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Mental health monitoring apps for depression and anxiety in children and young people: A scoping review and critical ecological analysis

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ABSTRACT

There is considerable concern about increasing rates of anxiety and depression among children and young people (CYP). Mental health technologies, such as smartphone applications, are proposed as a potential solution. However, the effectiveness of mental health mobile applications for managing, moderating and treating anxiety and depression in CYP is uncertain. The purpose of this scoping review is to outline the extent of the clinical evidence base of mental health apps with monitoring functions for depression and anxiety in CYP, to categorise the range of monitoring features, to understand their various purposes, and to analyse these 'technical mechanisms' in apps from the perspective of *critical ecological analysis*. It provides a novel conceptual framework for researching how CYP may use and critically engage with mental health apps. We searched Ovid MEDLINE, PsycINFO, and Scopus databases, and 39 studies met the inclusion criteria. The analysis focuses attention on the ecological (mental, social and environmental) dimensions of life, health and emotional experience and the purposes of mental health monitoring apps. We evaluate the way that technical *mechanisms*, such as metrics are used in apps, examine their effects on *responsibility* for managing and treating distress and consider the *rationalities* that guide their development. The paper concludes that examination of the bioethics and neuroethics of these technologies is necessary and urgent. This requires paying closer attention to the social practices of technology-enabled self-monitoring, and the ways in which these frame mental health as a form of individualised emotional regulation.

1. Introduction

There is a high prevalence of mental health disorders among children, adolescents, and young people (CYP). Data suggests that globally, up to 20 percent of adolescents experience mental disorders (United Nations Children's Fund, 2019). The World Health Organization (WHO) (2020) report that 'half of all mental health conditions start by 14 years of age but most cases are undetected and untreated'. In the United Kingdom (UK), for instance, The Children's Society states that, '75% of young people who are experiencing mental health problems aren't receiving treatment' (Gee, 2018). Digital health interventions (DHIs), such as mental health mobile phone applications have become increasingly prevalent, presented as a way to make up for this shortfall in service provision (Grist et al., 2019). High rates of mental distress among CYP, lack of treatment availability, and moves towards delivering some mental health care digitally form the background to a 'triple global public mental health challenge' presented by the Coronavirus Disease 2019 pandemic (COVID-19) (Campion et al., 2020, p.657). Some argue that mental health services and therapies should therefore be rapidly digitalised (Torous et al., 2020b, p.1). However, the effectiveness of digital mental health technologies in assessing, managing, and attempting to treat mental health issues is not certain, especially in relation to children and young people. Although COVID-19 has accelerated the implementation of digital mental health services in the UK and elsewhere, these have not been sufficiently evaluated (The Lancet Psychiatry, 2021).

The objectives of this paper are: (1) to review the extent of research on mental health monitoring apps, (2) to identify the various 'purposes' of monitoring functions and their 'technical mechanisms', (3) to outline the clinical evidence base (efficacy) of mood and anxiety monitoring apps in managing and treating symptoms of anxiety and depression in CYP, and (4) to provide future direction for the field of mental health app development in 'real-world' contexts. The paper extends the analytic framework of 'digital ecologies of youth mental health' (Fullagar et al., 2017b. p.1) to investigate how the functions of monitoring and data capture produce novel forms of ethical responsibility in relation to

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mental health. We unpack varying assumptions related to what the purpose of monitoring is, what methodologies should be used to assess them, and whether it is therapeutic. Our primary interest is to shed light on the range, types and functions of mental health monitoring apps, describe the current evidence base on their efficacy, and to provide a conceptual framework for understanding how CYP use such apps in particular social environments – the focus of a follow-on study. We define mental health monitoring apps as a broader social phenomenon implicated in the production of posthuman forms of subjectivity, instead of merely as a tool for the treatment of anxiety, depression and mental health. We argue for the importance of exploring how distress is shaped and mediated by technologies, for this is integral to understanding the consequences of the turn towards digitalised mental healthcare.

Rather than pursuing a clinical definition of mental health, anxiety and depression, we respond to calls to 'attend to mental distress and psychopathology as phenomena that bring the neurological, psychological, psychopharmacological, and sociological together' (Callard and Fitzgerald, 2015, p.6). We advance this interdisciplinary perspective in two key respects. Firstly, we combine recent developments in critical social sciences of health that utilise *new materialist* and *posthumanist* frameworks (Andrews, 2019; Fullagar et al., 2017a, 2017b; Lupton, 2018, 2020) with a novel application of philosophical approaches to ecology (Guattari, 2000; Citton, 2017). By drawing insights from these fields together, we focus on the sociotechnical and affective relations between user and app and elaborate the wider socio-political and economic context shaping design, promotion and use of these technologies. Secondly we investigate the value of reframing mental health in terms of 'modes of existence' (Andrews, 2019) which require more than technological interventions. These two perspectives generate a set of ethical considerations about the growing enthusiasm for and adoption of mental health monitoring apps to inform their use and application in community settings. The next section charts this enthusiasm by providing a background to the field of research on mental health apps and digital health interventions for CYP in relation to anxiety and depression.

2. Background

2.1. Depression and anxiety

Depression and anxiety are considered as 'common mental disorders' that are denoted as such because of their high prevalence among the general population (WHO, 2017). In relation to CYP, depression is one of the main causes of disability and illness among adolescents (WHO, 2020). The Mental Health Foundation (2018a) define depression as, 'a common mental disorder that causes people to experience low mood, loss of interest or pleasure, feelings of guilt or low self-worth, disturbed sleep or appetite, low energy and poor concentration'. Anxiety is defined as 'a feeling of unease, worry or fear which, when persistent and impact on daily life may be a sign of an anxiety disorder' (Mental Health Foundation, 2018b). There are various conditions (for example, Major Depressive Disorder) and degrees (mild, moderate, and severe) of anxiety and depression. Anxiety and depression often present comorbidly and there are debates as to whether they are distinct disorders or if they operate on a form of continuum, where depression is at one pole and anxiety at the other (Brady and Kendall, 1992). One basic way of differentiating anxiety from depression is that for anxiety the 'predominant emotion is fear, whereas in depression it is sadness' (Brady and Kendall, 1992, p.244).

2.2. Digital health interventions and mental health apps

Digital health interventions (DHIs) and mental health mobile applications (apps) have emerged over the last few decades as potential preventative and therapeutic tools to be used in mental healthcare (Hollis et al., 2017). There are numerous types of digital and electronic healthcare, for example, 'e-mental health', commonly refers to digital technologies that provide interventions via web-based platforms, tablets or smartphones and computers (Grist et al., 2019). Mobile mental health interventions can be based around various functions (e.g. SMS), but downloadable smartphone apps are currently the most common form (Grist et al., 2017). Due to the high rates of smartphone ownership, usage, and assumptions that CYP have a prescient grasp of smartphones and tablets, apps are viewed as a ubiquitous and powerful platform to distribute mental health interventions to CYP (Grist et al., 2017). Smartphone apps are demarcated from other mobile mental health tools such as telepsychiatry, in that, responsibility mainly lies with the patient to engage with the app, whereas telepsychiatry requires the clinician to learn and introduce new skills and practices of care (Pickersgill, 2019a).

Mood monitoring involves tracking symptoms, feelings and behaviours, and is a key part of cognitive-behavioural therapy (CBT) (Matthews and Doherty, 2011). Self-monitoring of mood has been seen to have beneficial therapeutic outcomes, as the information can be used to recognise triggers, build coping strategies, notice changes in treatment and help clients understand their behaviour better (ibid.). In a more critical vein, CBT has been considered as a 'manualized therapy' which has become the dominant treatment for a range of mental health difficulties in the UK, for example, owing to its cost-effectiveness (Pickersgill, 2019b, p.635). Whilst some mental health apps deliver CBT content and monitoring functions, there is variability in the way that apps are designed. For example, monitoring features are also distributed through remote sensing functions (both active and passive) to track a range of physical and mental phenomena, such as, sleep patterns, exercise and mood activity (Hollis et al., 2017). Owing to the expansion of the monitoring and tracking features of apps, Hollis et al. (2017, p.475) argue that the boundary between monitoring and interventions in DHIs will become 'increasingly blurred'. The actual purpose of monitoring, if it enhances treatment, or if it is therapeutic in its own right are thus pertinent questions in relation to its use in mental health apps for CYP.

There are now over 10,000 mental health apps commercially available (Torous et al., 2019, p.97). Whilst the number continues to increase, there are disparities in terms of the screening and testing of apps. Apps developed by clinical researchers undergo more scrutiny in terms of safety and to test efficacy, than private sector developers, a 'commercialization gap' exists (Martinez-Martin and Kreitmair, 2018, p.3). Research is not keeping pace with the vast array of apps currently available and the rapid advancements in the technologies that these apps utilise, as such, the efficacy, safety and 'real-world' effectiveness of mental health apps is not clear-cut (Grist et al., 2017; Torous et al., 2020a). Moreover, questions have been raised about whether children, adolescents, young people and adults actually want to engage with mental health apps and DHIs as a form of prevention and treatment of mental health issues (Hollis et al., 2017). Previous studies with young people suggest many reasons for why CYP may be reticent to use apps for mental health, these include: security, privacy, stigma, and lack of human contact (Kenny et al., 2016).

2.3. Efficacy of mental health apps

Meta-analyses of randomised controlled trials (RCTs) of smartphone interventions for depression in adults demonstrated a 'moderate positive effect on depressive symptoms' (Firth et al., 2017b, p.296). For smartphone interventions for anxiety in adults, Firth et al. (2017a, p.18) found that they decreased symptoms of anxiety more than control conditions. However, there has been issues with high attrition rates in RCTs (Torous et al., 2020a), leading some reviewers to argue for enabling in-app mood monitoring features to improve longer term use. Grist et al. (2017) found that few mental health apps have been designed specifically for CYP and found insufficient evidence for their effective use with children and young people in any setting, such as, 'real-world' scenarios of implementation.

2.4. Synopsis of reviews

Monitoring features have been identified as a core component of mental health apps. Nine out of 17 studies in a review by Seko et al. (2014) used apps or SMS in a self-monitoring capacity, while 10 out of 15 mobile mental health apps for CYP included in a review by Grist et al. (2017) had a self-monitoring element. Reviews have found that self-monitoring is considered as a therapeutic intervention in its own right as it reduces psychological distress, encourages treatment adherence and improves self-efficacy (Seko et al., 2014). Punukollu and Marques (2019, p.164) suggest that: 'The very act of engaging with MH monitoring may be beneficial for CYP'. Some contrasting conclusions have been drawn, Hollis et al. (2017) contend that mood monitoring is not therapeutic on its own but could still improve personalisation of technologies and encourage adherence to treatments. Smartphone apps are particularly suited to gather Ecological Momentary Assessment (EMA) data, which considers 'individuals' current experiences, behaviors, and moods as they occur in real time and in their natural environment' (Burke et al., 2017, n.p.). Reviews have assessed digital (wearable and mobile) tools that 'are able to capture the dynamic nature of depressive symptoms and disorders in children and adolescents' as well as potentially predict depressive states but have concluded that the effectiveness of such technologies for this purpose cannot yet be stated (Sequeira et al., 2020, p.321).

3. Study design and method

The scoping review method was adopted to map the broad area of mood and anxiety monitoring mental health app research, the concepts that ground it, and present the extent of the varying types of emerging

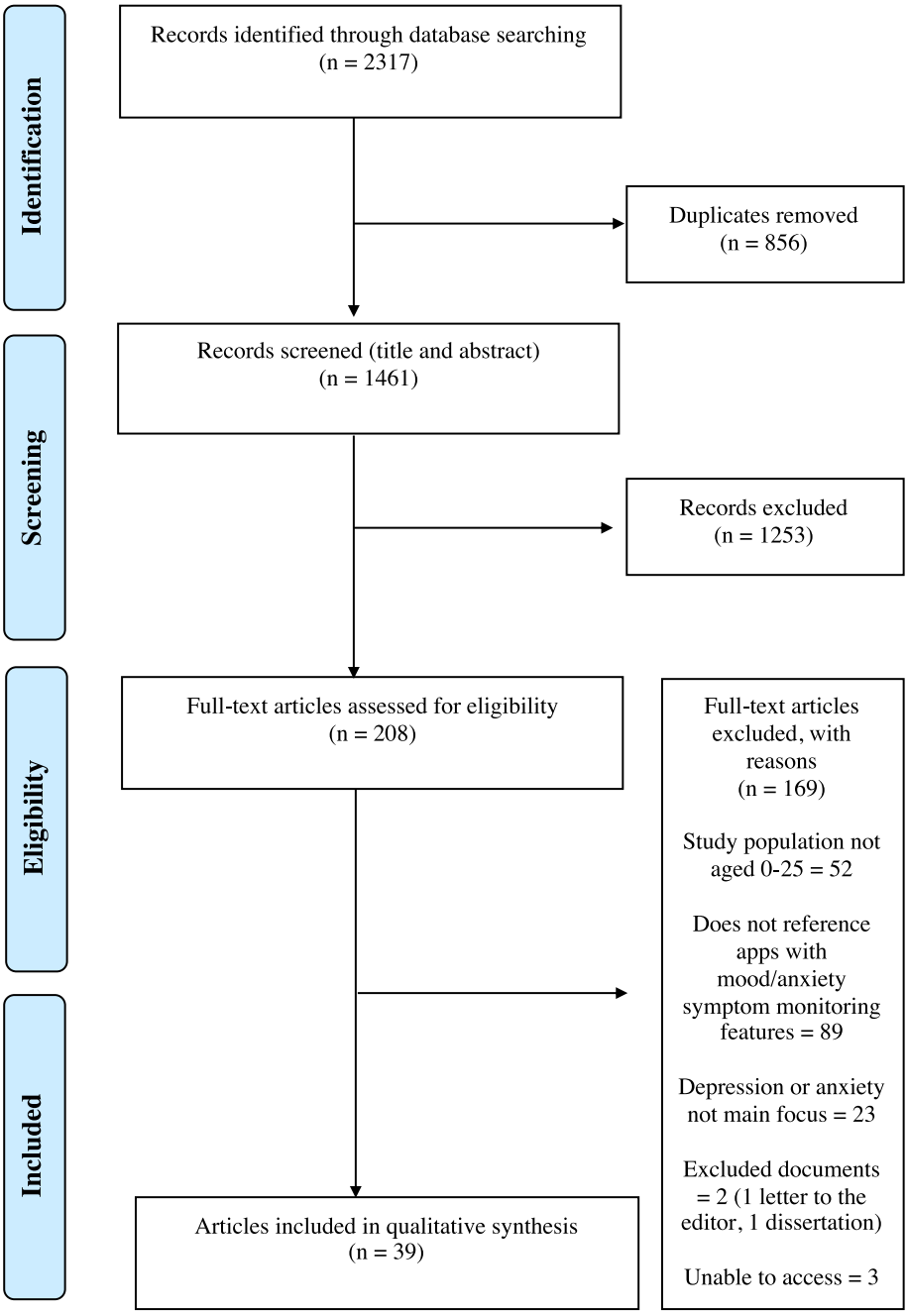

Fig. 1. PRISMA diagram.

evidence available (Arksey and O'Malley, 2005; Peterson et al., 2017). We use a hermeneutic approach to analysis, which has the goal of producing novel interpretations and advancing theoretical development with reference to a wider contextualising literature (Greenhalgh et al., 2018, p.3). We developed and applied a 'critical ecological analysis' (see section 3.4) to the results.

3.1. Identifying relevant studies: search strategy

In order to gain a comprehensive understanding of the research field, a systematic search strategy was developed. Three search concepts were explored: depression and anxiety, mobile mental health apps, and children and young people (see supplementary materials for Scopus search string). Medical Subject Headings (MeSH) terms were also used for the search concepts on PsycINFO and Ovid MEDLINE databases. The first author carried out an electronic search on the June 28, 2020 on three databases: PsycINFO, MEDLINE and Scopus, searches within title, abstract and keywords were performed. The searches conducted on the three databases produced 2317 results, after duplicates were removed, 1461 sources remained for screening (Fig. 1.).

3.2. Study selection: inclusion and exclusion criteria

Articles were eligible for full-text review if: (i) the primary focus was on depression and/or anxiety; (ii) the study involved smartphone applications with a mood or anxiety monitoring feature; (iii) the population of interest was children or young people (aged 0–25), or the mean age of participants was <25 years of age. Articles were excluded if the following were met: (i) if depression and/or anxiety were not the main focus; (ii) if the study only involves SMS/MMS mood and/or anxiety monitoring/tracking (not via smartphone app), or web-based interventions that do not involve a smartphone app; (iii) if the participants or the population of interest to the study was not children or young people. All methodology types were included (conceptual pieces, quantitative, qualitative, mixed methods, reviews and conference papers).

As it was difficult to fully establish from the abstract whether the study participants or population of interest was CYP and if apps had mood or anxiety symptom monitoring features, 208 articles were included for full-text review. After the literature was screened for eligibility and the inclusion and exclusion criteria were applied, 39 articles remained for inclusion in the review (Fig. 1.).

3.3. Charting the data

The first stage of charting the data (Arksey and O'Malley, 2005), involved reading each source and highlighting key passages in relation to the research objectives. The original texts were returned to repeatedly and the charting document updated as necessary (Levac et al., 2010). Studies have been categorised into types based on methodology. For results of the effectiveness of monitoring apps, mental health outcome data related to anxiety and depression were extracted from the articles. For the typology, details of apps with mood or anxiety symptom monitoring functions were charted from the studies.

3.4. Critical ecological analysis

An abductive and hermeneutic approach informed this analysis as we moved iteratively between the data from the studies reviewed and our theoretical framework. This framework draws on new materialist and posthumanist philosophies and furthers the notion of 'digital ecologies of youth mental health' (Fullagar et al., 2017b, p.1) from the social sciences of health literature to advance a *critical ecological analysis*. New materialist and posthumanist philosophies share a concern for decentring the human subject and bringing the non-human into the field of inquiry (Coole and Frost, 2010). Andrews and Duff (2019, p.124) explain a posthumanist approach: 'all things should be understood as products of distributed, expansive processes involving associations and encounters between multiple living/biological and material/technological actors'. In recent years theorists have sought to understand the role of material technologies in shaping consciousness, cognition, intelligence (Hayles, 2017), and attention (Citton, 2017). As such, we analyse the mental health apps reviewed as digital cultural texts and material objects.

Philosophical understandings of ecology in contemporary thought decentre the human and pay attention to the capacities of non-human others, digital and otherwise, with ecology acting as a 'cipher' for a 'new thinking of togetherness' (Hörl, 2017, p.3). A turn to ecology can also be felt across the social and life sciences: there is increasing interest in the interactions of technologies, mental health, the environments which people inhabit, and the relations between these (Duff, 2014; Brown and Reavey, 2019; Pykett et al., 2020). The specific approach to ecology that this paper draws on is Félix Guattari's (2000) theorisation of *ecosophy* as an ethical and political concept. Ecosophy has three interrelated and inseparable domains: 'the three ecological registers (the environment, social relations and human subjectivity)' (Guattari, 2000, p.28). The relevance of this to mental health is for an understanding of individuals, technologies and ecologies of being, as singularities that cannot be made divisible, owing to the relations that exist between them. In order to improve our ways of living and being we need solutions that act across the domains. Through this analytical approach, we conceptualise monitoring apps as digital cultural and material objects that have complex capacities to affect and be affected across ecological registers (mental, social and environmental). Encounters with apps produce relations that increase and decrease the capacity of the individual to act; theorised as the capacity to affect and be affected (Deleuze, 1988). Monitoring apps open up, mediate and close down possible forms of existence (Brassett, 2019; Lupton, 2020).

Our focus on the relationality of the mental, social and environmental in shaping health has synergies with other approaches in the social sciences. Biopsychosocial perspectives (Borrell-Carrió et al., 2004; Rose, 2019), including research which focusses on social, environmental and economic determinants of health (Allen et al., 2014), and approaches which think of health practices as relational, crossing multiple social fields (Veenstra and Burnett, 2014, p.194). These perspectives all complicate bounded or measurable ideas of the social in the health sciences. A posthumanist approach to health and recovery is processual, conceptualising both as extended events (Duff, 2014; Andrews, 2019). Health is considered 'not as a physiological or psychological condition, but instead as a mode of existence' continually being made through ecologies, relations and practices (Andrews, 2019, p.1113). These approaches suggest that there would be benefits to expanding the scope of mental health outcome measures on which most mental health monitoring apps are based beyond the individual, and for methodological advancements in evaluating feasibility and usability in their wider socio-spatial contexts.

We therefore develop a critical ecological framework to critically engage with literature on the efficacy of mental health monitoring apps and problematise the idea of apps as discrete 'tools'. We extend Fullagar et al.'s (2017b, p.1) consideration of mental health apps as part of 'digital ecologies of youth mental health' by questioning the separation of the human (app user) and technological objects (monitoring apps) by which they are proposed to achieve good mental health. After this section we present a typology that identifies different types of monitoring apps, their purposes and 'technical mechanisms'. In our discussion, we draw on this to speculate on how the metrics of the apps produce particular types of subjectivities, understandings about anxiety and depression, and responsibilities. Then, we discuss the rationalities that may shape the development of mental health monitoring apps for CYP.

3.5. Limitations

As this review only searched three databases, it is possible that some research has been missed. The search was limited to English language research, this circumscribes understandings of the global extent of the research in this field. Moreover, the articles reviewed in this study are generally based within a Western and scientific model of mental health, there are of course many other ontologies and epistemologies of mental health, and these need to be foregrounded in future research.

4. Results

4.1. Extent of the research

30 of the 39 studies have been published from 2017 onwards, signifying a substantial increase in research activity within this field. Within the acknowledged language limitation of the search strategy, over 80 per cent of the articles are published in Europe, North America and Australia, with only four authored by researchers based in Asia (Yoo et al., 2017; Hur et al., 2018; Panatagama et al., 2018; Gao et al., 2020).

The key characteristics of the studies are summarised in Table 1. There are 23 primary studies in total. Nine articles are acceptability, app design and/or usability studies, and a range of methods were used across these studies, such as focus groups, interviews and surveys. Generally, the purpose was to gather perspectives on prototype apps from intended users, clinicians and researchers to inform their design and to explore how monitoring apps may be used in 'real-world' environments. Five studies use methods of ecological momentary assessment (EMA) delivered via smartphone apps. In varying ways, they explore the use of EMA in researching the fluctuation of mood and/or symptoms of anxiety within 'real-world' settings. Six papers constitute feasibility studies with a trial element, whereby participants use a mental health monitoring app for a set period of time, provide feedback and in some cases, complete pre-post mental health measures. Two studies are RCTs, one reports positive outcome data related to depression (Hur et al., 2018) and the other reports no significant reduction for measures of anxiety and depression (Reid et al., 2011). The final primary study is a trial protocol.

There are 16 secondary studies in this review, 11 are review articles, two are conference papers, and two are reports. The remaining secondary study is a discussion paper that develops the 'digital ecologies of youth mental health' (Fullagar et al., 2017b, p.1) framework.

4.2. From efficacy to assemblages of mental health monitoring apps

In this section we outline the clinical outcomes of mental health monitoring apps for anxiety and depression across the studies. We then turn to a discussion of the trajectory of research into mental health monitoring apps, that is focused on the usability and acceptability of apps rather than proving effectiveness. We use our critical ecological framework to argue that understanding monitoring apps as part of assemblages is necessary in order to advance knowledge on their broader societal implications rather than how effective they are as discrete tools.

Nonetheless, studies on effectiveness are clearly of key importance to clinicians and healthcare providers and are worthy of attention. Similarly to the results of reviews conducted by Grist et al. (2017) and Dubad et al. (2018), we identified few studies that researched the effectiveness of mental health monitoring apps. Two RCTs (Reid et al., 2011; Hur et al., 2018) tested the efficacy of a mental health app with a monitoring feature in reducing symptoms of anxiety and/or depression in CYP. Hur et al. (2018) tested the scenario-based CBT mobile app, *Todac Todac* with a group of young people diagnosed with Other Specified Depressive Disorder. They argue that the results show that interventions on negative thinking can help in reducing anxiety, and this may concurrently alleviate depressive symptoms. The results of both RCTs highlight how the direct pathways to treating both anxiety and depression using monitoring mental health apps remain somewhat uncharted. Reid et al.'s (2011, p.2) effectiveness trial aimed to determine the mental health benefits of the *mobiletype* app when used in the context of existing care provision in a primary care 'real world' setting. A group of patients (aged 14 to 24) with mild and moderate mental health issues were recruited from general practices (Reid et al., 2011). The patients in the intervention group self-monitored via *mobiletype* by recording their mood, stress and daily activities, whereas the control group only recorded daily activities via the app (ibid.). There were no significant effects for depression and anxiety in the intervention group but for the overall sample there was a decrease in depression, anxiety and stress from the pre-test to six weeks post-test (ibid.). However, the intervention group did demonstrate an increase of 'emotional self-awareness' (Reid et al., 2011, p.10). The self-monitoring capacities afforded by the app were deemed to reduce symptoms of anxiety and depression in young people by making them more aware of emotions and stressors (Reid et al., 2011). Additionally, the continued contact with general practitioners and the act of participating in the trial is seen as contributing to positive mental health outcomes (ibid.).

The outcome of Reid et al.'s (2011) study points to the need to understand the relations between apps, users, healthcare providers and researchers to understand the effectiveness of apps as mental health interventions. Rather than thinking about mental health monitoring apps as tools, we think about them relationally. One way of thinking about the relations between apps, their capacity to affect, and how they produce affects, is through assemblage thinking. Assemblages are 'a heterogenous collection of components' which come together and fall apart through a composite array of relations between 'various combinations of bodies, expressions, institutions and signs' (Roy, 2018, p.207). Assemblages refer to how specific organisms or objects (for example, human or app) can be 'understood in terms of the *intensive environment* in which they emerge' (Dewsbury, 2011, p.148, emphasis in original). Assemblages of humans and health technologies can be analysed using new materialist frameworks. In Lupton's (2018, 2020) analyses, apps enchant users owing to 'thing-power' (after Bennett, 2010), affordances are distributed between the app, human user and situated contexts. For Fullagar et al. (2017b) pedagogies *urge* young people to perform certain modes of subjectivity. Such analyses complicate understandings of monitoring apps and their affects by forwarding a broader idea of outcomes in specific 'real-world' contexts.

Six reviews report clinical outcomes for anxiety and/or depression (Seko et al., 2014; Grist et al., 2017; Dubad et al., 2018; Garrido et al., 2019b; Gindidis et al., 2019; Punukollu and Marques, 2019). Whilst some of the reviews also detail research pertaining to DHIs with mental health outcome data, *mobiletype* is the only mental health app with monitoring features designed for CYP where anxiety and depression outcome data was reported across the reviews. This suggests that ten years after this study was published, it is still the only mental health monitoring app specifically designed for young people, which has undergone a quality assessed RCT. Although there is little evidence in terms of efficacy, six of the papers are feasibility studies, with some acting as preliminary investigations before a RCT is carried out (e.g. Fuller-Tyszkiewicz et al., 2018; Stallard et al., 2018). Four of the six feasibility studies report mental health outcome data in relation to anxiety and depression. Whiteside et al.'s (2019) pilot study of *Anxiety*

Table 1
Characteristics of studies included in review (n = 39).

Primary research				
[Reference] Authors (Year)	Methods and broad aim	Population of interest	Monitoring apps cited[a]	Anxiety and depression results[b]
Acceptability, app design and usability studies				
[1] Davies et al. (2017)	Evaluation and usability: app analytics, online survey and interviews with young people to evaluate MH app.	YP	*In Hand*	/
[2] Dewa et al. (2019)	Acceptability: interviews with young patients to explore the acceptability and feasibility of MH apps, wearables and social media to detect mental health deterioration.	YP	NS	/
[3] Fuller-Tyszkiewicz et al. (2018)	Usability, acceptability and app design: interviews with professionals, researchers and target users to evaluate usability of a personalised, self-guided app for depression.	NS	*BlueWatch*	/
[4] Gao et al. (2020)	Usability: cognitive interviews, questionnaires and pilot testing with children and families to develop and test the usability of an app to assess and monitor emotional distress in younger children.	Children	*PROMIS*	/
[5] Garrido et al. (2019a)	Usability: focus groups to explore young people's perspectives on six available MH apps.	YP	*Mindshift* *MoodMission* *Pacifica* *What's Up*	/ / / /
[6] Grist et al. (2018)	Usability and acceptability: online survey to explore how female adolescents use the internet and apps for health, and their perspectives on MH apps.	Adolescents	NS	/
[7] Hetrick et al. (2018)	App design: workshops with young people and clinicians to codesign a self-monitoring mood app.	YP	Unnamed app	/
[8] Kenny et al. (2016)	App design and acceptability: focus groups to explore adolescents' needs and concerns in relation to MH apps.	YP	*CopeSmart*	/
[9] Patwardhan et al. (2015)	App design and usability: pilot trial to facilitate design of MH platform to accompany a school-based early intervention protocol.	Children	*REACH*	/
EMA				
[10] Asselbergs et al. (2016)	Pilot study to explore mobile phone based unobtrusive EMA with proxy measures for clinical states.	NS	*eMate* *iYouVu*	/ /
[11] Cushing et al. (2017)	Exploratory latent profile analysis of EMA data to identify invalid responses and investigate mood profiles.	YP	*PETE*	/
[12] Geyer et al. (2018)	EMA study to examine the impact of social anxiety and depression severity on the relationship between in-the-moment affect and perceptions of social interactions.	NS	*Sensus*	/
[13] Kirchner et al. (2017)	EMA study to analyse adolescents' daily perceptions of sadness/depression, anxiety and somatic problems.	Adolescents	*Acer Liquid Z-200*	/
[14] Poerio et al. (2013)	Experience sampling to explore the association between mind-wandering and negative mood.	NS	*SESAMO*	/
Table 1. (*cont.*)				
Feasibility				
[15] Lim et al. (2019)	Feasibility and acceptability: focus groups and trial to examine the acceptability, feasibility, and safety of +Connect.	YP	*+Connect*	–
[16] Matthews and Doherty (2011)	Feasibility: user consultation and survey, clinical and non-clinical evaluations of mood charting app.	YP	*Mobile Mood Diary*	/
[17] Reid et al. (2012)	Feasibility: to assess utility, usability and feasibility of app in clinical settings.	YP	*mobiletype*	–
[18] Stallard et al. (2018)	Uncontrolled open trial of BlueIce, designed to help young people manage distress and urges to self-harm.	YP	*BlueIce*	+
[19] Van Dam et al. (2019)	Feasibility study: questionnaires, interviews and trial of EMA app to investigate whether the use of emojis is feasible for research purposes, as a clinical tool for self-monitoring, and to explore feasibility of the app as an intervention.	Adolescents	*G-Moji*	/
[20] Whiteside et al. (2019)	Feasibility: overview of design of Anxiety Coach and pilot study to illustrate its feasibility and potential capabilities.	Children	*Anxiety Coach*	+
Trials				
[21] Hur et al. (2018)	RCT to test whether scenario-based CBT MH app decreased symptoms of depressive disorder, using mood monitoring app as comparator.	NS	*Todac Todac* unnamed mood charting app	+ +
[22] Reid et al. (2011)	RCT to examine the MH benefits of mobiletype as an adjunct to primary care.	YP	*mobiletype*	–
[23] Werner-Seidler et al. (2020)	Trial protocol for RCT of a series of MH apps developed to prevent high school students from developing depressive symptoms.	Adolescents	*Future Proofing App*	/
Secondary research				
Conceptual analysis				
[24] Fullagar et al. (2017b)	Conceptual analysis of NHS recommended MH apps.	YP	*Pacifica*	/
Conference papers				

(*continued on next page*)

Table 1 (*continued*)

Primary research				
[Reference] Authors (Year)	Methods and broad aim	Population of interest	Monitoring apps cited[a]	Anxiety and depression results[b]
[25] Panatagama et al. (2018)	Outlines the development of the SocioEmpathy app and usability survey results.	Children of divorcees	*SocioEmpathy*	/
[26] Yoo et al. (2017)	Examines the development of a MH app for measuring and managing depression in adolescents.	Adolescents	Unnamed app	/
Reports				
[27] Sequeira et al. (2019)	Outlines method of digital phenotyping (DP) via smartphones for data collection.	Children and adolescents	*CopeSmart*	/
			mobiletype	/
			PETE	/
			StudentLife	/
[28] Tingley et al. (2020)	Presents the design, content and initial outcome of BlueIce.	Adolescents	*BlueIce*	/
Reviews				
Table 1. (*cont.*)				
[29] Bruce and Kutcher (2016)	Narrative review and app search of electronic interventions for adolescent depression and anxiety.	Adolescents	*Mobiletype*	/
			Mind Your Mood	/
			MoodScope	/
[30] Bry et al. (2018)	Systematic content analysis of mobile products marketed toward anxiety in youth.	YP	NS	/
[31] Carper (2017)	Media review and analysis of Anxiety Coach app.	NS	*Anxiety Coach*	+
[32] Dubad et al. (2018)	Systematic review to examine what the psychometric properties of mobile mood-monitoring applications are, their usability, and positive and negative clinical impacts for CYP.	CYP	*CopeSmart*	/
			MoA²	/
			Mobiletype	–
			StudentLife	/
[33] Garrido et al. (2019b)	Systematic review and meta-analysis to determine factors that relate to outcomes, adherence and engagement with digital MH interventions and their effectiveness in addressing anxiety and depression in young people.	YP	*Anxiety Coach*	–
			mobiletype	–
[34] Gindidis et al. (2019)	Systematic scoping review to understand app-use in adolescent MH care.	Adolescents	*CopeSmart mobiletype*	/
				/
[35] Grist et al. (2017)	Systematic review to appraise the efficacy and acceptability of mobile apps for MH in children and adolescents younger than 18 years.	CYP	*Anxiety Coach*	/
			CopeSmart	/
			Daybuilder	/
			mobiletype	–
			Mobile	/
			Mood Diary	/
			REACH	/
			The ACT app	/
[36] Hollis et al. (2017)	Meta-review and systematic review to evaluate the evidence-base for DHIs for CYP and consider approaches to evaluation and implementation.	CYP	*mobiletype*	/
[37] Punukollu and Marques (2019)	Systematic review to critically evaluate literature about the use of apps in the detection, management and maintenance of CYPs' MH and well-being.	CYP	*mobiletype*	–
[38] Seko et al. (2014)	Scoping review to map the current state of knowledge regarding mobile MH for young people.	YP	*Mobiletype*	+
			Mobile Mood Diary	/

(*continued on next page*)

Table 1 (*continued*)

Primary research					
[Reference] Authors (Year)	Methods and broad aim	Population of interest	Monitoring apps cited[a]	Anxiety and depression results[b]
[39] Sequeira et al. (2020)	Scoping review to evaluate apps and wearable technologies that have been used to monitor depression in CYP.	CYP	*CopeSmart*	/
			Daybuilder	/
			eMate	/
			iYouVU	/
			mobiletype	/
			PETE	/
			StudentLife	/

CYP = children and young people, MH = mental health, NS = not specified YP = young people.

[a] Apps primarily targeting depression and/or anxiety with monitoring features charted.

[b] Results of clinical measures of anxiety and/or depression for interventions using monitoring apps: + = positive effect/reduction in symptoms, - = no significant reduction, / = not studied or reported.

Coach, found that this exposure therapy app showed improvements on a measure for child anxiety. Additionally, Stallard et al. (2018) found a statistically significant decrease in symptoms of anxiety and depression over the course of their trial of *BlueIce*. Yet both of these studies had involvement of clinicians and continuing care and therefore they could not state whether it was the app, the face-to-face care or a combination of both that improved symptoms. This further highlights the need to conceive of mental health monitoring apps as part of assemblages, rather than discrete tools. Taking this novel conception as a starting point may help to shed future light on why it is that overall, the results of the trials and feasibility studies align with conclusions from previous reviews (i.e. Grist et al., 2017) – that there is currently little evidence to support the efficacy of mental health monitoring apps for reducing symptoms of anxiety and depression in CYP.

Others have similarly argued that research should still focus on how best to implement them in 'real-world' settings (Gindidis et al., 2019). Yet they do so from a perspective which apparently seeks to evade the regulatory frameworks associated with healthcare interventions. Davies et al. (2017, p.116) state that the mental health monitoring app, which is the focus of their usability study, *In Hand*, should not need to undergo an RCT, because the app is a 'self-help tool' (similar to content found online) and not an intervention, therefore the 'level of evidence required to provide assurances of quality should not be expected to be as extensive as would be required for clinical interventions or medical devices'. Thus, apps such as *In Hand*, are considered as tools for 'individualised self--improvement' (Crosby and Bonnington, 2020, p.933), rather than medical interventions. To consider *In Hand* as only a self-help tool, however, obfuscates the ways in which apps emerge through the intensive environments of assemblages.

In their usability study, Garrido et al. (2019a) note that 'interventions may be effective in reducing symptoms, but they often fail to engage young people'. Here the emphasis is placed on the failure of the app to engage, rather than investigating further whether apps as interventions 'work' therapeutically in 'real-world' environments, or put another way, how interventions work across ecologies. Mental health monitoring apps, conceived of as an environmental media technology (Hörl, 2017), are mobile and spatially distributed across environments, and are themselves, distributive. Examining apps in this way, understanding their distributive affects and thinking through app-based interventions as part of assemblages of bodies, organisations, objects and other entities thus advances understandings of 'real-world' effectiveness.

A focus on improving engagement in research on mental health apps is driven by high attrition rates in trials, and high rates of people discontinuing use of apps in 'real-world' settings, with many discarded after a single use (Garrido et al., 2019a; Torous et al., 2020a). Moreover, the cost-effectiveness of app-based interventions and the idea that they may relieve pressure from mental health services also gives impetus to the imperative of designing engaging apps. From a critical ecological perspective, engagement can also be considered as orienting children and young people's attention (Citton, 2017) in certain ways, capitalising on their attention as a measure of engagement. With the focus on engagement, the effectiveness of apps arguably becomes blurred.

To explore what makes apps appealing to CYP, some studies incorporated co-design methodologies. In various ways, and to varying degrees, apps are designed through consultation with the intended target users - children and young people - however, their needs and desires for mental health apps are not always fully realised, which will limit the acceptance of apps in 'real-world' contexts. For example, in Dewa et al.'s (2019) acceptability study, they found that young people wanted an app that could be used in a mental health crisis. This is against the background of risks of delays in accessing mental health services; monitoring functions that detect for example, problems with sleep would require 'immediate action following detection', indicating the need for clinicians to be able to respond to young people in real-time (Dewa et al., 2019, p.11). In Hetrick et al.'s (2018) app design study, they found

young people to be enthusiastic about self-monitoring functions, but that real-time support was a necessity. They argue that by funding mental health services adequately, the real-time monitoring of the app, 'could be realised in terms of identifying and intervening with young people in real time to deal with acute risk of suicide rather than using the app as a digital diary' (Hetrick et al., 2018, n.p.). Such a statement suggests that apps should, and could, have a monitoring capacity that flags accelerating levels of depression to mental health services. However, the clinicians in their study did not think that responding in 'real time' would be feasible, Hetrick et al. (2018, n.p.) contend that one way of reconciling this is 'to design embedded interventions to enable young people to manage their own distress.' This (re)places the responsibility of managing symptoms of depression on the individual and the app. The viability of mental health apps appears to only apply when these are semi-autonomous technologies (involving app and human user), without the intervention of other humans. The need for 'real-time', immediate and crisis support shows that for apps to be effective interventions in 'real-world' environments, they need to be more than didactic tools for individualised self-improvement (Crosby and Bonnington, 2020). This recognises the need for a healthcare assemblage involving systems of care and adequately funded services to respond to distress.

To summarise, there is a turn towards research methodologies that focus on what makes monitoring apps engaging to CYP rather than researching their efficacy as interventions and there is ambiguity as to what the appropriate thresholds of evaluation should be for monitoring apps. This latter point may be due to a lack of clarity on what the purposes of monitoring functions in mental health apps are, the level of responsibility that mental health apps should have in terms of providing 'treatment', and wider political and economic rationales that guide their development. Moreover, addressing the methodological limitations of existing studies in terms of real-world and long-term usage of these apps in already existing therapeutic environments, suggests that the *purpose*, *responsibilities* and *rationales* should be the focus of future research. The typology provided below establishes how the critical ecological analysis framework generates a new theoretical lens through which to investigate these issues.

4.3. Towards a typology of mental health monitoring apps

Across the 39 articles, 32 apps with monitoring features, that are based primarily on targeting anxiety and/or depression are mentioned (Table 2). These apps form the typology developed in this review, which is based on the monitoring *purposes* of apps: for intervention; for management or assessment; or for data collection. The typology establishes what monitoring features apps have and some of their 'technical mechanisms' such as self-report metrics. In the discussion section we tease out these mechanisms through our critical ecological framework, to consider how apps generate specific ideas about anxiety, depression and mental health. This shifts the line of research enquiry from whether apps *work*, to what they *do*.

4.3.1. Monitoring apps as interventions

Of the mental health monitoring apps identified in the literature, 17 are categorised as apps that have monitoring features linked to interventions, as their broad purpose is to provide activities or resources that act as a form of therapeutic treatment for symptoms of depression and/or anxiety (Table 2). Of these apps, all rely on active self-report ratings of mood or anxiety, except from the *Future Proofing app* which is also designed to collect data passively, such as, Global Positioning System (GPS) information (Werner-Seidler et al., 2020). A key function across these apps is for self-monitoring features (such as, mood evaluation trackers and mood diaries) to be used before, and sometimes after, engaging with a task delivered via the app (*+Connect, Anxiety Coach, BlueIce, BlueWatch, In Hand, Mood Mission, Pacifica, REACH,* unnamed app; Hetrick et al., 2018). After rating mood or symptoms of anxiety, some apps direct the user's attention to inspirational quotes (*In Hand*), 'mood-lifting' activities (*BlueIce*), or psychoeducational material informed by positive psychology principles (+*Connect*). Positive psychology advocates for individuals to learn to skilfully manage their own emotions and to be responsible for their own 'psychological governance' (Pykett and Enright, 2016, p.53). The discourses found in the features outlined above reflect notions of self-optimisation (Lupton, 2014) which can work to produce neoliberal entrepreneurial subject positions (Elias and Gill, 2018). The use of such features and discourses in these apps suggests that a common understanding is that responsibility should be placed on the individual to manage and treat their own distress, which neglects social and environmental aspects of mental health, and underlines the political economic rationales that shape the design of some mental health monitoring apps.

Several of these apps provide activities based on CBT. *Anxiety Coach*, for example, is built around exposure-based CBT: users select fears and worries from a database and undertake exposure tasks based on these, providing fear ratings every two minutes during the task, for the user to track their symptoms over time (Carper, 2017). As Fullagar et al. (2017b, p.1) have elaborated, there is a pedagogical function to this, mood apps operate within a digital ecology moderated by 'therapeutic expertise'. Pedagogical modes of address and the affective affordances of apps produce intensities such as shame, despair and pleasure, the user partakes in self-judgement and modifies their behaviour through relations with apps; new ways of thinking, understanding and learning about mental health (i.e. changes in habit) are produced (Fullagar et al., 2017b, p.4). The intended outcome of the 'affective work' (Fullagar et al., 2017b, p.11), of engaging with the app appears to be for the user to think differently in response to anxiety or fear; an intervention on the 'mental' register that elides wider ecologies. Moreover, as Fullagar et al. (2017b) explains through understanding apps pedagogically, the various affects that apps can produce highlights how apps are more complex than self-improvement 'tools'.

The specific metric (word, emoticon or scale) used for self-report of mood or symptoms of anxiety for nine of the intervention apps is not specified in the articles, this could be because some of the articles did not focus on the design and development of apps. In systematic and scoping reviews, the description of features of apps is generally sparse, so it is difficult to analyse them as digital cultural texts. For the eight apps

Table 2
Typology of monitoring apps.

Types	Apps [reference]
Monitoring apps as interventions	*+Connect* [15], *Anxiety Coach* [20, 31, 33, 35], *BlueIce* [18, 28], *BlueWatch* [3], *CopeSmart* [8,27,32, 34, 35, 39], *In Hand* [1], *Mindshift* [5], *MoodMission* [5], *MoodScope* [29], *Pacifica* [5, 24], *REACH* [9, 35], *SocioEmpathy* [25], *The Act App* [35], *Future Proofing App* [23], Unnamed app [7], Unnamed app [26], *What's Up?* [5]
Monitoring apps for management and assessment	*Daybuilder* [35, 39], *G-Moji* [19], *Mind Your Mood* [29], *MoA²* [32], *Mobile Mood Diary* [16, 35, 38], *mobiletype* [17, 22, 27, 29, 32, 33, 34, 35, 36, 37, 38, 39], *PROMIS* [4], Unnamed mood charting app [21]
Monitoring apps as digital objects for data collection	*Acer Liquid Z-200* [13], *eMate* [10, 39], *iYouVu* [10, 39], *PETE* [11, 27, 39], *SESAMO* [14], *Sensus* [12], *StudentLife* [27, 32, 39]

where the metric was detailed in the literature, two of the apps use numeric scales for users to rate the severity of anxiety or fear (*Anxiety Coach*, *REACH*), and *CopeSmart* has a numeric scale (0–10) for users to rate how happy, angry, depressed, stressed and anxious they are feeling at that moment (Kenny et al., 2016). *In Hand*, *Pacifica*, and an unnamed app (Yoo et al., 2017) present words for users to select in response to how they are currently feeling (e.g. 'great': *In Hand*, Davies et al., 2017). Two apps feature emoticons for users to choose from in order to capture their current mood (*Pacifica* and *SocioEmpathy*). And one unnamed app has a feature that allows the user to customise colours to represent specific moods (Hetrick et al., 2018). The metrics used across these apps thus delimit responses; users must fit their symptoms and perception of mood into a discrete response on a scale or reductive visual representation. Moreover, apps do not afford the user much allowance for uncertainty. The metrics used often present being 'stressed' or 'anxious' (*CopeSmart;* Kenny et al., 2016) as distinct emotional experiences that do not blur, leak and overlap. In relation to attention ecologies, Citton (2017) argues that to control for the increase in speed afforded by digitalisation, standardisation is common in technical mechanisms, thus, the apparent *ease* afforded by apps for the user to rate their mood quickly and repeatedly, or to report symptoms of anxiety, is recompense for standardisation of responses. Some apps also have 'free-text field' functions which allow users to type how they are feeling, affording the user with a space to describe their mood or symptoms. For example, the metricised self-report ratings in the *CopeSmart* prototype are supplemented with open response features, users can type responses to questions, such as, 'What stressors/problems have you experienced in the past 24hrs?', but answers are capped to a 500-character limit (Kenny et al., 2016, p.268), potentially constricting capacities for emotional expression and closing down capacities for the user (Lupton, 2020).

4.3.2. Monitoring apps for management and assessment

From the 39 studies, the monitoring features of eight apps are primarily for management and assessment of depression and/or anxiety (Table 2). Whilst these apps share many features of intervention apps, their primary purpose appears to be for documenting and tracking mood and anxiety over time as a form of management of mental health. As well as having a mood or anxiety monitoring feature, five apps in this category afford users to monitor a range of other activities, such as sleep, stress, and daily activities (*Daybuilder, MoA^2, Mobile Mood Diary, mobiletype*, unnamed comparator app; Hur et al., 2018). Monitoring in these apps is widened beyond mood or symptoms of anxiety, emphasising physiological and social aspects of mental health, perhaps indicating the influence of biopsychosocial models of mental health in the development of these apps. Some of the apps (*mobiletype, Mind Your Mood, Mobile Mood Diary*) allow for data to be shared with clinicians so that they can review a patient's mood fluctuations over time, thus including other actors with therapeutic expertise to assist the user and app in *making sense* of monitoring data (Fullagar et al., 2017b), widening the assemblage to include other bodies, and moving the emphasis from an individualistic mental/psychological register.

In other studies, apps are being developed with 'technical mechanisms' such as emojis that are predictive of mood, rather than involving other humans in the 'sense making' process. In Van Dam et al.'s (2019) study of *G-Moji* the capacities of monitoring apps to recognise and predict the behaviour of the user does not always seamlessly align with the user's interpretation, the disallowance for ambiguity in interpreting how one feels in self-report metrics is mirrored in discussions of the predictive capacities of prototype monitoring mental health apps. Van Dam et al. (2019) found that the prototype emojis developed for *G-Moji* were sometimes inaccurate and did not predict the human user's mood correctly. Concerns were raised by participants about the app wrongly predicting their mood and making them feel worse, and that the app may become the voice of distress (Van Dam et al., 2019). Whilst this highlights inconsistency in the apps' capacities to capture and predict mood, it also demonstrates the enmeshment of the technological object and human user. The app as the embodied 'voice' becomes less distinct from the user, both are responsible for the 'affective work', responsibility is dispersed, and autonomy over who or what defines levels of distress becomes opaque.

4.3.3. Monitoring apps as digital objects for data collection

A third type of monitoring app was observed across the 39 studies, those that are designed for collecting data in research studies, seven apps have this purpose (Table 2). This type of app is distinct from the previous two categories because the primary purpose is to act as a technological object through which to disseminate surveys for EMA methods of data collection for mental health research. One of the rationales for EMA methods is to provide data that has an immediacy, rather than retrospective self-report ratings (Asselbergs et al., 2016). As political economist Will Davies (2017, p.27, emphasis in original) describes, 'They seek to capture how the research subject feels *right now*, or as close to that as possible'. Six apps are used in EMA studies (*Acer-Liquid Z-200, eMate, iYouVu, PETE, SESAMO, Sensus*), and all but one (*iYouVu*) of these apps collect data through self-report surveys: at various times, participants are signalled to record their mood and a range of other activities. For example, in Cushing et al.'s (2017, pp.1566-1567) study, participants completed four surveys per day (via the *PETE* app) for the 20 day trial, responding to questions such as, "How upset are you feeling right now?", this is answered on a scale of "Not at all" to "Extremely". The use of metrics delimits potentialities for emotional expression, the user has to unambiguously judge their understanding of in the moment distress and select a single word on a scaled response. One app was solely used for passive data collection (*iYouVu*), the app collects data without the users' knowledge, this consists of sensor data and app logs (e.g. when the screen is switched on and off) (Asselbergs et al., 2016). The remaining app in this category is based on data collected through smartphone sensors (*StudentLife*). This app autonomously collects data on mood, sleep, physical exercise and activities, the autonomous functionality of the app arguably redistributes responsibility for identifying triggers of distress to the app itself. There is an evident economic logic to designing apps with technical mechanisms that can supposedly learn and identify distress themselves. It serves to shift responsibility in the assemblage, placing greater emphasis on the app, the user and the data produced through engagements, rather than between human bodies in the healthcare system.

5. Discussion

In this section, we draw further on Félix Guattari's (1995, 2000) work on ecology (ecosophy) and subjectivity, and Yves Citton's (2017) writings on ecology and attention, to critically analyse the ecologies and 'technical mechanisms' of apps outlined in the typology. This focuses on the rationalities of the 'affective work' (Fullagar et al., 2017b, p.11) of apps, human users and assemblages. We offer a relational consideration of mental health that critiques individualistic ideas of anxiety and depression as solely internal (psychological or mental) phenomena. Our analysis highlights how the technical mechanisms of apps are implicated in the distribution of *awareness* and *responsibility*.

5.1. Technical mechanisms, metrics and ecologies

Measurements of mental health are obviously not new, however, the mechanisms by which we might *capture* mental health or wellbeing are (Atkinson, 2020). Although mood charting is an established practice that has been used in various forms over the last two centuries (Davies, 2017), the digitalisation of monitoring and tracking alters the way in which children, young people, and adults, engage with this practice. Yves Citton (2017, p.10) argues that attention is the critical resource of our time. Attention and value formation have always been closely connected, however, the 'development of quicker new vectors' of digitalisation 'induces quantitative effects that qualitatively alter the

orientation of our digitalized attention – and which therefore over-determine the collective valorizations with respect to which our social behaviour is calibrated' (Citton, 2017, p.67). This necessitates unpicking the 'technical mechanisms' of which digitalisation is based (Citton, 2017).

As illustrated in the discussion of the efficacy of monitoring apps for treating depression and anxiety in CYP, the mental health outcomes are not clear-cut. This may be because depression and anxiety are in fact not categorical (Pickersgill, 2019b), neat and closed modalities with little variability, but *continuous* variables, with a number of possible values (or experiences) of them. As Erin Manning (2016, p.172) writes of depression: ' … it has become clear to me that what we call depression is nothing if not plural: it expresses itself in an infinity of ways from sadness to hunger, from loss to anguish and anxiety, from a frenetically quiet inner panic to a full-fledged panic attack, from the stillness of a body incapable of moving to an agitated body'. This narrative description lays out the diversity of emotions, affects, feelings, intensities and frequencies of movement associated with depression that can be conceived of as body-world relations rather than contained to the individual (Beljaars, 2020), or mental register (Guattari, 2000). The consequence of an emphasis on mental health outcome measures, formulated by standardised metrics is to force the singularity and multiplicity of emotional states (that are not confined to the individual) into a 'coherent scientific object' (Pykett and Cromby, 2017, p.197).

The standardised metrics of apps then, are not attuned to capturing ecological intensities and fluctuations of anxiety and depression. The movements across mental, social and environmental registers (Guattari, 2000), and socio-material relations that produce anxiety and depression, are assemblages that become abstracted into a number, word or emoji. Relations that form bodies and their capacities to act are not universal (Grosz, 2017), bodies are affected by anxiety and depression in myriad ways, and to various degrees owing in part to the wider socio-spatial and temporal ecologies that situate individuals (Atkinson and Scott, 2015). This leads us to a similar conclusion to Crosby and Bonnington (2020, p.935) who have argued that apps for anxiety and depression that are focused solely on the psychological are 'ill-equipped' to address 'complex, social and environmental factors that create distress'.

The mobilisation of Ecological Momentary Assessment (EMA) methods in some of the studies included in the review signals a slightly different trajectory in relation to monitoring and mental health research. The use of EMA is to produce data related to the temporal: assisting capture of the *variability and fluctuations* of mood and symptoms within an individual's environment (Asselbergs et al., 2016; Cushing et al., 2017). Studies in this review by Kirchner et al. (2017) and Geyer et al. (2018) used EMA to deliver surveys asking questions about current mood and symptoms of anxiety at random or semi-random times during the day, others used apps such as *eMate* (Asselbergs et al., 2016) to signal at set times per day. Self-report responses to EMA surveys are also via metrics, such as numeric or Likert scales. Whether using random or set times for signalling, the temporal moment is privileged in both regards, indicating that such moments are conceived of 'as the most authentic account of experience, emotion, cognition and our associated wellbeing' (Atkinson, 2020, p.3). The frequencies, fluxes, intensities and durations of anxiety and depression as modes of existence evade capture through such methods.

A minority of the EMA studies reviewed attempted to take participants' 'real-world' socio-spatial ecologies into account, perhaps reflecting the influence of biopsychosocial models in the mental health field. For example, Geyer et al. (2018) aimed to observe the relationship between sociality and depressive and anxious states through participants responding to questions on current mood and social activities. Such research potentially widens the scope of 'internal' depressive and anxious states (the mental register) to other ecological registers (social) that contribute to modes of existence. However, individuals are only attached to one - seemingly measurable - aspect of ecologies. In Geyer et al.'s (2018) study, information on the number of social interactions that can be easily quantified and made illustrative of the state of one's mental distress are employed. In contrast to the studies reviewed, viewing mental health as *ecosophical*, gives rise to questioning the ways of living (Guattari, 2000) that produce modes of existence. Ways of living are brought about by interactions between non-human technologies, ecologies (environmental, social, material) and human subjectivities. The ways in which these relations produce distress, depression and anxiety, our understandings of what these are, and where responsibility for intervening in them is located needs to be more comprehensively articulated.

To further understand the relations between apps and human users, we turn to literature on the philosophies of technicity and ecology where Hörl (2017) refers to the process of individuation. This is theorised by philosopher of technology, Gilbert Simondon in the following way: 'individuation cuts across all modes of existence, from the microphysical via the living to the psychically collective and even cosmological level of existence, finally to the mode of existence of technical objects' (in Hörl, 2017, p.47). Individuation is thus a continuous process that is not restricted to the human, it affects other entities. In this theorisation, the subject/object binary becomes blurred. Such a perspective departs from some socio-psychological literature on individuation, Maslach et al. (1985, p.730), for example, define individuation as a 'state in which the person feels differentiated to some degree, from other people and objects'. In contrast to the notion of 'mental health outcomes', modes of existence are not held by an individual subject distinguished from others, nor do they 'emerge' from an individual alone.

5.2. Techno-ecologies of subjectivity: distributed responsibilities

Whilst monitoring apps may not capture embodied, ecological and singular experience associated with anxiety and depression, they do standardise experience, orient attention and produce capacities to act in certain ways. Citton (2017) theorises attention as an interface that links subject to object, it is at such interfaces that individuation takes place. Ash et al. (2018, p.167) conceptualise apps as interfaces and examine the ways that they 'modulate user action' through various non-discursive modalities, such as button arrangement, vibrations, sound effects, and colours. This work makes visible the affective, sensory and technical capacities of apps which are not considered in the majority of articles reviewed. To explain how monitoring mechanisms of apps might produce action and orient attention in individuating ways, we draw on Guattari's (1995, 2000) writings on subjectivity. Guattari's theorisations depart from ideas of individuals as having a fixed and stable identity and form. Subjectivity is instead, 'plural and polyphonic' (Guattari, 1995, p.1), its production(s) are multiple: it is the '*ensemble of conditions* which render possible the emergence of individual and/or collective instances' (Guattari, 1995, p.9, emphasis added). Thus, the subject is a complex fluctuating accretion, an entangled assemblage of various components that is 'before and beyond the individual' (Genosko, 2009, p.106).

Within this interpretive schema, techno-ecologies produce components of subjectification (Guattari, 1995; Genosko, 2009). The 'units' of metrics embedded in monitoring apps (Likert scales, colours, words, numbers, emoticons, and emojis) and the standardised values they ascribe to depression and anxiety, technologically, materially and discursively produce subjectivities. From the literature reviewed, monitoring apps and their technical mechanisms, are designed to generate awareness, identification, and anticipation of anxious and depressive feelings, thoughts and behaviours (Reid et al., 2011; Hur et al., 2018). An increase in self-awareness is often considered to be the *active* therapeutic component of monitoring functions (Hollis et al., 2017). Making children and young people aware of emotions, feelings and behaviours associated with depression and anxiety is aimed at increasing their capacities to act. The self in this instance is configured as contained to the individual body (or the mental/psychological register), but recognition of mood or symptoms is actualised through contact with

the monitoring app: reflexivity, awareness and responsibility of anxiety and depression are thus distributed and emerge through relations with technologies. Affect accumulates in such moments of recognition (Watkins, 2010). Thus, it is not only the self that accumulates affect; the technical mechanisms of objects are also designed to produce affect, they are co-implicated in moments of recognition. For Guattari (1995, p.4): ' … technological machines of information and communication operate at the heart of human subjectivity not only within its memory and intelligence, but within its sensibility, affects and unconscious fantasms'. Monitoring capacities of apps do not simply 'improve' users understanding, knowledge or awareness of anxiety or depression, but through 'units' (Ash et al., 2018), they act on affectual registers to orient the user to reflect in measurable and quantifiable ways. Some apps are designed to assist the user in recognition through notifications (for example, *REACH, Anxiety Coach*): vibrations or sounds nudge the user to partake in a moment of recognition, to rate their mood or levels of anxiety, and to subsequently engage in tasks to improve this rating. Features such as histories of mood ratings in the form of calendars (*CopeSmart*), or graphs that show mood scores over time (*BlueWatch*), direct the user to compare, contrast and recognise digitalised representations of mood or levels of anxiety, and to act on them to feel and behave differently in the future. The 'affective work' of recognition is thus distributed between app and user through the monitoring units of the app.

5.3. Rationalities of digitalisation

Mental health monitoring apps (as technological *and* affective objects) cannot be viewed as distinct from the ensemble of conditions that contribute to their design and production. One purpose of a Guattarian perspective is to 'attend to the regimes by means of which subjectivity is produced and to intervene in them' (Genosko, 2009, p.107). Similarly, Ash (2015) argues that we should be questioning who is attempting to organise the affective capacities of technologies and for what rationale. We thus need to question what is 'intended' to be produced through interactions with apps: where attention is designed to be oriented, and to query the set of knowledge's, technical mechanisms, affects, and affordances that are drawn upon in clinical research and commercial development of monitoring mental health apps.

Political health economies shaped by *rationalities* of neoliberalism are part of the ensemble of conditions in which assemblages of mental health apps come together (and fall apart). The papers in this review suggest that the political-economic rationales for the development of mental health monitoring apps are that they are relatively low-cost, improve access to treatments, and may 'ease the burden' on mental health services for CYP (Grist et al., 2018, p.305). However, some of the studies in this review suggest that the desire for apps and other DHIs to fill the gaps in service provision, *without* the involvement of other humans will not be met with acceptance and use of mental health apps by CYP. For example, Reid et al. (2011), Stallard et al. (2018) and Whiteside et al.'s (2019) results indicated that apps demonstrate positive mental health outcomes *with other humans* and healthcare organisations involved in the assemblage. The conclusion of the clinicians in Hetrick et al.'s (2018) study suggests that apps should be formed around embedded interventions for the user to engage with alone, rather than 'real time' clinician responses. This demonstrates the ethical and political dimensions of designing mental health technologies and the trade-offs that occur between integrating the needs of potential users of mental health apps, mental health services capacities to respond, and how researchers and developers' ideas of what and who should be responsible for mental distress, are shaped by wider political and economic rationales (Pickersgill, 2019b).

In terms of future technical mechanisms of monitoring mental health apps, some of the articles that utilised EMA methods, and results from Sequeira et al.'s (2020) scoping review, suggest that there are moves towards app-based monitoring technologies that can provide seemingly objective, passive data related to mood and anxiety, which could be predictive of whether an individual is depressed or anxious. In Van Dam et al.'s (2019, p.9) feasibility and EMA study of *G-Moji*, they note that future research within this field should be oriented towards digital phenotyping, 'which shows a representation of a person's digital patterns, that can help understand their mental health problems'. Our typology shows that monitoring apps are being developed to passively collect data from individuals and this is used to infer children and young people's mood and mental health symptoms. The use of passive data collection via monitoring and digital phenotyping technologies to predict mental ill-health opens up further bioethical and neuroethical questions related to who sets the thresholds of distress and normality (Birk and Samuel, 2020). In this way, mental health monitoring apps are part of a wider rationality of the redistribution of responsibility for health and ill-health (Martinez-Martin and Kreitmair, 2018). Given the current lack of a clear overarching regulatory framework for mental health apps, an important future research task will be to identify and shape the governance issues surrounding the use of predictive mental health vulnerabilities and risks, and biases in computational algorithms underpinning forthcoming apps (Carr, 2020).

Moreover, there are broader epistemological, social, political, and cultural questions regarding how depression and anxiety among children and young people are perceived, treated, and governed. One important avenue of enquiry highlighted by our analysis is in the consideration of how digitalisation as a process shapes the discourses of mental health in particular societal contexts. The mechanisms of 'attention economies', such as algorithms, prioritise what we see, what we pay attention to, and there is a value to this (Citton, 2017). The mood and anxiety monitoring data generated is affective and valuable: to the user, app, health governance, research, and commercial developers. Commercial valorisation can be considered as a form of psychopolitical control (Han, 2017). Drawing on Foucault's writings on genealogy, Lindner (2020, p.88) argues that the effects of rolling out technologies (such as sensors and wearables) in numerous faculties of life, including health, can be viewed as part of a haphazard process towards what they argue is a turn to a 'behavioural gaze'. The sensors used in apps in some of the EMA studies perhaps present the technical mechanisms of future commercial mental health apps, producing data that could be harnessed for digital phenotyping. This 'behavioural gaze' also includes the way that CBT acts as a 'powerful ally in the automation of mental health care' (Russell, 2020, p.28). As we have shown, the metrics of monitoring apps attempt to make depression and anxiety, *categorical*, and in doing so leave out ecologies of mental health that depart from the mental register. Further avenues of research might therefore explore the ways that psychological therapies are mobilised in the design of active and passive monitoring functionalities of mental health apps in light of this behaviourist turn.

6. Conclusion: rethinking mental health monitoring apps

This paper has outlined the extent of research on mental health monitoring apps for anxiety and depression targeted at children and young people in a Western and anglophone context. It has demonstrated that the evidence base for the efficacy of monitoring mental health apps for treating anxiety and depression in CYP is still lacking. A significant amount of research is focusing on making mental health apps engaging, rather than testing their effectiveness. The typology of mental health monitoring apps developed in this study highlights the numerous ways in which monitoring features and technical mechanisms (such as metrics) are mobilised in mental health apps: to assist interventions, to assess or manage anxiety and depression, or to act as a digital object in which to collect data. Our analysis of these types of mechanisms sets out a way to theorise what the technical mechanisms of apps *do*, particularly in relation to subjectivity, awareness and responsibility. This typology could be used as an organising framework for future research which charts key monitoring features of apps, and as a basis for investigating

what kinds of effects and affects (therapeutic or otherwise) monitoring via apps might produce. This would be aided by better reporting of the monitoring features and the metrics used in relevant studies.

The ecological and relational approach to mental health that has been mobilised in this review supports an emerging current in psychiatric literature which indicates that there is a need for apps to be conceptualised as part of a wider system of mental health care, rather than an end product or the sole 'agent of change' (Mohr et al., 2017, p.427). The analysis provided here using the concept of assemblage and our ecological approach thus responds to calls in the health sciences for social, cultural, and environmental contexts of health to be incorporated into understandings of public health (Hinchcliffe et al., 2018). It is certainly not yet clear how mental health technologies could serve this complex task, but there is appetite within the medical and health sciences to advance thinking and methods which more adequately attend to complexity. Greenhalgh and Papoutsi (2018, p.3), for instance, make the case for taking into account the wider ecologies that situate the results of clinical trials. Others urge attention to the multi-faceted nature of health inequalities and their causes, understanding systems as open and in flux rather than closed and bounded (Durie and Wyatt, 2013).

Using our critical ecological approach, we have theorised relations between apps and human users through beginning to unpack the technical mechanisms of monitoring features; the multiple purposes of monitoring functions (including the production of awareness); the affective work of app and user and how this reshapes responsibility; and how apps are a production of an ensemble of conditions that, in a UK context, are guided by rationales of neoliberal capitalism. Rather than conceiving of apps as a tool or product, they may be better understood as part of assemblage that includes multiple bodies, affects, relations, ethical and political concerns that need to be examined together. By encouraging meticulous recording of symptoms, behaviours and feelings, monitoring generates knowledges, habits and modes of existence that alter the way in which children and young people collectively think and feel about mental health, anxiety and depression. The increased use of passive monitoring mechanisms will also undoubtedly reshape our ideas about mental health. These collective and cultural long-term consequences of e-mental health technologies are rarely considered in the medical literature. The responsibility produced through technical mechanisms of monitoring apps affirms the idea of anxiety and depression as primarily internal phenomena that are based within individual bodies, and as such, requires an individual to have the capacities to ameliorate such feelings, emotions, thoughts and behaviours. An alternative pathway for enquiry is to question the particular ways of living, societal, ecological and economic formations that contribute to distress. The ecological and ecosophical understandings of health, being and feeling well outlined here can generate novel concerns from which to begin such enquiry.

Declaration of competing interest

None.

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Appendix A. Supplementary data

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