (2012) reported an indir-ect association between app use and depression

symptoms via increased emotional self-awareness. The app, however, did not significantly reduce rumination.

Qualitative feedback from two studies also sug-gested that mood-monitoring apps can help improve self-awareness (Kenny et al. 2015), and self-reflection on emotions or behaviours (Sacco, 2015).

Though they did not test this premise directly, Ansell et al. (2015) hypothesised that app-based monitoring could have promoted self-awareness in participants sub-sequently reducing (perceived) interpersonal hostility.

In Khor et al. (2014b), parents rated their children with high-functioning autism as showing fewer symp-toms of behaviour and emotional problems following use of the self-monitoring app.

Treatment implications

Five studies reported results that could have implica-tions for the prevention and treatment of mental health problems. Mobile app data gathered by Dennis et al. (2015) were used to identify high-risk groups for sub-stance use, which could potentially help with relapse prevention. Crooke et al. (2013) suggested that mood-monitoring apps could help investigate adolescents' motivations for drinking, thus informing the develop-ment of interventions.

Qualitative feedback from therapists suggests that the use of mobile apps could help facilitate engage-ment with participants suffering from various mental health problems (Matthews & Doherty, 2011). Reid et al. (2012) reported that the Mobiletype app facilitated the assessment and management of youth mental health problems and reduced consultation time with paediatricians; the data captured enabled more indi-vidually focused consultations, which assisted in rap-port building and communication.

In the third of a series of papers detailing their RCT, Reid et al. (2013) explored the potential treatment ben-efits of 'Mobiletype'. In comparison to the control pro-gramme, the app significantly increased general practitioners' (GPs) understanding of their patients' health and current functioning, and aided diagnoses, communication, medication and referrals. However, there was no significant effect on doctor's confidence, doctor–patient rapport or pathways to care.

Finally, in a conference paper by Loventoft et al. (2012), clinicians highlighted the usefulness of self-monitoring when combined with therapy.

Quality assessment

Please see online Supplementary Fig. S1 for an overall depiction of the risk of bias domains across studies.

Risk of selection bias was difficult to assess in many studies, as they often lacked treatment, control or com-parison groups. Three studies (all using the same RCT data) were deemed at low risk of selection bias due to a clear description of the randomisation and conceal-ment allocation process (Reid et al. 2011, 2013; Kauer et al. 2012). Two studies were at unclear risk of selec-tion bias because randomised sequence generation and method of allocation concealment were not suffi-ciently described (Matthews et al. 2008b; Reid et al. 2009). One study was considered at high risk of selec-tion bias (Scotti, 2015) as there was no random alloca-tion process for the control condition.

Only the RCT study (three publications) addressed the blinding of participants and personnel, and was thus considered at low risk of performance bias (Reid et al. 2011, 2013; Kauer et al. 2012). The risk of detection bias in these studies was unclear due to a lack of clarity on blinding of outcome assessments.

The risk of attrition bias was difficult to ascertain in three studies. In one study (Kenny et al. 2015), a num-ber of participants were not included in the final sam-ple due to restrictions on school access (no other information was available). Bossmann et al. (2013) excluded 15 participants from the final sample due to 'missing data', but did not provide further informa-tion, including whether any analyses were performed to address missing data. Reid et al. (2012) was consid-ered at unclear risk of attrition bias, as there was no information on the participants (21%) lost to follow-up. The remaining studies appeared to be at low risk of attrition bias. There was insufficient information to assess the risk of reporting bias in all studies but those of the RCT, which addressed pre-specified out-comes and appeared to be at low risk (Reid et al. 2011, 2013; Kauer et al. 2012). All studies appeared to be at unclear or high risk of other types of bias.

Discussion

The aim of this review was to summarise and evaluate evidence for the use of mobile mood-monitoring apps in young people (aged 10–24 years) from clinical and non-clinical populations. We specifically focused on psychometric properties, usability and clinical impacts.

Psychometric properties of mood-monitoring apps

Few studies assessed psychometric properties. There was limited evidence for reliability, with four studies demonstrating questionable to excellent levels of internal consistency. Studies examining concurrent (n = 3) and face (n = 2) validity were also sparse, mak-ing it difficult to draw firm conclusions. Face validity findings, e.g. could have been moderated by sample characteristics, e.g. reduced insight in participants with autism (Khor et al. 2014a).

The limited assessment of psychometric properties observed in the youth literature mirrors the adult lit-erature. Evidence for concurrent validity in adult populations is inconclusive (Depp et al. 2012; Palmier-Claus et al. 2012; Faurholt-Jepsen et al. 2014). Inconsistent methodology across these studies, e.g. momentary (Depp et al. 2012) v. retrospective assess-ments (Faurholt-Jepsen et al. 2014), varying periods between the event and participants' recollection of the event (Palmier-Claus et al. 2012), likely contribute to variable findings. Previous evidence suggests that real-time mood measurement methods (e.g. EMA) only have a modest correlation with retrospective assessments, such as questionnaires (Ebner-Priemer & Trull, 2009). This leads to the conceptual question of whether retrospective measures are the most appropri-ate comparators when assessing the validity of mood-monitoring apps. Questionnaires measure an individual's retrospective view of their mood state over a number of days. While they are subject to recall bias, this bias incorporates other emotional processing (e.g. contexts) that the more instantaneous assessment of mood (e.g. EMA) may not capture, or at least as richly. Thus, the two assessment methods may be measuring different types of affective experience. As it is difficult to draw robust conclusions about the val-idity of apps using retrospective assessments, future studies should further examine psychometric proper-ties using other sources of comparative data, e.g. active smartphone app data (i.e. app assessments) with pas-sive sensor smartphone data (Nicholas et al. 2015; Sandstrom et al. 2016b), associations with clinical rating scales (Faurholt-Jepsen et al. 2016).

Usability of mood-monitoring apps

The usability of mood-monitoring apps was more extensively studied, and overall studies suggest that apps are usable for young people. However, there were some within- and between-study differences in participants' perceptions of apps, and participation rates.

Generally, participation rates were lower in studies where participants had mental health difficulties (Reid et al. 2011; Kauer et al. 2012), problematic drink-ing patterns (Kauer et al. 2009) or autism spectrum dis-orders – especially those with lower IQ (Khor et al. 2014a). In particular, participation levels were low for those living without set routines (Kauer et al. 2009). This is an important consideration, as youths with mood-related problems, e.g. borderline personality disorder, often have disorganised daily routines (Fleischer et al. 2012). This suggests a need to tailor apps for different clinical populations (Kauer et al. 2009).

Some studies indicated that incentives could posi-tively influence participation rates (e.g. Ansell et al. 2015; Dennis et al. 2015). It may not be financially feas-ible to offer incentives in non-research settings. However, results tentatively suggest that participation rates may be better for mobile apps than traditional paper-based assessments irrespective of incentives (Matthews et al. 2008b). Participation rates for paper-based diaries are as low as 11% (Stone et al. 2003) com-pared with 30–99% for mood-monitoring apps in the current review. This supports that apps could lead to better adherence rates than non-digital assessment tools in young populations. Factors that could improve participation rates include the use of less intensive assessments (e.g. once-daily rather than multiple times), shorter assessments and the incorporation of staff monitoring or automatic reminders (Huh et al. 2014).

Studies from the adult literature are somewhat con-gruent in supporting the usability of mood-monitoring apps (Bardram et al. 2013), though evidence suggests that increasing age (e.g. 'middle age') may lower like-lihood of mood-monitoring app use (Depp et al. 2012). Both adult (Palmier-Claus et al. 2013) and ado-lescent (Bradford & Rickwood, 2014) populations expressed some reservations about using apps due to the perceived risk of reduced personal contact (Palmier-Claus et al. 2013).

Overall our review demonstrated that young people positively perceive apps (Reid et al. 2009) and would be willing to use this technology in real-life settings (Kenny et al. 2015; Tregarthen et al. 2015). Very few studies considered clinician perspectives on mood-monitoring apps. Matthews & Doherty (2011) found that therapists' confidence with technology was the biggest barrier to the use of mood apps. More qualita-tive studies are now needed to further explore young peoples' (and clinicians') perceptions (Hollis et al. 2016) to broaden our understanding of factors pertin-ent to the uptake of mood-monitoring apps in real-life settings.

Positive and negative clinical impacts of mood-monitoring apps

Few of the included studies assessed the clinical impacts of the mood-monitoring apps. Although evi-dence was generally positive (e.g. facilitating assess-ment, management and GPs' understanding), most studies relied on subjective participant feedback (Sacco, 2015) rather than RCT methodology with objective outcome measures.

The preliminary evidence (Kauer et al. 2012) very tentatively suggests that electronic mood-monitoring apps could function as an intervention tool (Seko

et al. 2014; Olff, 2015; Faurholt-Jepsen et al. 2016). Intriguingly, results from the one RCT indicated that mood-monitoring apps might reduce depression in youths by increasing their levels of emotional aware-ness (Kauer et al. 2012). Similarly, though in a non-experimental study, Khor et al. (2014b) reported that self-monitoring improved parent-reported behavioural and emotional problems in participants with autism. While these results are promising, they require replica-tion and future studies may further explore the mechanisms via which apps could potentially impact on clinical outcomes. One possibility is that mood apps could have a positive impact on clinical symp-toms due to patient/participant expectations regarding their benefits. This phenomenon, coined the digital pla-cebo effect, is an overlooked area, which also merits future investigation (Torous & Firth, 2016).

We were unable to fully examine the potential nega-tive impacts of mood-monitoring apps in youth popu-lations, as they were not directly investigated in studies. However, Reid et al. (2009) found that partici-pants did not always respond to questions truthfully to avoid having to answer further questions. Thus, this type of assessment could potentially lead to the inaccurate assessment (and treatment) of mental health problems.

A small number of adult studies report on the nega-tive effects of mood-monitoring apps. There is some suggestion that apps may increase negative reactivity (Ainsworth et al. 2013), increase focus on negative symptoms and thoughts (Palmier-Claus et al. 2013), and potentially maintain depressive symptoms (Faurholt-Jepsen et al. 2015). Given the evidence from the adult literature, research on the possible harmful effects of app use in youths is needed before these tools are routinely used in clinical practice. Part of this endeavour should seek to identify the optimal bal-ance between a monitoring schedule, which accurately captures affective dynamic processes, while minimis-ing respondent workload (Bolger et al. 2003; Trull et al. 2015). This is particularly important, not only because it affects participation rates, but also because the responsibility of self-monitoring could impose a burden on young people (Shiffman et al. 2008), might result in unnecessary pressure (Lupton, 2013; Seko et al. 2014) and exacerbate mental health problems (Conner & Reid, 2012; Faurholt-Jepsen et al. 2015).

Future work may investigate potential ethical issues surrounding the use of mood-monitoring apps. For example, their use could lead to an over-reliance on technology in young populations, which could exacer-bate mental health problems (Thomée et al. 2011). There could also be information security-related risks (e.g. digital theft) that could compromise confidential-ity (Prentice & Dobson, 2014). Finally, youths could use apps as a replacement for treatment and health monitoring (Tregarthen et al. 2015). Considering the importance of the therapeutic alliance for successful treatment outcomes (Karver et al. 2006), the efficacy of smartphone apps could be reduced if they are used without clinicians' involvement (Prentice & Dobson, 2014).

Strengths and limitations

As far as we are aware, this is the first review to sys-tematically examine and quality assess the evidence for the psychometric properties, usability and clinical outcomes of mood-monitoring apps in youth. However, our results should be considered through the lens of a number of limitations.

First, despite undertaking a comprehensive search, there were very few high-quality studies available for inclusion in the review. There was only one primary RCT highlighting the need for more trials on the efficacy of mood-monitoring apps in young people. Indeed, our quality assessment indicated that the majority of studies included some form of bias. For example, many studies were at high or unclear risk of sampling (e.g. self-selected samples) and attrition bias. This could have affected the generalisability of our findings or led to an overestimation of positive effects, e.g. our findings may only apply to individuals with less severe psychopathology who are more likely to engage with services.

Second, studies demonstrated a great variability in terminology (especially for implementation outcomes, e.g. acceptability) making interpretations and cross-study comparisons difficult (inconsistent terminology is also a common feature of the adult app literature). For example, we found that 'acceptability' was defined very differently across studies, ranging from proxy markers, i.e. utilisation data (Tregarthen et al. 2015) to participants' experience of burden (Dennis et al. 2015). This highlights the need for more careful delineation and measurement of implementation out-comes in future work (Proctor et al. 2011).

Third, there were large variations in samples and methodologies, again making cross-study comparisons difficult and quantitative synthesis (i.e. meta-analysis) impossible. Thus, some of our conclusions remain ten-tative pending further rigorous, higher quality research (e.g. RCTs).

Fourth, it should be noted that studies in this review often used apps that were specifically developed for the study, and therefore not publically available through app platforms (e.g. iTunes). Thus, there is a need for more research to assess the evidence for apps that are freely downloaded and used by youth,

and whether their use can be incorporated into clinical care (Nicholas et al. 2015).

Clinical and research implications

Mood-monitoring apps could potentially have positive effects in both clinical and sub-clinical youth popula-tions. Indeed, mood-monitoring apps may help youth identify and address burgeoning mental health and substance use problems (Dennis et al. 2015), and pos-sibly utilise more adaptive coping strategies (Kauer et al. 2012). Further research is needed to examine the effects of these apps in samples with serious mental disorders, such as bipolar disorder (Grunerbl et al. 2015), borderline personality disorder (Lederer et al. 2014) and psychosis (Ben-Zeev et al. 2014; Palmier-Claus et al. 2014).

Evidence, though limited, suggests that mood-monitoring apps could potentially aid diagnosis and treatment decision-making (Reid et al. 2013). Future studies should explore whether this technology could aid in the assessment of disorders that can be difficult to differentiate [e.g. borderline personality disorder, bipolar disorder (Yen et al. 2015)] by providing rich data about the timing and extent of mood fluctuations.

As technological innovations have been endorsed at a government level, integrating mood-monitoring apps within mental health services may improve access and relieve some of the strain these services are currently experiencing [e.g. by improving access to mental health treatment (Department of Health, 2013)]. However, to date, the potential positive and negative impacts of apps have not been sufficiently investigated in youth.

Supplementary material

The supplementary material for this article can be found at https://doi.org/10.1017/S0033291717001659.

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Appendix 2: uMARS (Stoyanov et al., 2016)

Instructions for use:

Raters should:

1. Use the app and trial it thoroughly for at least 10 minutes;
2. Determine how easy it is to use, how well it functions and does it do what it purports to do;
3. Review app settings, developer information, external links, security features, etc.

Scoring

A: Engagement Mean Score = _____

B: Functionality Mean Score = _____

C: Aesthetics Mean Score = _____

D: Information Mean Score* = _____

* Exclude questions rated as "N/A" from the mean score calculation.

App quality mean score _____ = A + B + C + D / 4

The *App subjective quality* scale can be reported as individual items or as a mean score, depending on the aims of the research.

The *Perceived impact* items can be adjusted and used to obtain information on the perceived impact of the app on the user's knowledge, attitudes and intentions related to the target health behaviour.

Mobile Application Rating Scale: user version (uMARS)

App Name: _____

Circle the number that most accurately represents the quality of the app you are rating. All items are rated on a 5-point scale from "1.Inadequate" to "5.Excellent". Select N/A if the app component is irrelevant.

App Quality Ratings

SECTION A

Engagement – fun, interesting, customisable, interactive, has prompts (e.g. sends alerts, messages, reminders, feedback, enables sharing)

1. **Entertainment: Is the app fun/entertaining to use? Does it have components that make it more fun than other similar apps?**
   1 Dull, not fun or entertaining at all
   2 Mostly boring
   3 OK, fun enough to entertain user for a brief time (< 5 minutes)
   4 Moderately fun and entertaining, would entertain user for some time (5-10 minutes total)
   5 Highly entertaining and fun, would stimulate repeat use

2. **Interest: Is the app interesting to use? Does it present its information in an interesting way compared to other similar apps?**
   1 Not interesting at all
   2 Mostly uninteresting
   3 OK, neither interesting nor uninteresting; would engage user for a brief time (< 5 minutes)
   4 Moderately interesting; would engage user for some time (5-10 minutes total)
   5 Very interesting, would engage user in repeat use

3. **Customisation: Does it allow you to customise the settings and preferences that you would like to (e.g. sound, content and notifications)?**
   1 Does not allow any customisation or requires setting to be input every time
   2 Allows little customisation and that limits app's functions
   3 Basic customisation to function adequately
   4 Allows numerous options for customisation
   5 Allows complete tailoring the user's characteristics/preferences, remembers all settings

4. **Interactivity: Does it allow user input, provide feedback, contain prompts (reminders, sharing options, notifications, etc.)?**
   1 No interactive features and/or no response to user input
   2 Some, but not enough interactive features which limits app's functions
   3 Basic interactive features to function adequately
   4 Offers a variety of interactive features, feedback and user input options
   5 Very high level of responsiveness through interactive features, feedback and user input options

5. **Target group: Is the app content (visuals, language, design) appropriate for the target audience?**

   1 Completely inappropriate, unclear or confusing
   2 Mostly inappropriate, unclear or confusing
   3 Acceptable but not specifically designed for the target audience. May be inappropriate/ unclear/confusing at times
   4 Designed for the target audience, with minor issues
   5 Designed specifically for the target audience, no issues found

SECTION B

Functionality – app functioning, easy to learn, navigation, flow logic, and gestural design of app

6. **Performance: How accurately/fast do the app features (functions) and components (buttons/menus) work?**

   1 App is broken; no/insufficient/inaccurate response (e.g. crashes/bugs/broken features, etc.)
   2 Some functions work, but lagging or contains major technical problems
   3 App works overall. Some technical problems need fixing, or is slow at times
   4 Mostly functional with minor/negligible problems
   5 Perfect/timely response; no technical bugs found, or contains a 'loading time left' indicator (if relevant)

7. **Ease of use: How easy is it to learn how to use the app; how clear are the menu labels, icons and instructions?**

   1 No/limited instructions; menu labels, icons are confusing; complicated
   2 Takes a lot of time or effort
   3 Takes some time or effort
   4 Easy to learn (or has clear instructions)
   5 Able to use app immediately; intuitive; simple (no instructions needed)

8. **Navigation: Does moving between screens make sense; Does app have all necessary links between screens?**

   1 No logical connection between screens at all /navigation is difficult
   2 Understandable after a lot of time/effort
   3 Understandable after some time/effort
   4 Easy to understand/navigate
   5 Perfectly logical, easy, clear and intuitive screen flow throughout, and/or has shortcuts

9. **Gestural design: Do taps/swipes/pinches/scrolls make sense? Are they consistent across all components/screens?**

   1 Completely inconsistent/confusing
   2 Often inconsistent/confusing
   3 OK with some inconsistencies/confusing elements
   4 Mostly consistent/intuitive with negligible problems
   5 Perfectly consistent and intuitive

SECTION C

Aesthetics – graphic design, overall visual appeal, colour scheme, and stylistic consistency

10. **Layout: Is arrangement and size of buttons, icons, menus and content on the screen appropriate?**

    1 Very bad design, cluttered, some options impossible to select, locate, see or read
    2 Bad design, random, unclear, some options difficult to select/locate/see/read
    3 Satisfactory, few problems with selecting/locating/seeing/reading items
    4 Mostly clear, able to select/locate/see/read items
    5 Professional, simple, clear, orderly, logically organised

11. **Graphics: How high is the quality/resolution of graphics used for buttons, icons, menus and content?**

    1 Graphics appear amateur, very poor visual design - disproportionate, stylistically inconsistent
    2 Low quality/low resolution graphics; low quality visual design – disproportionate
    3 Moderate quality graphics and visual design (generally consistent in style)
    4 High quality/resolution graphics and visual design – mostly proportionate, consistent in style
    5 Very high quality/resolution graphics and visual design - proportionate, consistent in style throughout

12. **Visual appeal: How good does the app look?**

    1 Ugly, unpleasant to look at, poorly designed, clashing, mismatched colours
    2 Bad – poorly designed, bad use of colour, visually boring
    3 OK – average, neither pleasant, nor unpleasant
    4 Pleasant – seamless graphics – consistent and professionally designed
    5 Beautiful – very attractive, memorable, stands out; use of colour enhances app features/menus

SECTION D

Information – Contains high quality information (e.g. text, feedback, measures, references) from a credible source

13. **Quality of information: Is app content correct, well written, and relevant to the goal/topic of the app?**

    N/A There is no information within the app
    1 Irrelevant/inappropriate/incoherent/incorrect
    2 Poor. Barely relevant/appropriate/coherent/may be incorrect
    3 Moderately relevant/appropriate/coherent/and appears correct
    4 Relevant/appropriate/coherent/correct
    5 Highly relevant, appropriate, coherent, and correct

14. **Quantity of information: Is the information within the app comprehensive but concise?**

    N/A There is no information within the app
    1 Minimal or overwhelming
    2 Insufficient or possibly overwhelming
    3 OK but not comprehensive or concise
    4 Offers a broad range of information, has some gaps or unnecessary detail; or has no links to more information and resources
    5 Comprehensive and concise; contains links to more information and resources

15. **Visual information: Is visual explanation of concepts – through charts/graphs/images/videos, etc. – clear, logical, correct?**

N/A There is no visual information within the app (e.g. it only contains audio, or text)
1 Completely unclear/confusing/wrong or necessary but missing
2 Mostly unclear/confusing/wrong
3 OK but often unclear/confusing/wrong
4 Mostly clear/logical/correct with negligible issues
5 Perfectly clear/logical/correct

16. **Credibility of source: does the information within the app seem to come from a credible source?**

N/A There is no information within the app
1 Suspicious source
2 Lacks credibility
3 Not suspicious but legitimacy of source is unclear
4 Possibly comes from a legitimate source
5 Definitely comes from a legitimate/specialised source

App subjective quality

SECTION E

17. **Would you recommend this app to people who might benefit from it?**

1	Not at all	I would not recommend this app to anyone
2		There are very few people I would recommend this app to
3	Maybe	There are several people I would recommend this app to
4		There are many people I would recommend this app to
5	Definitely	I would recommend this app to everyone

18. **How many times do you think you would use this app in the next 12 months if it was relevant to you?**

1 None
2 1-2
3 3-10
4 10-50
5 >50

19. **Would you pay for this app?**

1 Definitely not
2
3
4
5 Definitely yes

20. **What is your overall (star) rating of the app?**

1	★	One of the worst apps I've used
2	★★	
3	★★★	Average
4	★★★★	
5	★★★★★	One of the best apps I've used

Perceived impact

SECTION F

1. **Awareness – This app has increased my awareness of the importance of addressing the health behaviour**

Strongly disagree				Strongly Agree
1	2	3	4	5

2. **Knowledge – This app has increased my knowledge/understanding of the health behaviour**

Strongly disagree				Strongly Agree
1	2	3	4	5

3. **Attitudes – The app has changed my attitudes toward improving this health behaviour**

Strongly disagree				Strongly Agree
1	2	3	4	5

4. **Intention to change – The app has increased my intentions/motivation to address this health behaviour**

Strongly disagree				Strongly Agree
1	2	3	4	5

5. **Help seeking – This app would encourage me to seek further help to address the health behaviour (if I needed it)**

Strongly disagree				Strongly Agree
1	2	3	4	5

6. **Behaviour change – Use of this app will increase/decrease the health behaviour**

Strongly disagree				Strongly Agree
1	2	3	4	5

Further comments about the app?

THANK YOU!

QUT Queensland University of Technology

YOUNGANDWELL Cooperative Research Centre

Appendix 3: CWPT participant information sheet (quantitative mood-monitoring study)

Participant Information Sheet

Project title: An investigation into the usefulness of mood-monitoring applications for the assessment and engagement of young people with mood swings.

You are being invited to take part in a study, which investigates whether mood-monitoring applications (apps) are useful for assessing and engaging young people with mood swings.

Before you decide if you want take part, it is important for you to understand what the study is about, why the study is being done, and what will happen when you take part. Please take time to read this information sheet very carefully and talk about it with your family, friends, or a health professional (e.g., your treating consultant), if you would like to. If anything is not clear or if you would like more information, please do not hesitate to contact us using the contact details at the end of the sheet.

Why is this research being done?

There are many young people who struggle with mood swings, which can cause difficulties in their everyday lives. We would like to find out if mood-monitoring apps are useful when it comes to assessing mood swings. We would also like to investigate if this type of technology helps young people feel more engaged with their treatment. From this information, we hope to understand whether mood-monitoring apps could be used more widely to help young people with these problems.

Who is being invited to take part?

We want to invite young people between 16 and 24 years old with mood swings to take part in the study. We are asking you to take part because of your age and because you have experienced mood swings. Because of the nature of the study, all participants also need to have access to an iPhone or Android (4.0 or up) smartphone and an email address in order to take part. We can help you check whether you have the right phone to take part in the study.

Do I have to take part?

No, it is up to you whether you take part or not. You will be asked to sign a consent form to say that you are happy to take part. However, you can still change your mind and stop participating in this study at any time. Just tell either someone on the research team or let your treating clinician know. You do not have to give any reasons. Withdrawing from the

study will not affect you or your care in any way. We would also like you to know that, if you become very unwell during the study, we will have to withdraw you from the study. No other data would be collected and we would only use the data up until the point of withdrawal.

What will happen during the study?

1. If, after reading this form, you agree to take part, you will be asked to sign a consent form to show that you are happy to participate.
2. Ms Dubad (PhD Student) will help you download a mood-monitoring app called "Catch It" and a reminder app. Ms Dubad will go through the apps and the rest of the study with you to make sure everything is clear.
3. You will then be asked to complete three questionnaires.
4. After three weeks, you will be asked to complete the same three questionnaires.
5. You will then be asked to track your mood with the mood-monitoring app two times a day for three weeks.
6. At the end of the study, you will complete the same three questionnaires for the last time.

There are a few things we have to explain about the study:

1) You can either complete the questionnaires electronically (e.g., via a link on your phone) or on paper (Ms Dubad will bring you the paper version and pick it up).
2) Ms Dubad will need your telephone number to contact you during the study via text message. You do not have to text back. The texts are sent to help you remember to complete the questionnaires and start the mood-monitoring period. We will not send more than two extra text messages to help you remember. Ms Dubad will not contact you for anything other than the study.
3) If you have an iPhone, you will be asked to download a reminder app called "Mind Jogger". Because we do not want you to pay for anything, we will provide you with a voucher code, which will let you download the app for free.
4) We will ask you to email your mood results to Ms Dubad's email address. The app has a feature that can help you do this but everything about this will be explained to you at the start of the study.
5) To help us answer some of our research questions, we have to look at some of your records (e.g., your diagnosis). We will only look at the information that we need for our study. Everything we analyse and write about in reports will be anonymous.

What are the possible disadvantages and risks of taking part?

Support during the study

In this study, you will be asked to rate your mood using the smartphone app. It is important to remember that your ratings will not be checked in real-time. This means that if you feel very low in mood and might feel unsafe, the researcher will not know about this straight away.

If you do become upset during the study and need support, please contact your GP or a member of your mental health team, such as your psychiatrist, clinical care coordinator or a different mental health worker from your team.

You might also want to get in touch with "Mental Health Matters", which is a free 24/7 helpline for people living in Coventry and Warwickshire. Through this number, you will be able to talk to highly trained and experienced support workers who use their counselling skills to give you emotional guidance and information. Their telephone number is **0800 616 171**.

Please only contact emergency service (**dial 999**) if you are at immediate risk of harm or in a life-threatening situation.

Data privacy

It might be helpful to know that no personal data is stored by the app. The app will also have a pin option to help protect your privacy. We do advise you that you secure your phone with a PIN or special code which only you can access.

We would like you to know that because we will ask you to send your mood results to Ms Dubad, we will see your email address, which might not be anonymous. Please remember that we will give you an anonymous study number that we will link to your mood results. Once the mood results have been received via email and saved securely, we will delete your email.

Practical information

We would finally like you to know that we will try our best to make sure you meet with Ms Dubad the same day you would come in for your appointment with your clinician. If this is not possible, we could also find a different time and/or meeting place that is more convenient to you.

What are the possible benefits of taking part?

It is too early to say whether the study has direct benefits for you right now. However, by taking part, you will help us find out if digital mood-monitoring technology is useful for young people with mood swings.

Is the research safe and who has checked it?

The study has ethical approval from the NHS Research Ethics Committee. Local permission has also been obtained from Coventry and Warwickshire Partnership Trust Research and Development department.

Who is organising and funding the research?

The research is organised by the University of Warwick. The research is funded by the Economic and Social Research Council and by Coventry and Warwickshire Partnership Trust.

Will my taking part in the research be kept confidential?

Yes. All responses will be kept separate from personal identifiable data. Your responses will be stored securely on a computer and nobody will have access to it apart from the researchers and a statistician, who will help us with analysing and understanding the data. If you choose to complete your questionnaires on paper, these will be locked away in a filing cabinet at the University. Your name will not be written on any of the questionnaires.

The mood-monitoring app itself does not store personal information and data from the app will be anonymised using your anonymous study number after you have emailed it.

The research team will need to look at some of your personal data (e.g., your age) from your medical records. This information will help us with the analysis of data. Please remember we will only look at the information that is needed for our study. All information will be anonymised.

If you share something that worries us, then we might have to tell your treating clinician. We will let you know if we plan to do this.

If you would like us to, we can let your GP know that you have taken part in the study. We will not share your answers with your GP unless we have your permission.

What happens at the end of the study?

You will receive a £25 gift voucher in recognition of the time spent participating in the study which includes compensation for any potential travel costs you may have experienced. If you would like to, we might also invite you to an individual interview or to a focus group where

you can talk about your experiences of using the app with other young people who have taken part in the study. You can let us know in the consent form if you want to be contacted about this.

Once the study is complete, your personal identifiable data and anonymized copies of the study data will be held securely (in a locked filing cabinet, or on an encrypted file system) for 10 years, which is a requirement of the University. Data will be destroyed after this. When the study has been completed, Ms Dubad (PhD student) will write about the findings in her thesis for the University. Ms Dubad and her supervisors also aim to publish the findings in research journals and present the findings at conferences. Everything we write about or present will be anonymous.

What if there is a problem?

If there is a problem, please contact either:

Professor Max Birchwood
Chief Investigator and Supervisor
Mental Health and Wellbeing
Division of Health Sciences
Warwick Medical School
University of Warwick
Coventry
CV4 7AL
Email: [redacted]

OR

Muna Dubad
PhD student
Mental Health and Wellbeing
Division of Health Sciences
Warwick Medical School
University of Warwick
Coventry
CV4 7AL
Telephone: [redacted]

Who can I contact if I have a complaint about the study?

This study is covered by the University of Warwick's insurance and indemnity cover. Any complaint about the way you have been dealt with during the study or any possible harm you might have suffered will be addressed. Please address your complaint to the person below, who is a senior University of Warwick official entirely independent of this study:

Head of Research Governance

Research & Impact Services

University House

University of Warwick

Coventry

CV4 8UW

Tel: 024 76 522746

Email: researchgovernance@warwick.ac.uk

You can also contact the Patient Advice and Liaison Service. Their contact details are:

Patient Advice and Liaison Service

Coventry and Warwickshire Partnership NHS Trust

Wayside House

Wilsons Lane

Coventry

CV6 6NY

Telephone:

0800 212 445 (Freephone)

024 7653 6804

Email: PALS.Complaints@covwarkpt.nhs.uk

How can I find out more about the study?

- You can contact either your treating clinician for more information about the study or contact the research team who are based at Warwick Medical School, University of Warwick, Coventry, CV4 7AL[1] and at The Birmingham Institute for Mental Health, University of Birmingham, Edgbaston, Birmingham, B15 2TT[2]. Further contact details for the research team are provided below:
    1. Professor Max Birchwood (Chief Investigator and Supervisor)[1]: [redacted]
    2. Professor Steven Marwaha (Supervisor): [redacted] [1,2]
    3. Dr Catherine Winsper (Supervisor): [redacted] [1]
    4. Ms Muna Dubad (PhD Student) [1]
        - Email: [redacted]
        - Telephone: [redacted]
- For general advice and guidance, you can also contact the Patient Advice and Liaison Service. Their contact details are described above.

Thank you for reading this information sheet!

Appendix 4: CWPT consent form (quantitative mood-monitoring study)

WARWICK
THE UNIVERSITY OF WARWICK

Name of Service:

Participant Identification Number:

CONSENT FORM

Title of Project: An investigation into the usefulness of a mood-monitoring application for the assessment and engagement of young people with mood swings.

Name of Chief Investigator: Professor Max Birchwood

Please initial box

1. I confirm that I have read the information sheet (version 3.1) for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily. ☐
2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason, without my medical care or legal rights being affected. ☐
3. I understand that if I withdraw from the study, no further data will be collected, and that the research team will only use data collected up until that point. ☐
4. I understand that relevant sections of my medical notes and data collected during the study, may be looked at by individuals from the University of Warwick, from regulatory authorities or from the NHS Trust, where it is relevant to my taking part in this research. I give permission for these individuals to have access to my records. ☐
5. I agree to my General Practitioner being informed of my participation in the study. ☐
6. I understand that if I share something that worries the researchers, that the researchers might have to let my treating clinician know. ☐
7. I agree for my mobile number and email address to be shared with the research team for the purpose of the study only. ☐

[redacted]

8. I understand that, when emailing my mood results, the research team might be able to tell from my email address that it was my data. I also understand my original email will be deleted once my data has been anonymised and is no longer required for the purpose of the study. ☐

9. I agree to take part in the above study. ☐

Name of Participant	Date	Signature
Name of Person Taking Consent	Date	Signature

[redacted]

Centre Number:

Study Number:

Participant Identification Number for this trial:

CONSENT FORM

Title of Project: An investigation into the usefulness of mood-monitoring applications for the assessment and engagement of young people with mood instability.

Name of Chief Investigator: Professor Max Birchwood

After this study ends, a focus group or individual interview (face-to-face or telephone) will be held in which participants can discuss their experiences of using the mood-monitoring application. This study will help us understand what impact use of the application has had from the unique perspective of young people.

Please initial box

☐

Please put your initials in the box on the right if you would like to be considered for and contacted about taking part in this focus group or individual interview. More information about the study will be provided when you are contacted. Signing this only means you would like to be considered. You can always change your mind later.

Name of Participant	Date	Signature
Name of Person taking consent	Date	Signature

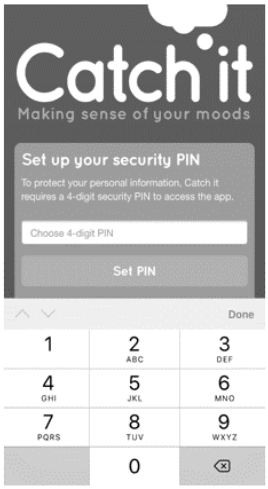
[redacted]

Appendix 5: Instructions for the 'Catch It' app

'Catch It': Overview and Instructions

Set up your security PIN:

The research team will give you a PIN which only you and the research team have access to. You will need this PIN every time you access the app.

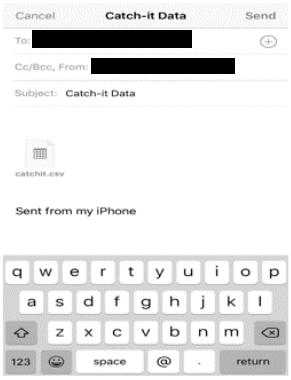


Main menu:

In the main menu, you will find all the different features of the app. If you click on "examples" you will find examples of how a mood diary can be completed. Yours does not have to look this way. If you click on "read more" you will find more information about the app and further explanations. "View diary" allows you to look at your old diary entries.

Email your mood results:

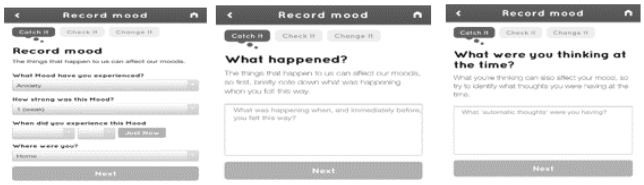
To email your mood diary, please click on "share diary". This should take you to your email account. Please enter Ms Dubad's email address in the "to" field: [redacted] You can see an example what this might look like below. However, each phone might do this a little bit differently. Ms Dubad can help you with this.



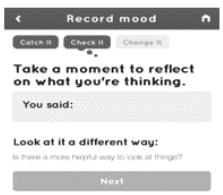
Completing a mood diary:

There are different steps you take to complete a diary on the app.

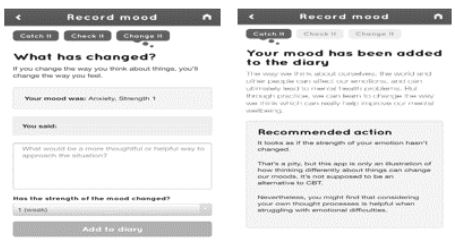
1. Catch It:
   "Catch" your mood by describing what mood you experienced, how strong it was, when you experienced (this should ideally be "right now") and where you were. Try to give a bit of information about what happened when you were feeling that way and what you were thinking at the time, when you click 'next'.



2. Check It:
   At this point, the app tries to encourage you to reflect on what you said and look at the situation differently.



3. Change It:
   If you can, try to see if you can think of more helpful thoughts to replace the thoughts you might be having. If you can't think of anything to change or do not feel there is anything to change, feel free to write that down or anything else that you are thinking. At the bottom, you can also indicate whether the strength of your mood has changed. You might not always feel changes, but that is OK. When you have added the mood to the diary, the app will give you a brief summary about any changes and possible recommendations. Note that these are standard statements, which are not detailed or tailored to your specific and unique experiences.



Appendix 6: DERS-SF (Kaufman et al., 2016)

Please indicate how often the following apply to you.

	Almost Never (0-10%)	Sometimes (11-35%)	About Half of the Time (36-65%)	Most of the Time (66-90%)	Almost Always (91-100%)
1. I pay attention to how I feel.	○	○	○	○	○
2. I have no idea how I am feeling.	○	○	○	○	○
3. I have difficulty making sense out of my feelings.	○	○	○	○	○
4. I care about what I am feeling.	○	○	○	○	○
5. I am confused about how I feel.	○	○	○	○	○
6. When I am upset, I acknowledge my emotions.	○	○	○	○	○
7. When I am upset, I become embarrassed for feeling that way.	○	○	○	○	○
8. When I am upset, I have difficulty getting work done.	○	○	○	○	○
9. When I am upset, I become out of control.	○	○	○	○	○
10. When I am upset, I believe that I will end up feeling very depressed.	○	○	○	○	○
11. When I am upset, I have difficulty focusing on other things.	○	○	○	○	○
12. When I am upset, I feel guilty for feeling that way.	○	○	○	○	○
13. When I am upset, I have difficulty concentrating.	○	○	○	○	○
14. When I am upset, I have difficulty controlling my behaviours.	○	○	○	○	○
15. When I am upset, I believe there is nothing I can do to make myself feel better.	○	○	○	○	○
16. When I am upset, I become irritated with myself for feeling that way.	○	○	○	○	○
17. When I am upset, I lose control over my behaviour.	○	○	○	○	○
18. When I am upset, it takes me a long time to feel better.	○	○	○	○	○

Appendix 7: Engagement Scale (Cunningham et al., 2009)

Please indicate how much you agree with the following statements.

	Strongly Agree	Agree	Somewhat Agree	Don't know	Somewhat Disagree	Disagree	Strongly Disagree
1. I guess I have faults, but there's nothing I really need to change.	○	○	○	○	○	○	○
2. Being here is pretty much a waste of time because I don't have any problems that need to be changed.	○	○	○	○	○	○	○
3. Maybe this place will be able to help me.	○	○	○	○	○	○	○
4. I hope that someone here will have some good advice for me.	○	○	○	○	○	○	○
5. I am hoping that this place will help me to understand myself better.	○	○	○	○	○	○	○
6. I am finally doing some work on my problems.	○	○	○	○	○	○	○
7. I feel that staff here care about me even when I do things that they do not approve of.	○	○	○	○	○	○	○
8. I believe that staff here like me.	○	○	○	○	○	○	○
9. I feel that staff members here appreciate me - they really get me as a person.	○	○	○	○	○	○	○
10. Staff here understands my situation and my problems.	○	○	○	○	○	○	○
11. Staff here is genuinely concerned about my welfare.	○	○	○	○	○	○	○
12. I trust the staff here.	○	○	○	○	○	○	○
13. The staff here trust me.	○	○	○	○	○	○	○
14. Staff and I are working towards goals we agree on.	○	○	○	○	○	○	○
15. I have established a good understanding with the staff here of the kind of changes that would be good for me.	○	○	○	○	○	○	○
16. Staff and I agree on what is important for me to work on.	○	○	○	○	○	○	○
17. I am clear on what my responsibilities are around here, especially with regard to my work with my psychiatrist and/or other mental health professionals.	○	○	○	○	○	○	○

Appendix 8: ALS-SF (Oliver & Simons, 2004)

Please indicate how well the following statements describe you.

	Very Undescriptive	Undescriptive	Descriptive	Very Descriptive
1. At times I feel just as relaxed as everyone else and then within minutes I become so nervous that I feel light-headed and dizzy.	○	○	○	○
2. There are times when I have very little energy and then just afterwards I have about the same energy level as most people.	○	○	○	○
3. One minute I can be feeling OK and then the next minute I'm tense, jittery, and nervous.	○	○	○	○
4. I frequently switch from being able to control my temper very well to not being able to control it very well at all.	○	○	○	○
5. Many times I feel nervous and tense and then I suddenly feel very sad and down.	○	○	○	○
6. Sometimes I go from feeling extremely anxious about something to feeling very down about it.	○	○	○	○
7. I shift back and forth from feeling perfectly calm to feeling uptight and nervous.	○	○	○	○
8. There are times when I feel perfectly calm one minute and then the next minute the least little thing makes me furious.	○	○	○	○
9. Frequently, I will be feeling OK but then I suddenly get so mad that I could hit something.	○	○	○	○
10. Sometimes I can think clearly and concentrate well one minute and then the next minute I have a great deal of difficulty concentrating and thinking clearly.	○	○	○	○
11. There are times when I am so mad that I can barely stop yelling and other times shortly afterwards when I wouldn't think of yelling at all.	○	○	○	○
12. I switch back and forth between being extremely energetic and having so little energy that it's a huge effort just to get where I am going.	○	○	○	○
13. There are times when I feel absolutely wonderful about myself but soon afterwards I often feel that I am just about the same as everyone else.	○	○	○	○
14. There are times when I'm so mad that my heart starts pounding and/or I start shaking and then shortly afterwards I feel quite relaxed.	○	○	○	○
15. I shift back and forth between being very unproductive and being just as productive as everyone else.	○	○	○	○
16. Sometimes I feel extremely energetic one minute and then the next minute I might have so little energy that I can barely do a thing.	○	○	○	○
17. There are times when I have more energy than usual and more than most people and then soon afterwards I have about the same energy level as everyone else.	○	○	○	○
18. At times I feel that I'm doing everything at a very slow pace but then soon afterwards I feel that I'm no more slowed down than anyone else.	○	○	○	○

Appendix 9: GHQ-12: Goldberg and Williams, 1988

Have you recently...

1. Been able to concentrate on what you're doing?	Better than usual	Same as usual	Less than usual	Much less than usual
2. Lost much sleep over worry?	Not at all	No more than usual	Rather more than usual	Much more than usual
3. Felt you were playing a useful part in things?	More so than usual	Same as usual	Less useful than usual	Much less useful
4. Felt capable of making decisions about things?	More so than usual	Same as usual	Less so than usual	Much less capable
5. Felt constantly under strain?	Not at all	No more than usual	Rather more than usual	Much more than usual
6. Felt you couldn't overcome your difficulties?	Not at all	No more than usual	Rather more than usual	Much more than usual
7. Been able to enjoy your normal day-to-day activities?	More so than usual	Same as usual	Less so than usual	Much less than usual
8. Been able to face up to your problems?	More so than usual	Same as usual	Less so than usual	Much less able
9. Been feeling unhappy and depressed?	Not at all	No more than usual	Rather more than usual	Much more than usual
10. Been losing confidence in yourself?	Not at all	No more than usual	Rather more than usual	Much more than usual
11. Been thinking of yourself as a worthless person?	Not at all	No more than usual	Rather more than usual	Much more than usual
12. Been feeling reasonably happy, all things considered	More so than usual	About same as usual	Less so than usual	Much less than usual;

Appendix 10: Example demographic information and GP Information form (applicable to Non-NHS participants)

WARWICK
THE UNIVERSITY OF WARWICK

STUDY ID:
DATE:

PARTICIPANT INFORMATION:

1. **Gender – are you: (please circle)**

   - Female
   - Male
   - Other
   - Prefer not to say

   If other, could you please describe your gender identity?

   _____

2. **Date of birth:** _____

3. **Ethnic group – which best describes you? (please circle)**

- White British
- Other White background
- Black British
- Black African
- Black Caribbean
- Other Black background
- Indian
- Pakistani
- Bangladeshi
- Chinese
- Other Asian background
- Black Caribbean and White
- Black African and White
- Asian and White
- Other Dual Heritage
- Traveller
- Other Ethnic Group
- Prefer not to say

4. **How would you describe your current employment status (please circle)**

- Employed
- Not in education, employment or training
- In education/learning
- In training
- Self employed
- Other: _____
- Prefer not to say

[redacted]

5. **Current diagnosis:** _____

6. **Are you currently taking medication for your mental health problem? (please circle)**

- Yes
- No

7. **Are you currently receiving psychological therapy for your mental health problem?**

- Yes
- No
- Prefer not to say

GP INFORMATION:

Would you like us to inform your GP about your participation in this study? (Please tick)

☐ YES ☐ NO

If 'YES', please provide your GP details below:

GP name: _____

Address: _____

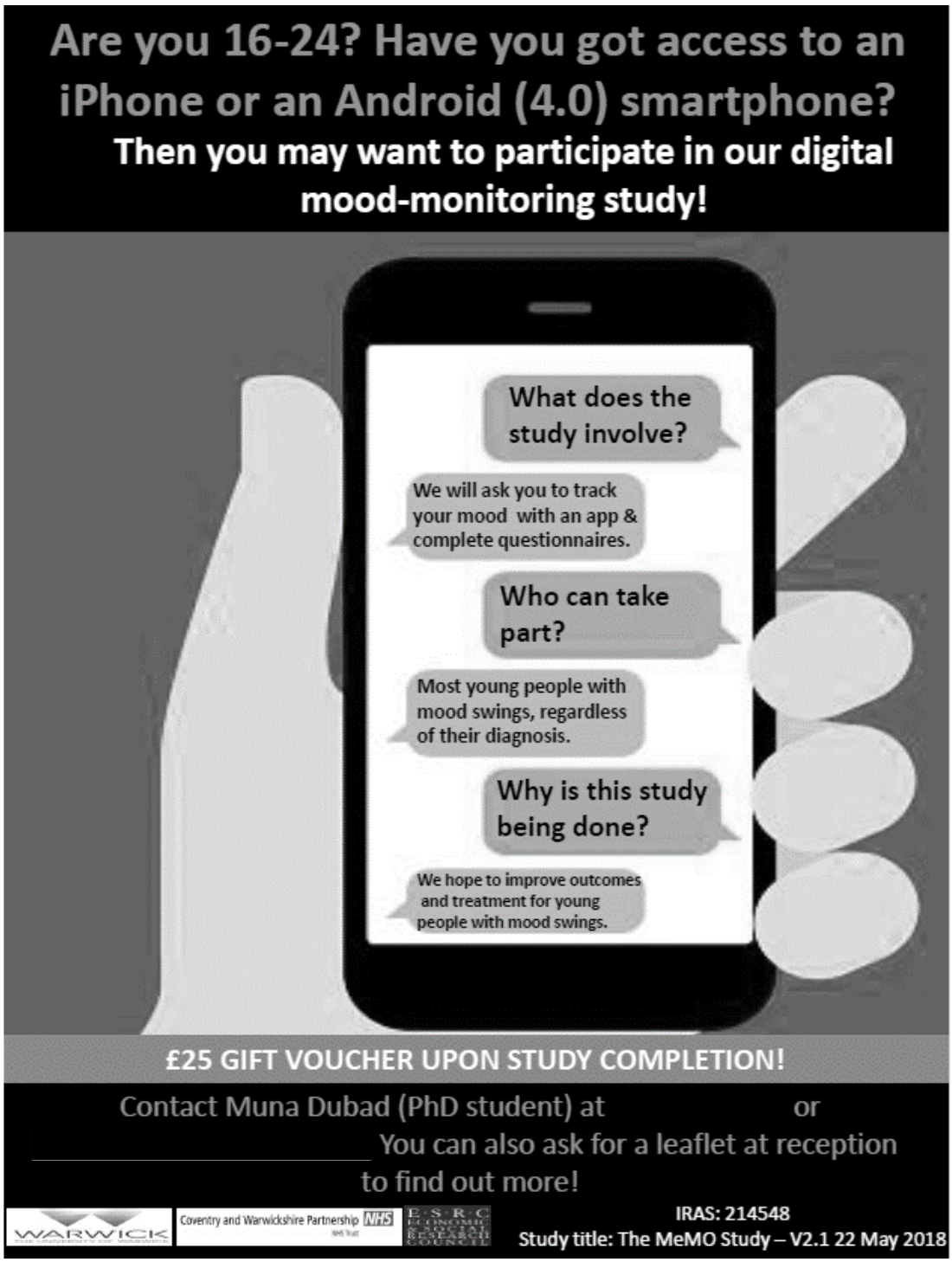
_____

_____

Thank you very much for completing this form!

[redacted]

Appendix 11: Example study poster



Appendix 12: CWPT patient participant information sheet (qualitative mood-monitoring study)

Participant Information Sheet

Project title: Exploring young people's experiences of using a smartphone application to monitor their mood.

You are being invited to take part in a study which aims to explore young people's experiences of using a smartphone application (app) to monitor their mood through a focus group or individual interview.

Before you decide if you want take part, it is important for you to understand what the study is about, why the study is being done, and what will happen when you take part. Please take time to read this information sheet very carefully and talk about it with your family, friends, or a health professional (e.g., your treating consultant), if you would like to. If anything is not clear or if you would like more information, please do not hesitate to contact us using the contact details at the end of the sheet.

Why is this research being done?

There are many young people who struggle with mood swings, which can cause difficulties in their everyday lives. We would like to find out if mood-monitoring apps are useful when it comes to assessing mood swings. We would also like to investigate if this type of technology helps young people feel more engaged with their treatment and whether it helps young people feel more in control of their mental health and wellbeing. Although the previous study you took part in helped us better understand what impact the app has had in statistical terms, we would now like to hear about your experiences of taking part in the study and see what impact it had from your unique perspective. From this information, we hope to understand whether mood-monitoring apps could be used more widely to help young people with these problems.

Why am I being asked to take part?

We are inviting young people who took part in the digital mood-monitoring study. You participated in this study and previously indicated that you would like to be considered for and contacted about taking part in a focus group after the mood-monitoring study ended. Only those who gave their consent to be contacted, are invited to take part.

Do I have to take part?

No, it is up to you whether you take part or not. You will be asked to sign a consent form to say that you are happy to take part. However, you can still change your mind and stop participating in this study at any time. Just tell either someone on the research team or let your treating clinician know. You do not have to give any reasons. Withdrawing from the study will not affect you or your care in any way.

What will happen during the study?

You will join a group of six to eight young people who have all taken part in the mood-monitoring study. The group will last for about an hour during which you will be asked to share your experiences of taking part in the study. You will be asked questions about different topics such as the ease of use of the app, self-management/self-regulation strategies, and communication with mental health professionals.

If not enough young people can take part in the focus group or if you feel more comfortable with an individual interview, Ms Dubad (PhD student) may also offer you an individual face-to-face or telephone interview, depending on your own preference. The individual interview will address the same topics as the focus group.

What are the possible disadvantages and risks of taking part?

Some of the topics might feel somewhat personal. However, anything you share in the group will remain confidential, which means that it cannot be shared outside of the group. Everyone who takes part will have to agree to this. Anything that you share in the individual interview will also be kept confidential. Furthermore, you are not expected to share anything you do not feel comfortable with sharing.

Please also note that any travel costs you experience as a result of taking part in this study, will be refunded to you, if required.

What are the possible benefits of taking part?

You might enjoy meeting young people with similar experiences in the focus group. As with the digital mood-monitoring study, by taking part in the focus group or individual interview, you will help us find out if digital mood-monitoring technology is useful for young people with mood swings.

Is the research safe and who has checked it?

The study has ethical approval from the NHS Research Ethics Committee. Local permission was also sought from Coventry and Warwickshire Partnership Trust Research and Development department.

Who is organising and funding the research?

The research is organised by the University of Warwick. The research is funded by the Economic and Social Research Council and by Coventry and Warwickshire Partnership Trust.

Will my taking part in the research be kept confidential?

Yes. The researcher will record the discussions for both the focus group and individual interviews, which will be anonymised and will remain confidential. Everyone who takes part in the focus group will be expected to keep the focus group discussions confidential.

The research team will need to look at some of your personal data (e.g., your age) from your medical records. This information will help us with the analysis of data. Please remember we will only look at the information that is needed for our study. All information will be anonymised.

If you share something that worries us, then we might have to tell your treating clinician. We will let you know if we plan to do this.

If you would like us to, we can let your GP know that you have taken part in the study. We will not share your answers with your GP unless we have your permission.

Finally, we will record all of the discussions from the focus group and interviews using a recording device. These recordings will be sent to a transcription service that has been approved by the University of Warwick. It is important that these recordings stay anonymous. You will therefore be reminded not to share personal information about yourself so we can protect your anonymity.

What happens at the end of the study?

You will receive a £10 gift voucher in recognition of the time spent participating in the focus group or individual interview. Once the study is complete, your personal identifiable data and anonymized copies of the study data will be held securely (in a locked filing cabinet, or on an encrypted file system) for 10 years, which is a requirement of the University. Data will be destroyed after this. When the study has been completed, Ms Dubad will write about the findings in her thesis for the University. Ms Dubad and her supervisors also aim to publish

the findings in research journals and present the findings at conferences. Everything we write about or present will be anonymous.

What if there is a problem?

If there is a problem, please contact either:

Professor Max Birchwood
Chief Investigator and Supervisor
Mental Health and Wellbeing
Division of Health Sciences
Warwick Medical School
University of Warwick
Coventry
CV4 7AL
Email: [redacted]

OR

Muna Dubad
PhD student
Mental Health and Wellbeing
Division of Health Sciences
Warwick Medical School
University of Warwick
Coventry
CV4 7AL
Telephone: [redacted]

Who can I contact if I have a complaint about the study?

This study is covered by the University of Warwick's insurance and indemnity cover. Any complaint about the way you have been dealt with during the study or any possible harm you might have suffered will be addressed. Please address your complaint to the person below, who is a senior University of Warwick official entirely independent of this study:

Head of Research Governance

Research & Impact Services

University House

University of Warwick

Coventry

CV4 8UW

Tel: 024 76 522746

Email: researchgovernance@warwick.ac.uk

You can also contact the Patient Advice and Liaison Service. Their contact details are:

Patient Advice and Liaison Service

Coventry and Warwickshire Partnership NHS Trust

Wayside House

Wilsons Lane

Coventry

CV6 6NY

Telephone:

0800 212 445 (Freephone)

024 7653 6804

Email: PALS.Complaints@covwarkpt.nhs.uk

How can I find out more about the study?

- You can contact either your treating clinician for more information about the study or contact the research team who are based at Warwick Medical School, University of Warwick, Coventry, CV4 7AL[1] and at The Birmingham Institute for Mental Health,

University of Birmingham, Edgbaston, Birmingham, B15 2TT[2]. Further contact details for the research team are provided below:

1. Professor Max Birchwood (Chief Investigator and Supervisor)[1]: [redacted]
2. Professor Steven Marwaha (Supervisor): [redacted] [1,2]
3. Dr Catherine Winsper (Supervisor): [redacted] [1]
4. Ms Muna Dubad (PhD Student) [1]
   - Email: [redacted]
   - Telephone: [redacted]

- For general advice and guidance, you can also contact the Patient Advice and Liaison Service. Their contact details are described above.

Thank you for reading this information sheet!

Appendix 13: CWPT patient consent form (qualitative mood-monitoring study)

WARWICK
THE UNIVERSITY OF WARWICK

Name of Service:

Participant Identification Number:

CONSENT FORM

Title of Project: Exploring young people's experiences of using a smartphone application to monitor their mood.

Name of Chief Investigator: Professor Max Birchwood

Please initial box

1. I confirm that I have read the information sheet (version 3.1) for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily. ☐
2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason, without my medical care or legal rights being affected. ☐
3. I understand that relevant sections of my medical notes and data collected during the study, may be looked at by individuals from the University of Warwick, from regulatory authorities or from the NHS Trust, where it is relevant to my taking part in this research. I give permission for these individuals to have access to this data. ☐
4. I understand that audio recordings collected during the study will be transcribed by an external transcription service approved by the University of Warwick. I give permission for these individuals to have access to this data. ☐
5. I agree to my General Practitioner being informed of my participation in the study. ☐
6. I understand that if I share something that worries the researchers, that the researchers might have to let my treating clinician know. ☐
7. I agree to take part in the above study. ☐

[redacted]

Name of Participant	Date	Signature
Name of Person Taking Consent	Date	Signature

Appendix 14: CWPT clinician participant information sheet (qualitative mood-monitoring study)

Participant Information Sheet

Project title: To examine from the perspective of clinicians the usefulness of using the mood-monitoring application.

You are being invited to take part in a study, which aims to explore the usefulness of using the mood-monitoring application (app) from the perspective of clinicians.

Before you decide if you want take part, it is important for you to understand what the study is about, why the study is being done, and what will happen when you take part. Please take time to read this information sheet carefully. If anything is not clear or if you would like more information, please do not hesitate to contact us using the contact details at the end of the sheet.

Why is this research being done?

There are many young people who struggle with mood swings, which can cause difficulties in their everyday lives. We would like to find out if mood-monitoring apps are useful when it comes to assessing mood swings. We would also like to investigate if this type of technology helps young people feel more engaged with their treatment and whether it helps young people feel more in control of their mental health and wellbeing. In addition to exploring young people's perspectives on this technology, we would also like to explore clinicians' perspectives of seeing patients with mood swings who used the app. By exploring both perspectives, we hope to understand if mood-monitoring apps could be used more widely in clinical practice to help patients.

Why am I being asked to take part?

We would like to explore clinicians' perspectives of seeing patients with mood swings who used the app.

Do I have to take part?

No, it is up to you whether you take part or not. You will be asked to sign a consent form through which you will give your consent. However, you have the right to withdraw from this study at any time by letting someone on the research team know. You do not have to give any reasons. Withdrawing from the study will not affect you in any way.

What will happen during the study?

After signing the consent form, you will be asked to indicate whether you would like to partake in either a focus group, individual face-to-face interviews, or individual telephone interviews. If sufficient interest is expressed for a focus group, you will be invited to participate in a focus group with other clinicians. The group will consist of six to eight people who have all seen patients who participated in the mood-monitoring study. The group will last for about an hour during which you will be asked to share your experiences of seeing these patients and compare these to your experiences of seeing patients who did not use the app. Different topics will be discussed such as the usefulness of the digital mood-monitoring data and the benefits/problems of using the app to engage young people with mood instability. If not enough clinicians can take part in the focus groups, clinicians will be offered to either engage in individual face-to-face or telephone interviews, depending on their own preference. The individual interviews will address the same topics as the focus group.

What are the possible disadvantages and risks of taking part?

You should not experience any disadvantages or risks as a result of taking part.

What are the possible benefits of taking part?

Sharing your experiences will help us find out if digital mood-monitoring technology is useful in clinical practice.

Is the research safe and who has checked it?

Ethical approval has been sought from the NHS Research Ethics Committee. Local permission has also been obtained from Coventry and Warwickshire Partnership Trust Research and Development department.

Who is organising and funding the research?

The research is organised by the University of Warwick. The research is funded by the Economic and Social Research Council and by Coventry and Warwickshire Partnership Trust.

Will my taking part in the research be kept confidential?

Yes. All discussions, both in the case of focus groups and individual interviews, will be anonymised and kept confidential. If a focus group is carried out, all participants will have to agree to keep all discussions confidential.

It should be noted that an audio recording device will be used to record discussions from focus groups/interviews. These recordings will be password-protected and transcribed by an external transcription service that has been approved by the University of Warwick. The data that will be transcribed will be anonymous. You will therefore be reminded not to disclose personal identifiable information during the discussions, in order to protect the anonymity of the data.

What happens at the end of the study?

Once the study is complete, your personal identifiable data and anonymized copies of the study data will be held securely (in a locked filing cabinet, or on an encrypted file system) for 10 years, which is a requirement of the University. Data will be destroyed after this. When the study has been completed, Ms Dubad (PhD student) will write about the findings in her thesis for the University. Ms Dubad and her supervisors also aim to publish the findings in research journals and present the findings at conferences. Everything we write about or present will be anonymous.

What if there is a problem?

If there is a problem, please contact:

Professor Max Birchwood
Chief Investigator
Mental Health and Wellbeing
Division of Health Sciences
Warwick Medical School
University of Warwick
Coventry
CV4 7AL
Email: [redacted]

OR

Muna Dubad
PhD student
Mental Health and Wellbeing
Division of Health Sciences
Warwick Medical School

University of Warwick
Coventry
CV4 7AL
Email: [redacted]
Telephone: [redacted]

Who can I contact if I have a complaint about the study?

This study is covered by the University of Warwick's insurance and indemnity cover. Any complaint about the way you have been dealt with during the study or any possible harm you might have suffered will be addressed. Please address your complaint to the person below, who is a senior University of Warwick official entirely independent of this study:

Head of Research Governance

Research & Impact Services

University House

University of Warwick

Coventry

CV4 8UW

Tel: 024 76 522746

Email: researchgovernance@warwick.ac.uk

How can I find out more about the study?

- You can contact the research team who are based at Warwick Medical School, University of Warwick, Coventry, CV4 7AL[1] and at The Birmingham Institute for Mental Health, University of Birmingham, Edgbaston, Birmingham, B15 2TT[2]. Further contact details for the research team are provided below:
    1. Professor Max Birchwood (Chief Investigator and Supervisor)[1]: [redacted]
    2. Professor Steven Marwaha (Supervisor): [redacted][1,2]
    3. Dr Catherine Winsper (Supervisor): [redacted][1]
    4. Ms Muna Dubad (PhD Student)[1]

- Email: [redacted]
- Telephone: [redacted]

Thank you for reading this information sheet!

Appendix 15: CWPT clinician consent form (qualitative mood-monitoring study)

WARWICK
THE UNIVERSITY OF WARWICK

Name of Service:

Participant Identification Number:

CONSENT FORM

Title of Project: To examine from the perspective of clinicians the usefulness of using the mood-monitoring application for young people with mood swings.

Name of Chief Investigator: Professor Max Birchwood

Please initial box

1. I confirm that I have read the information sheet (version 3) for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily. ☐
2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason, without my medical care or legal rights being affected. ☐
3. I understand that data collected during the study, may be looked at by individuals from the University of Warwick, from regulatory authorities or from the NHS Trust, where it is relevant to my taking part in this research. I give permission for these individuals to have access to this data. ☐
4. I understand that audio recordings collected during the study will be transcribed by an external transcription service approved by the University of Warwick. I give permission for these individuals to have access to this data. ☐
5. I agree to take part in the above study. ☐

[redacted]

Name of Participant	Date	Signature
Name of Person Taking Consent	Date	Signature

[redacted]

Name of Service:

Participant Identification Number:

CONSENT FORM

Title of Project: To examine from the perspective of clinicians the usefulness of using the mood-monitoring application.

Name of Chief Investigator: Professor Max Birchwood

Please circle below which interview method(s) you would prefer:

A I would prefer to take part in a focus group with other clinicians.

B I would prefer to take part in an individual face-to-face interview.

C I would prefer to take part in an individual telephone interview.

D I have no preference.

[redacted]