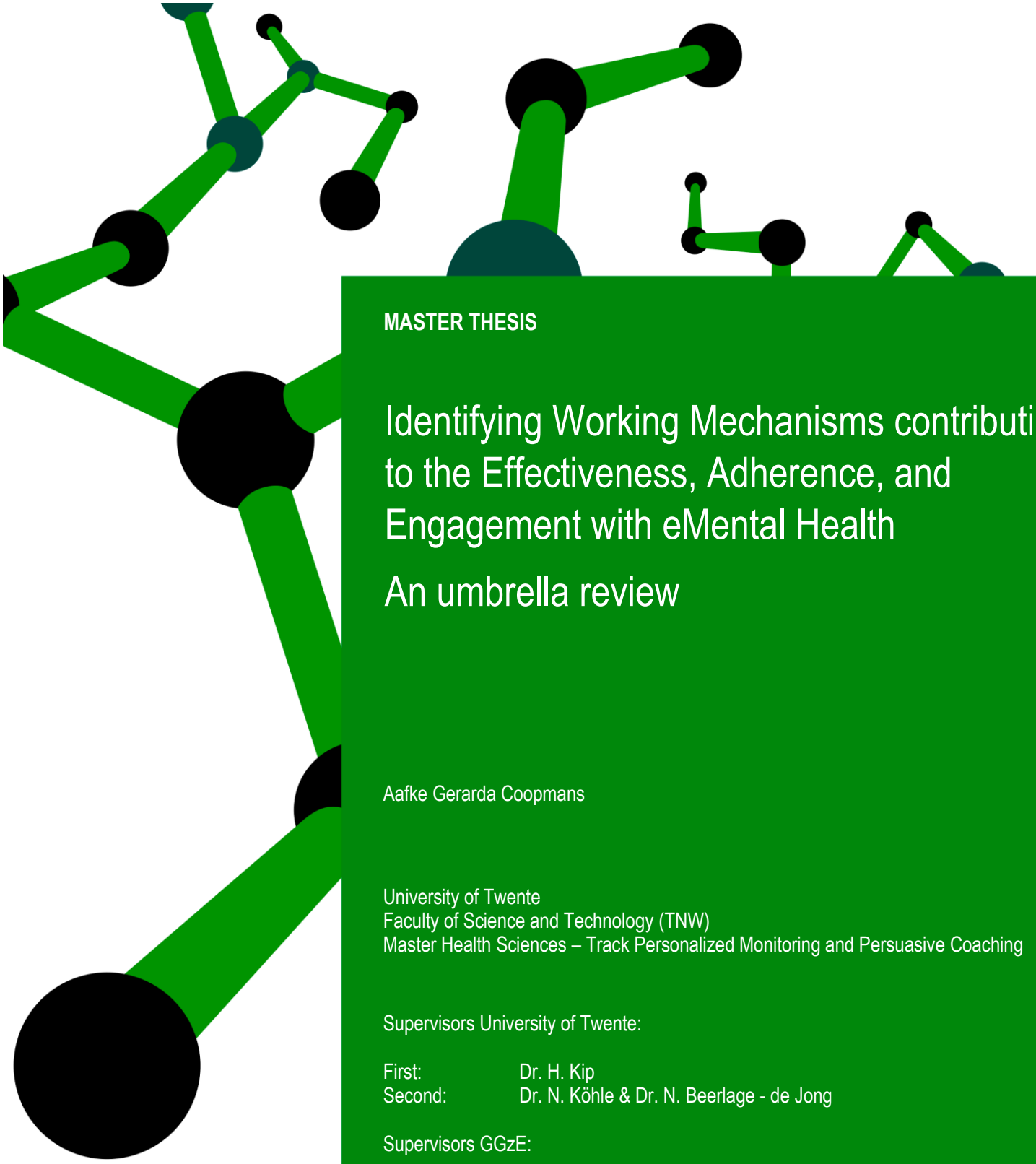

MASTER THESIS

Identifying Working Mechanisms contributing to the Effectiveness, Adherence, and Engagement with eMental Health

An umbrella review

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Abstract

Background: The use of eMental health interventions can be of added value for the prevention and treatment of mental health problems. However, the benefits of these interventions in real-world settings are not realized yet. This may be explained by the low effectiveness in real-world settings, non-adherence or non-engagement with eMental health interventions. Improving eMental health interventions by incorporating working mechanisms in the design can help to decrease these types of problems. In the literature, diverse examples of working mechanisms are available. For example, the features of the Persuasive System Design (PSD) model and the Behaviour Change Techniques (BCTs) of the Behaviour Change Technique Taxonomy V1 can be used to increase effectiveness, adherence and engagement. However, the evidence on how working mechanisms contribute to these outcomes is spread over reviews for different types of interventions or working mechanisms. This causes that designers need to search at different places for the required evidence and therefore an approach that combines the evidence in one overview will be of added value for eMental health design.

Objective: The current study aimed to identify working mechanisms in eMental health interventions and examine their relation with the effectiveness, adherence and engagement.

Method: The umbrella review of systematic reviews and meta-analyses was conducted in four steps. First, a literature search in the databases PubMed, PsychInfo and Scopus was conducted to find relevant systematic reviews and meta-analyses. Second, relevant systematic reviews and meta-analyses according to the predefined inclusion and exclusion criteria were selected. Third, relevant data of the working mechanisms were extracted using a data extraction form in Excel. Fourth, the extracted data were synthesized to identify and examine working mechanisms used in eMental health interventions. This was done by coding the working mechanisms and their evidence inductively and deductively, using the PSD features and BCTs.

Results: A total of 13 reviews were included in the current umbrella review. These reviews covered a wide range of interventions and disorders, such as internet-based therapies, online substance-use interventions, anxiety and depression. The umbrella review identified working mechanisms within and outside the existing frameworks of PSD and BCT. Furthermore, the evidence of the included reviews showed that the PSD feature Self-monitoring, the BCTs Problem Solving, Behaviour Substitution, Credible Source and the new working mechanism Visualization were significantly contributing to the effectiveness of eMental health interventions. In addition, the included reviews showed that the PSD features Reduction, Tunnelling, Personalization, Tailoring, Rewards, Reminders, Trustworthiness, Expertise and Authority lead to a higher adherence. Moreover, the included reviews found evidence which showed that the PSD features Tailoring, Reminders, Liking, Similarity, Surface Credibility and Trustworthiness were related to the engagement with eMental health interventions.

Discussion: The findings of the current study showed which working mechanisms have the potential to contribute to the effectiveness, adherence and engagement with eMental health interventions. The identified working mechanisms included PSD features, BCTs, and other working mechanisms. However, the definitions of these working mechanisms were limited. In relation to the outcome, the PSD features related more to adherence and engagement compared to BCTs, which related more to effectiveness. Furthermore, the results showed overlap and differences between the working mechanisms which can be used to revaluate existing models. However, these findings are a first step towards an overview and therefore more attention should be paid on identifying, updating and examining working mechanisms.

Chapter 1 Introduction

1.1 The added value of eMental health interventions

The use of technologies, such as the smartphone or the computer, can be of added value for the prevention and treatment of mental health problems. Providing prevention and treatment via technology is referred as eMental health, which is a sub domain of eHealth (1). First, eMental health interventions can be beneficial for treating and preventing mental health problems because these interventions can increase the access to care. The use of the internet and devices as the smartphone make mental healthcare independent from time and place which increases the access to care (1, 2). Therefore, eMental Health interventions can be provided to a larger amount of people compared to traditional care (3, 4). Increased access is also beneficial for decreasing the gap between the demand for care and the amount of care available (2). Secondly, eMental health interventions can lower the threshold to ask for help by providing users the option to talk anonymously (1, 4). Anonymous help can be beneficial for discussing sensitive subjects such as sexual abuse. Third, eMental health interventions have a wide range of new possibilities to prevent and treat mental health problems compared to traditional care (1). For example, providing treatment in other dimensions, such as Virtual Reality, or the option to personalize content to the needs and preferences of the user (1-4). Fourth, eMental health interventions can empower patients to self-manage and take control of their own health (1, 2, 4). This is in line with the positive health definition stating: 'Health as the ability to adapt and self-manage, in light of the physical, emotional and social challenges of life' (5, 6). Despite all these benefits, the added value is not realized yet in practice (1). A possible explanation for this is the problem with effectiveness in real-world settings, which means that eMental health interventions are not reaching the desired effects and thus not fulfilling its promise of providing added value (1). Therefore, more insight is needed on how to improve eMental health interventions in order to receive the full benefits of it in practice.

1.2 The challenges with the effectiveness, adherence and engagement

The measured effects of eMental health interventions in clinical trials differ from the effects in practice. In the literature, eMental health interventions have shown promising results in reaching the desired outcomes (7-11). For example, the use of virtual reality in the treatment of post-traumatic stress syndrome or autism seems to be beneficial (10, 11). However, the translation to real-world settings can be problematic due to different factors, such as the users' knowledge on eHealth and financial barriers (1, 12, 13). As a result, the effectiveness and the amount of evidence stating effectiveness in real-world settings is significant lower than the evidence provided by clinical trials (1). The effectiveness is also influenced by how users use the intervention. When the intervention is used as intended, which is called adherence, the effectiveness is higher (14). If the user does not use the intervention as intended, the effect decreases (14). At the moment the adherence rates are low and not much is known about what contributes to adherence (1, 15, 16). Therefore, another challenge is improving eMental health interventions in order to increase adherence with these interventions. Furthermore, effectiveness is also influenced by how the user is involved in the eMental health interventions, which refers to engagement (1, 17). However, several barriers decrease the level of engagement with eMental health intervention, such as technical problems and a lack of personalization (18). Low engagement is problematic because if the engagement between the user and the eMental health intervention is suboptimal, it is more

likely that the user does not use the system as often and as intended (18). Therefore, more insight is needed in both the effectiveness, adherence, and engagement and these outcomes need be considered together while improving eMental health interventions.

1.3 The added value of working mechanisms in eMental health interventions

Incorporating working mechanisms in the design of eMental health interventions can be a possible solution to increase effectiveness, adherence and engagement. In the literature, diverse conceptualizations for these working mechanisms are available, such as active ingredients and key components (19-21). These conceptualizations have in common that it is an intervention part which contributes to the outcome of the intervention or a mediator of this outcome to produce the desired effects. Next to this, reviews focused on specific groups of working mechanisms or working mechanisms operationalized in a specific type of intervention, are available. These reviews provide evidence for the relation between the working mechanism and effectiveness, adherence or engagement, which can be used in the design to increase these outcomes (1, 20, 22-25). Therefore, evaluating how and in which degree working mechanisms contribute to the effectiveness, adherence and engagement with eMental health interventions is of added value for the design of these interventions.

The persuasive system design (PSD) model, of Oinas-kukkonen and Harjumaa, within 4 categories with each 7 features, is an example of an examined group of working mechanisms (26). The PSD features are aimed to increase the persuasiveness of a technology, causing users to act or do the things the technology is aimed at (26). For example, the PSD features of the Primary Task Support category, can be used by developers to support the user to do tasks in the technology. Reduction, a convenient amount of content, is such feature which can help the person to fulfil the tasks of the technology. Moreover, the PSD features of the Dialogue Support category, can help the user to keep moving towards their goal, such as reminders. The features of the Credibility Support category can help designers to design a system that is trustworthy. For example, by offering trustful information from a reliable health organisation. The features of the Social Support category can help designers to design a system that motivates the user by providing social influence, such as competing with others. Because all of this, the PSD features can be of added value for increasing the adherence and adherence can lead to a higher effectiveness (14). Therefore, studies about which PSD features contribute to adherence is relevant for designers and help designers to decide which features are of added value in the design. Currently, diverse studies providing this information are available.

The Behaviour Change Technique (BCT) Taxonomy V1, within 16 categories and 93 Behaviour Change Techniques (BCTs), is another example of an examined group of working mechanisms (27). These BCTs can be defined as an observable replicable component of an intervention aimed to change behaviour (1, 27). This means specifically, when incorporating a BCT, the intervention stimulate behaviour change (27). For example, the BCTs of the category Goals and Planning stimulate behaviour change by setting goals and planning the behaviour. Another example is the Social Support category. The BCTs of this category are aimed to stimulate behaviour change via social support, such as peer support. The ability to stimulate behaviour change make BCTs beneficial in eMental health and eHealth interventions (28, 29). However, the evidence of these BCTs and PSD features is shredded over different reviews for different types of interventions. Therefore, a study approach which can bring all the available evidence together is relevant for the design and evaluation of eMental health interventions to deal with the challenges with the effectiveness, adherence and engagement

1.4 Research aim and questions

The current study conducted an umbrella review of systematic reviews and meta-analyses aimed to identify working mechanisms in eMental health interventions and examine their relation with the effectiveness, adherence and engagement. An umbrella review is an approach which can bring evidence from different reviews and meta-analyses together into one overview. Therefore, it is a relevant approach to bring all the evidence on working mechanisms together to support the design and evaluation of eMental Health interventions. The research question and sub questions addressed in the current umbrella review were:

Which working mechanisms are related to the effectiveness, adherence and engagement with eMental health interventions according to systematic reviews and meta-analyses*?*

Sub research questions:

1. Which working mechanisms of eMental health interventions are studied in systematic reviews and meta-analyses?
2. How is each working mechanism of eMental health interventions defined in systematic reviews and meta-analyses?
3. To what extent does each working mechanism contributes to the effectiveness, adherence and engagement with eMental health interventions according to systematic reviews and meta-analyses?

Chapter 2 Method

2.1 Research design: umbrella review

An umbrella review is a systematic approach to find systematic reviews and meta-analyses to provide an overview of their evidence (30). The difference with a systematic review is that an umbrella review only considers systematic reviews and meta-analyses for inclusion.

2.2 Literature search

The electronic search strategy used to search for relevant systematic reviews and meta-analyses was developed together with information specialists from the University of Twente and GGzE. The search strategy was based on the following four search components: working mechanism (1), eHealth (2), mental health (3) and review (4). These four search components were combined using Boolean operations during the search. In Table 1 an overview of the components and their search string used during the search can be found. The search strings were adjusted to the functionalities of the specific database in which the search was conducted. The search strings per database can be found in Appendix 1. In addition, to generate a comprehensive overview of the literature and to prevent that relevant systematic reviews and meta-analyses were missed, multiple electronic databases were used during the search. Specifically, the multidisciplinary database Scopus, the medical database PubMed and the medical database focused on mental health PsychInfo.

Table 1 The search components and their search strings used during the seach

Search component	Search string
Working mechanism	(mechanism* OR component* OR feature* OR technique*)
Mental health	(psychiat* OR psycholog* OR mental* OR DSM-5) W/3 or AND (health* OR disorder* OR disease* OR illness* OR problem*)
eHealth	("eMental health" OR "e-mental Health" OR eHealth OR e-health OR mHealth OR m-health OR "mobile health" OR "web-based health" OR "digital health" OR "digital behaviour change intervention" OR telemedicine OR tele-medicine OR telehealth OR tele-health OR teleps*)
Review	(meta-anal* OR metaanal* OR review* OR “research integration” OR overview OR synthesis)

2.3 Review selection

The review selection to select relevant systematic reviews and meta-analyses was conducted in three phases. First, duplicates were removed using the reference manager Endnote and titles were screened independently by two researchers (AC & IB) on eligibility. The titles were screened on only two inclusion criteria, 1 and 2, to include titles as broad as possible and to prevent that relevant reviews and meta-analyses were excluded. Second, the abstracts were screened on eligibility by one researcher (AC) and were included if these met inclusion criteria 2, 4, 5 and 6. However, the abstracts were excluded if these met exclusion criteria 8, or 9 or 10. Third, the full-texts were screened on eligibility by two researchers (AC & IB). In this phase, the articles needed to meet all the six inclusion criteria in order to be included. However, if the full-text met one of the four exclusion criteria the article was excluded. The selection process was supported with Rayyan, a review manager which supports reviewers during the selection by providing options as blind screening and labelling records. Table 2 provide an overview of the inclusion and exclusion criteria and their operationalization per phase.

Table 2 The inclusion and exclusion criteria per screening phase used during the review selection

Type of criteria	Code	Definition criteria	Phase[1]
Inclusion	IN1	The article is written in Dutch or English	Title
	IN2	The study is focused on eMental Health interventions, operationalized as: 'the use of technologies to prevent and treat mental health disorders' (1)	Title
	IN3	The article is a peer-reviewed article published in a scientific journal	Title
	IN4	The study design is a systematic literature review or meta-analysis, operationalized as: a systematic approach of conducting a literature review with clear reproducible method descriptions, such as the PRISMA guidelines	Abstract
	IN5	The population is people with mental health disorders or problems without physical conditions or somatic disorders	Abstract
	IN6	The study examined working mechanisms in terms of mechanisms, (persuasive) features, (behaviour change) techniques or other components in eMental Health interventions	Full text
Exclusion	EX7	The full-text of the article is not available	Full text
	EX8	The study summarized (effective) eMental Health interventions or technologies	Abstract
	EX9	The study examined a specific technology or operationalization of a component used in eMental Health interventions, such as videoconference and biofeedback	Abstract
	EX10	The study examined eMental Health intervention(s) without examining the incorporated working in terms of mechanisms, (persuasive) features, (behaviour change) techniques or other components	Full text

1 = screening phase in which the criteria was used

2.4 Data extraction

The data were copy-pasted from the included systematic reviews and meta-analyses in a data extraction form in Excel with three categories: (1) review characteristics, (2) eMental health component, and (3) relation with outcome. These categories were based on the sub research questions. First, the aim, title, authors and year of publication were extracted. In addition to this, other study characteristics, such as the population, investigated (type of) interventions, outcome measurements and study design, were also copy-pasted. Second, the eMental health intervention components and their definitions were copy-pasted from the result sections. Third, the quantitative and qualitative information such as text fragments stating a relation between a specific eMental health intervention component and effectiveness, or adherence, or engagement were reported. An empty extraction form can be found in Appendix 2.

2.5 Data synthesis

The copy-pasted eMental Health intervention components were coded by one researcher (AC) to identify working mechanisms. All the described intervention components were coded to identify as much working mechanisms as possible, even the working mechanisms which were not seen as a working mechanisms by the authors of the included reviews themselves. If the name and description of the component was, according to the researcher (AC), in line with the definition and name of a PSD feature or BCT, the component was deductively coded as a PSD feature or BCT (26, 27). Components which did not fit into the two frameworks, according to the researcher, were inductively coded. When no consensus could be made on how to code a specific component the researcher discussed this with other involved researchers (IB & HK). After coding, the component descriptions were analysed and compared. The definition which was the closest to the definition of the review was used to decrease the level of interpretation. When a definition was provided by the article itself this definition was used. After this, parts of the extracted text fragments or quantitative outcomes stating a relation with outcome were highlighted and inductively coded using three colours. The colour green meant that there was a significant effect between the working mechanism and outcome, orange meant that the working mechanism showed an effect in some primary studies and not in others, and the colour red meant that there was no effect between the working mechanism and the outcome.

Chapter 3 Results

3.1 Included systematic reviews and meta-analyses

The selection process started with 765 records. After removing duplicates 591 unique records remained which were screened on title. The main reason to exclude a title was that it was not focused on the use of technology for the prevention or treatment of mental health disorders and therefore did not meet inclusion criteria 1 (IN1). After the title selection 191 titles remained from which the abstracts were read. During the abstract selection the most abstracts were excluded because the population had somatic or physical disorders with or without mental health disorders (IN5). After the abstract selection 45 full-texts were read, which resulted in 13 included systematic reviews and meta-analyses. The main reason to exclude articles was that it was a systematic search in app stores and not in scientific databases, and therefore not meet inclusion criteria 4 (IN4). The PRISMA flowchart in Figure 1 includes the amount of records which met the inclusion and exclusion criteria per phase.

The 13 included reviews were published between 2011 and 2020 and had the following study designs: meta-analysis (n=5), systematic review (n=4), realist synthesis (n=2), literature review (n=1) and scoping review (n=1). Overall, the included reviews had three types of aims. First, studies aimed to provide an overview of the available literature, such as all the evidence on Guidance. Second, studies aimed to provide an overview of PSD features or other working mechanisms used in specific eMental health interventions. Third, studies aimed to examine the relation between working mechanisms, such as BCTs, and outcomes as engagement. Moreover, a wide range of disorders were covered in the reviews such as depression, anxiety and substance-use disorders. Next to this, also a wide range of interventions were covered in the reviews such as online substance-use interventions, smartphone apps for treatment or monitoring, behaviour change interventions, internet-based interventions and therapies. In 11 of the 13 reviews a quality assessment, such as risk of bias or a methodological assessment, was conducted. For more detailed information about the review characteristics see Table 3.

Figure 1 PRISMA flowchart of the selection process aiming to included relevant reviews and meta-analyses

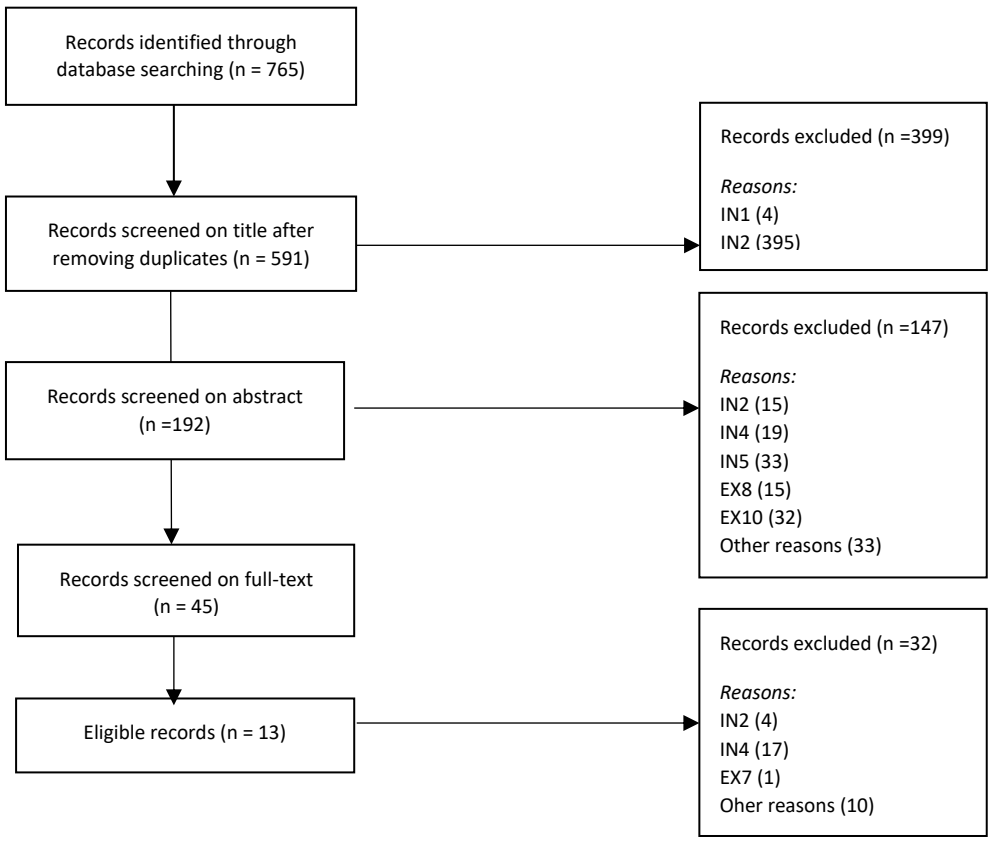


Table 3 Study design, objective, intervention, participants, primary outcome of the included review and the characteristics of the included studies, structured according to study design

Author, year of publication	Included review/ meta-analysis					Single studies in review/meta-analysis			
	Study design	**Study objective**	**Type of intervention**	**Participants**	**Primary outcome**	**Quality[1]**	**Included study designs**	**Period**	**#[2]**
(31) Melbye et al., 2020	Systematic review	To provide an overview and status of studies focused on smartphone-based monitoring, treatment or automatically generated data	Smartphone apps collecting self-monitoring or automatically generated data or a smartphone-based system for treatment	Individuals (<25) diagnosed or received treatment for a psychiatric disorder which was verified by clinician	Adherence to self-monitoring: completion rate percentage, amount of participants / modules/ data points completed the therapy	Risk of bias assessment with Cochrane Risk of Bias tool. The quality of evidence with GRADE guidelines	Randomized clinical trial / feasibility/ pilot/observational/retrospective cohort study	2015-2020	15
(32) Milward et al., 2018	Systematic review	To identify the most prevalent engagement promoting strategies aimed to increase use of online substance-use interventions and determine their effect on engagement	Online substance-use interventions (SUIs)	Individuals assessing an online SUI without age limit	Engagement: number of logins, pages viewed, sessions completed, web-sessions opened, features used, task achieved, time spent on intervention	Risk of bias assessment with Cochrane Collaboration tool	Randomised clinical trial /factorial randomised clinical trial	2006-2015	15
(33) Dogan et al., 2017	Systematic review	Examine the literature on smartphone-based systems combining subjective and objective data for self-monitoring of depressive symptoms	Smartphone based self-monitoring apps of depressive symptoms	Adult study participants with symptoms of depression without age limit, excluding pregnant women or women with a postpartum depression	Feasibility, adherence: dropout rates or compliance rate, clinical outcome: symptom changes or clinical mood state	Quality assessment using the Downs and Black Instrument	Feasibility studies/ Randomised clinical trial	2011-2017	29
(34) Lehto & Oinas-Kukkonen, 2011	Systematic review	Provide an overview of PSD features in web-based alcohol and smoking interventions	Web-based alcohol and smoking interventions	No specific population and no age limit was specified	Behavioural outcomes or program utilization, no operationalization was given	Methodological quality assessment with CONSORT 2010 checklist	Randomised clinical trial/ quasi-experimental designs	2004-2009	23
(35) Barakat et al., 2019	Meta-analysis	Define technological features in eTherapies for eating disorders, quantify the relation with clinical outcomes and adherence	eTherapy: treatment for eating disorders delivered via technological platform	Individuals with a full or subthreshold eating disorder (ED) without age or gender restrictions	Treatment outcome**:** pre-treatment and post treatment measures of eating disorder behaviours, adherence as treatment dropout scores	Methodological quality assessment with Quality index	Randomised clinical trial / non controlled trail/controlled trail	2006-2017	23

1 = quality assessment method review 2 = amount of studies included in the review

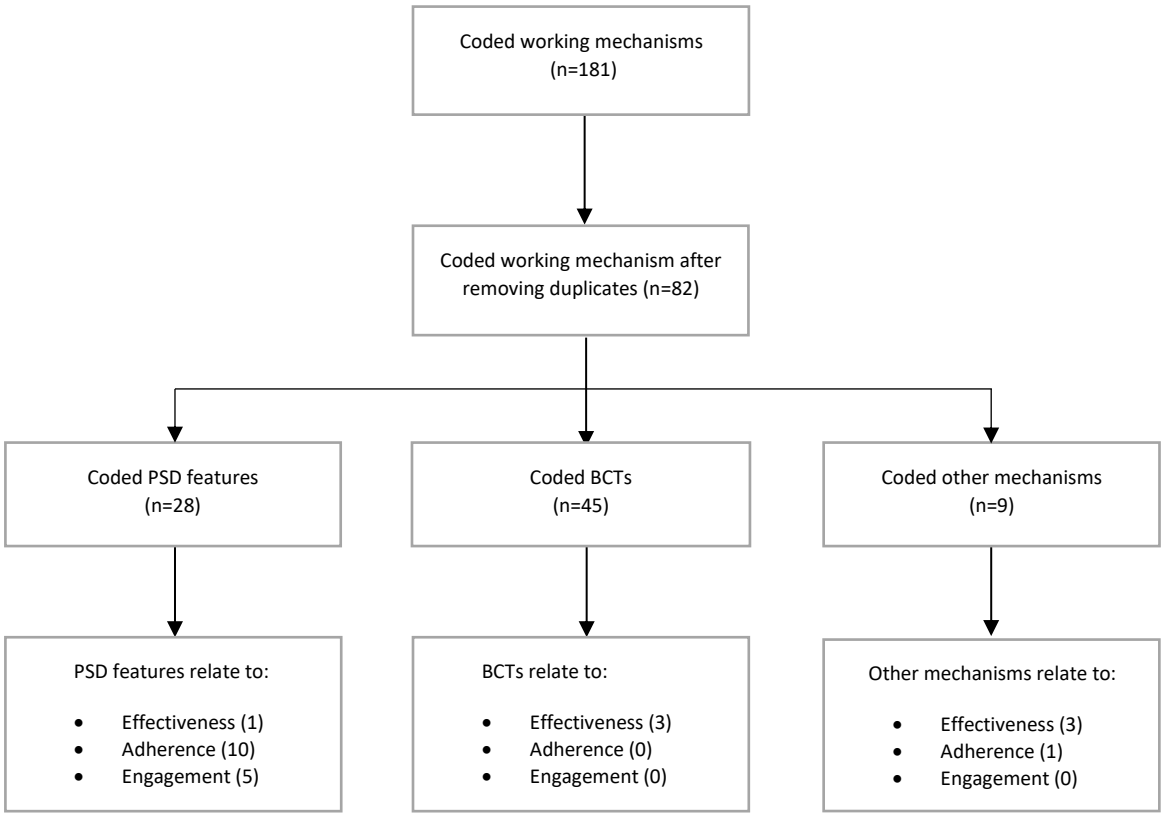
Author, year of publication	Included review/ meta-analysis					Single studies in review/meta-analysis			
	Study design	Study objective	Type of intervention	Participants	Primary outcome	Quality[1]	Included study designs	Period	#[2]
(36) Garnett et al., 2018	Meta-analysis	To describe, examine the relation between the BCT, the amount of BCTS, in digital behaviour change interventions and effectiveness	Digital behaviour change interventions to reduce alcohol consumption	Hazardous and/or harmful drinkers without age limit	Quantity of alcohol: 'mean difference in quantity of alcohol consumed in a specified time period between intervention and control for each trail' (36)	No quality or methodological assessment	Randomised clinical trial	Until 2015	41
(37) Domhardt et al., 2018	Meta-analysis	To summarise and evaluate evidence of intervention components in internet-based and mobile-based interventions for anxiety	Internet- and mobile-based interventions (IMIs)	Individuals (≥18 year) with an anxiety disorder at baseline	Anxiety symptom severity at post intervention and follow up, treatment adherence: completed modules or completed rate according to Donkin et al.	Risk of bias assessment with Cochrane risk of bias assessment tool	Randomised clinical trial	2003-2016	34
(38) Wahle et al., 2017	Meta-analysis	To provide an update of the overall effectiveness and identify system components of technology-mediated treatments for depression	Technology-based interventions for depression	Individuals with depressive symptoms without age limit. Exclusion: when combined with a non DSM 5 disorder or caused by environmental factors	Symptoms of depression	Study quality of the trails assessment with Jadad score	Randomised clinical trial	2003-2016	45
(39) Baumeister et al., 2014	Meta-analysis	Review the impact of guidance on the efficacy of internet-based interventions	Internet-based interventions (IBIs)	Adult participants (≥18 year) with a mental disorder according a relevant classification system, or subthreshold disorder or mental disturbances	Symptom severity: sum-score of a validated rating scale / self-report questionnaire. Adherence: mean number completed modules /percentage persons completed the whole treatment	Methodological quality assessment with Cochrane Risk of Bias tool	Randomised clinical trial	2006-2013	14
(40) Wozney et al., 2017	Realist synthesis	Explore technological and program delivery features of internet-based therapies for adolescent depression and document their potential relation with treatment outcome and program use	Internet-based therapies	Adolescents with depression no age limit specified	Symptom reduction, satisfaction, therapy adherence; no operationalization was given	Mixed method Appraisal tool (MATT)	Intervention/ mixed-methods/ qualitative study	2006-2016	59

Author, year of publication	Included review/ meta-analysis					Single studies in review/meta-analysis			
	Study design	**Study objective**	**Type of intervention**	**Participants**	**Primary outcome**	**Quality[1]**	**Included study designs**	**Period**	**#[2]**
(41) Radomski et al., 2019	Realist synthesis	Explore design and delivery features of iCBT and examine their relation with program use outcomes	Internet-based cognitive behavioral therapy(iCBT)	Children and adolescents younger (≤19 year) with anxiety disorder or symptoms according to the DSM 5 classification system	Program use: completion rate. Calculated and categorized the summary of program use for each study into high use (75%), moderate use (50-74%), low use (25-49%), or very low use (≤24%)	Mixed method Appraisal tool (MATT) score.	Intervention studies (clinical trials, protocols, theses, flyers or websites)	Until 2017	44
(42) Shim et al., 2017	Scoping review	To evaluate evidence of the role of human-support in internet-based psychological interventions for depression and anxiety	Internet-based psychological interventions (IPIs): a treatment delivered via internet	Individuals with depression or anxiety disorders (≥18)	Depression or anxiety symptoms	Risk of bias assessment with Cochrane Risk of Bias tool	Randomised clinical trial	2005-2016	19
(43) Lui et al., 2017	Literature review	To evaluate the evidence of the efficacy and effectiveness of mobile apps for psychological treatment	Mobile apps for treating mental health problems or for psychological treatments	Individuals (≥18 year) not limited to clinical samples	Efficacy and effectiveness, no operationalization was given	No quality or methodological assessment	Not described	2011-2016	21

3.2 Working mechanisms

The data synthesis aimed to identify working mechanisms resulted in 181 coded working mechanisms. After removing the duplicates of working mechanisms which were coded more than one time, 82 individual working mechanisms remained. From the 82 identified working mechanisms 28 were coded as a PSD feature, 43 as BCT and 9 as other working mechanisms which were not a PSD feature or a BCT. These codes were based on the interpretation of the researcher, which resulted in the identification of PSD features or BCTs which were not seen as a PSD feature or BCT working mechanism by the review authors themselves. The most identified working mechanism was the PSD feature Self-monitoring, which was coded in 7 of the 13 reviews. The BCTs were all coded in one or two reviews. The working mechanisms were categorized in working mechanisms with evidence, working mechanisms with inconclusive evidence and working mechanisms without evidence. Overall, the PSD features were investigated most in relation to adherence (n=10) and engagement (n=5) and the least on effectiveness (n=1). The BCTs were examined less frequent and more on the effectiveness (n=3) of eMental health interventions. The following sections provide an overview of the identified working mechanisms per model which were found to have a relation with effectiveness, adherence or engagement. An overview of the results of the data synthesis process can be found in Figure 2 and the specific codes of the identified working mechanisms can be found in Appendix 3.

Figure 2: Flowchart results data synthesis process



3.2.1 PSD features contributing to the effectiveness, adherence and engagement

For an overview of the 16 identified PSD features with evidence specified to the population and the type of intervention in which the PSD feature was operationalized see Table 4.

PSD features positively related to effectiveness.

The identified PSD feature Self-monitoring was, according to one review, which investigated PSD features, significant contributing to the effectiveness of internet-based therapies for adolescents with depression (40). This review found that when a user keeps track of their performance or progresses towards set goals it reduced symptoms of depression (40).

PSD features positively related with adherence

Ten identified PSD features were investigated in relation to adherence with eMental health interventions. First, the combination of Reduction and Tunnelling in internet-based cognitive therapies for adolescents with depression. One review showed that reducing the amount of therapy content combined with offering the content in steps increased the adherence with internet-based cognitive therapies (40). Second, another review found that the combination of Tailoring and Personalization increase the program use of internet-based cognitive behaviour therapies for adolescents with anxiety (41). Specifically, when an intervention was designed to the needs, preferences and context of the user, the user used the program more often (41). However, the program use was only increased when tailoring was combined with personalised content (41). Third, the PSD feature Reminders related to the adherence with eMental health interventions according to one review. Reminding children and adolescents with anxiety on their target behaviour in internet-based cognitive behaviour therapies was found to increase the program use of these therapies (41). Fourth, one review found that the PSD feature Rewards, rewarding children and adolescents with anxiety for target behaviours, in internet-based cognitive behaviour therapies, resulted in a higher usage of these therapies (41). Fifth, the combination of the PSD features Social role, Authority, Expertise and Trustworthiness increased program use (41). This means specifically that when the content of an eMental health intervention was trustful and offered by a reliable organisation or person the intervention was used more often. In addition, the review which found that Tailoring, Personalization, Reminders, Rewards, Social role, Authority, Expertise and Trustworthiness increased adherence stated that this was only found when additional support was given (41).

PSD features positively related with engagement

Five identified PSD features were found to be related to the engagement with eMental health interventions. First, the PSD feature Tailoring. One review found that designing the online substance-use intervention to the needs of the user increased the engagement with these interventions (32). However, how engagement was measured remains unclear. Second, the use of Reminders in online-substance use interventions. Two reviews found that reminding users about their target behaviour was contributing to the engagement with online substance-use interventions (32, 38). Third, the combination of Liking and Similarity in internet-based therapies for adolescents with depression. One review established that when internet-based therapies were visually appealing for adolescents with depression and remind it to themselves it was increasing the engagement with these type of online interventions (40). Fourth, the PSD feature Surface Credibility was found to be related to engagement in one review. This review found that when an internet-based therapy for adolescents with depression had a competent look and feel, the engagement with these therapies increased (40).

Table 4 PSD features with evidence; their target intervention, population, effect on outcomes and the quality of outcomes

Category	PSD feature[1]	Target intervention	Target population	Measurement[2]	O[3]	Review[4]	N[5]	Quality[6]
Primary task support	Reduction	Internet-based therapy	Adolescent depression	Adherence	↑	(40)	9	Moderate
	Tunnelling	Internet-based therapy	Adolescent depression	Adherence	↑	(40)	9	Moderate
	Tailoring	Internet-based cognitive behavioural therapy	Child and adolescent anxiety	Adherence	↑	(41)	8	High
		Online substance-use interventions	Not population specific	Engagement	↑	(32)	4	High
	Personalization	Internet-based cognitive behavioural therapy	Child and adolescent anxiety	Adherence	↑	(41)	8	High
	Self-monitoring	Internet-based therapy	Adolescent depression	Effectiveness	↑	(40)	6	High
Dialogue support	Rewards	Internet-based cognitive behavioural therapy	Child and adolescent anxiety	Adherence	↑	(41)	4	High
	Reminders	Internet-based cognitive behavioural therapy	Child and adolescent anxiety	Adherence	↑	(41)	6	High
		Online substance-use interventions	Not population specific	Engagement	↑	(32)	4	N/A
	Similarity	Internet-based therapy	Adolescent depression	Engagement	↑	(40)	8	High
	Liking	Internet-based therapy	Adolescent depression	Engagement	↑	(40)	8	High
	Social Role	Internet-based cognitive behavioural therapy	Child and adolescent anxiety	Adherence	↑	(41)	6	High
Credibility support	Trustworthiness	Internet-based cognitive behavioural therapy	Child and adolescent anxiety	Adherence	↑	(41)	6	High
	Expertise	Internet-based cognitive behavioural therapy	Child and adolescent anxiety	Adherence	↑	(41)	6	High
	Surface credibility	Internet-based therapy	Adolescent depression	Engagement	↑	(40)	6	High
	Authority	Internet-based cognitive behavioural therapy	Child and adolescent anxiety	Adherence	↑	(40)	6	High

1= Definitions can be found in Appendix 3 Table 1
2= An operationalization of the outcome measurements used can be found in Appendix 5
3= Effect on outcome in which ↑ means significant increase, ↓means significant decrease, * means no significant increase, ± means inconclusive results
4= Review which found the effect
5= Amount of included studies in the review which found the effect
6= Quality of studies which found the effect, N/A means there was no information about the study quality available

3.2.2 BCTs contributing to the effectiveness, adherence and engagement

For an overview of all the identified BCTs with evidence on effectiveness see Table 5. For the exact codes and definitions of all the identified BCTs see Appendix 3 Table 2.

BCTs positively related to effectiveness

Three identified BCTs contributed to the effectiveness of online substance-use interventions for hazardous and harmful drinkers according to one and the same review (36). The first BCT was Behaviour Substitution which reduced the quantity of alcohol consumed with 12 units per week (36). This BCT means that behaviour change was stimulated by showing the user an unwanted behaviour together with the opposite a wanted or a neutral behaviour. The second BCT was Problem Solving which reduced the quantity of alcohol consumed with 6 units of alcohol per week (36). This BCT aims to stimulate the user to analyse factors and strategies of their behaviour to identify facilitators which will help to overcome barriers. The third BCT was Credible Source which reduced the quantity of alcohol consumed with 4 units per week (36). This means that when a behaviour change intervention incorporates information and support from a reliable person or organisation it stimulates behaviour change.

BCTs not significantly related to effectiveness

A total of 20 BCTs, studied in the same review as the three effective BCTs of above, were not associated with a significant reduction in the quantity of alcohol consumed in both unadjusted and adjusted models (36). More specifically, when incorporating one of the following BCTs it did not cause a significant reduction in units of alcohol consumed per week: Goal setting (behaviour), Goal setting (outcome), Action planning, Discrepancy between current behavior and goal, Feedback on behaviour, Self-monitoring of behaviour, Self-monitoring of outcome(s) of behavior, Biofeedback, Feedback on outcome(s) of behaviour, Social support (unspecified), Social support (practical), Instruction on how to perform the behaviour, Information about antecedents, Information about health consequences, Salience of consequences, Information about social and environmental consequences, Social comparison, Pros and cons, Restructuring the social environment and Self-talk (36).

Table 5 BCTs with evidence; their target intervention, population, effect on outcomes and the quality of outcomes

BCT category	BCT[1]	Target intervention BCT	Target population BCT	Measurement[2]	O[3]	Review[4]	N[5]	Quality[6]
Goals and planning	Goal setting (behaviour)	Digital behaviour change interventions	Hazardous/harmful drinkers	Effectiveness	*	(36)	>4	N/A
	Problem Solving	Digital behaviour change interventions	Hazardous/harmful drinkers	Effectiveness	↑	(36)	>4	N/A
	Goal setting (outcome)	Digital behaviour change interventions	Hazardous/harmful drinkers	Effectiveness	*	(36)	>4	N/A
	Action planning	Digital behaviour change interventions	Hazardous/harmful drinkers	Effectiveness	*	(36)	>4	N/A
	Discrepancy between current behaviour and goal	Digital behaviour change interventions	Hazardous/harmful drinkers	Effectiveness	*	(36)	>4	N/A
Feedback and monitoring	Feedback on Behaviour	Digital behaviour change interventions	Hazardous/harmful drinkers	Effectiveness	*	(36)	>4	N/A
	Self-monitoring of behaviour	Digital behaviour change interventions	Hazardous/harmful drinkers	Effectiveness	*	(36)	>4	N/A
	Self-monitoring of outcome(s) of behaviour	Digital behaviour change interventions	Hazardous/harmful drinkers	Effectiveness	*	(36)	>4	N/A
	Biofeedback	Digital behaviour change interventions	Hazardous/harmful drinkers	Effectiveness	*	(36)	>4	N/A
	Feedback on outcome(s) of behaviour	Digital behaviour change interventions	Hazardous/harmful drinkers	Effectiveness	*	(36)	>4	N/A
Social support	Social support(unspecified)	Digital behaviour change interventions	Hazardous/harmful drinkers	Effectiveness	*	(36)	>4	N/A
	Social support (practical)	Digital behaviour change interventions	Hazardous/harmful drinkers	Effectiveness	*	(36)	>4	N/A
Shaping knowledge	Instruction on how to perform the behaviour	Digital behaviour change interventions	Hazardous/harmful drinkers	Effectiveness	*	(36)	>4	N/A
	Information about antecedents	Digital behaviour change interventions	Hazardous/harmful drinkers	Effectiveness	*	(36)	>4	N/A
Natural Consequence	Information about health consequences	Digital behaviour change interventions	Hazardous/harmful drinkers	Effectiveness	*	(36)	>4	N/A
	Salience of consequences	Digital behaviour change interventions	Hazardous/harmful drinkers	Effectiveness	*	(36)	>4	N/A
	Information about social and environmental consequences	Digital behaviour change interventions	Hazardous/harmful drinkers	Effectiveness	*	(36)	>4	N/A
Comparison of behaviour	Social comparison	Digital behaviour change interventions	Hazardous/harmful drinkers	Effectiveness	*	(36)	>4	N/A
	Behaviour substitution	Digital behaviour change interventions	Hazardous/harmful drinkers	Effectiveness	↑	(36)	>4	N/A
Comparison of outcomes	Credible source	Digital behaviour change interventions	Hazardous/harmful drinkers	Effectiveness	↑	(36)	>4	N/A
Reward and threat	Nonspecific reward	Digital behaviour change interventions	Hazardous/harmful drinkers	Effectiveness	*	(36)	>4	N/A
	Incentives	Online substance-use interventions	Not population specific	Engagement	±	(32)	2	Low
Antecedents	Restructuring the social environment	Digital behaviour change interventions	Hazardous/harmful drinkers	Effectiveness	*	(36)	>4	N/A

1= Definitions can be found in Appendix 3 Table 2
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3.2.3 Other mechanisms contributing to the effectiveness, adherence and engagement

For an overview of all identified working mechanisms with evidence see Table 6. For codes and definitions of all the identified working mechanisms see Appendix 3 Table 3.

Other working mechanisms positive related to effectiveness

Two working mechanisms were found to be related to the effectiveness of eMental health interventions. The first working mechanism was Visualisation. One review operationalized Visualisation as Multimedia, which is the way how the content is presented via screen, for example using videos, illustrations and audio fragments (35). This review found evidence that the use of multimedia in eTherapies for eating disorders reduced eating disorder symptoms (35). The second working mechanism was Guidance which refers to providing online additional guidance via the eMental health intervention. Guidance was operationalized in different ways, such as peer support or therapist support, and was positively contributing to the effectiveness of eMental health interventions in 3 of the 13 reviews (37, 39, 42).

Other working mechanisms not related to effectiveness

Evidence of the included reviews showed no significant relation between three working mechanisms and the effectiveness of eMental health interventions. First, one review examined Interactivity, which means that the eMental health intervention ask the user to actively engage and participate in the intervention via interactive activities and features. Examples of such interactive features are homework assignments, filling in multiple choice questions and setting goals (35). However, the review found that Interactivity did not significant decrease eating disorder symptoms (35). Second, the working mechanism Feedback, which means providing feedback on the behaviour, progress and results of the user. According to one review Feedback was not contributing to a reduction in eating disorders symptoms (35). Third, Guidance, which means providing additional online guidance via eMental health, operationalized in different ways such peer support. Guidance had no effect in reaching the desired effects according to two included reviews (35, 37).

Other working mechanisms positive related to engagement

The working mechanism Visualisation was found to have a relation to the engagement with eMental health interventions according to one review (32). This review found that online substance use interventions using multimedia increased engagement (32).

Other working mechanisms not significant related to adherence

Four identified working mechanisms did not significant increase adherence with online eating disorder therapies. First, the working mechanism Feedback. One review found that providing automated feedback during the online eating disorder therapy did not decrease dropout (35). Second, the same review found that Interactivity, which means including interactive activities such as homework tasks and quizzes, did not decrease the dropout rates (35). Third, one review found that Visualisation operationalized as Multimedia, which refers to offering intervention content via videos or illustrations, did not decrease the dropout rates (35). Fourth, one review found that Guidance was not significantly contributing to lower dropout rates. Guidance was operationalized as providing additional guidance via eMental health (35).

Table 6 Other working mechanisms with evidence; their target intervention, population, effect on outcomes and the quality of outcomes

Category	Mechanism[1]	Target intervention	Target population	Measurement[2]	O[3]	Review[4]	Amount[5]	Quality[6]
Delivery support	Interactivity	eTherapies for eating disorders	Eating disorder, no age limit	Effectiveness	*	(35)	23	N/A
		eTherapies for eating disorders	Eating disorder, no age limit	Adherence	*	(35)	23	N/A
	Visualisation	eTherapies for eating disorders	Eating disorder, no age limit	Effectiveness	↑	(35)	23	N/A
		eTherapies for eating disorders	Eating disorder, no age limit	Adherence	*	(35)	23	N/A
		Online substance-use interventions	Not population specific	Engagement	↑	(32)	2	Low
Guidance	Guidance	Online substance-use interventions	Not population specific	Engagement	±	(32)	4	Good-high
		Internet-based interventions (IBIs)	Adult participants (≥18 year) with a mental disorder	Effectiveness	↑	(39)	8	N/A
		Internet-based psychological interventions	Individuals with depression or an anxiety disorder (≥18)	Effectiveness	±	(42)	9	N/A
		Internet-based psychological interventions	Individuals with depression or an anxiety disorder (≥18)	Adherence	*	(42)	9	N/A
		Internet- and mobile based interventions	Individuals with anxiety (≥18 year)	Effectiveness	↑	(37)	4	N/A
		Internet- and mobile based interventions	Individuals with anxiety (≥18 year)	Adherence	↑	(37)	4	N/A
		eTherapies for eating disorders	Eating disorder, no age limit	Effectiveness	*	(35)	23	N/A
		eTherapies for eating disorders	Eating disorder, no age limit	Adherence	*	(35)	23	N/A
	Feedback	eTherapies for eating disorders	Eating disorder, no age limit	Effectiveness	↓	(35)	23	N/A
		eTherapies for eating disorders	Eating disorder, no age limit	Adherence	*	(35)	23	N/A

1= Definitions can be found in Appendix 3 Table 3
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3= Effect on outcome in which ↑ means significant increase, ↓means significant decrease, * means no significant increase, ± means inconclusive results
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Chapter 4 Discussion

4.1 Summary main findings

The current umbrella review aimed to identify working mechanisms in eMental health interventions and examine their relation with effectiveness, adherence and engagement. The findings of research question one: 'Which working mechanisms of eMental health interventions are studied in systematic reviews and meta-analyses?', led to the identification of 82 working mechanisms. These working mechanisms were PSD features (n=28), BCTs (n=45), and other working mechanisms (n=9) which did not fit in the PSD and BCT frameworks. In addition to this, the findings showed that the amount of reviews in which the working mechanisms were studied differ. The most studied working mechanisms were the PSD features of the two categories Primary Task Support and Dialogue Support. Specifically, the PSD features Self-monitoring (n=7) and Reminders (n=6) were studied the most. In contrast, the BCTs were the least studied working mechanisms (n=2). Furthermore, the findings of research question two: 'How is each working mechanism of eMental health interventions defined in systematic reviews and meta-analyses?', showed a lack of definitions and operationalization of the working mechanisms. Moreover, the findings of research question three: 'To what extent does each working mechanism contributes to the effectiveness, adherence and engagement of eMental health interventions according to systematic reviews and meta-analyses?, showed that the BCTs were studied from all the working mechanisms the most on effectiveness (n=3). Specifically, one review found that the BCTs, Behaviour substitution, Problem Solving and Credible source increased effectiveness of online substance-use interventions. In contrast, the PSD features were studied more on adherence (n=10) and engagement (n=5). The PSD features related to adherence had all evidence from one review. However, Reminders was studied in two reviews, and therefore had the strongest support of evidence of all PSD features for the relation with engagement.

The identification of new working mechanisms is a step forward in eMental health design

An interesting finding is the identification of working mechanisms which are not part of the BCT Taxonomy or the PSD model. Examples of these working mechanisms are Gamification, Visualisation and Interactivity. The identification of these working mechanisms addresses that the existing frameworks, the BCT Taxonomy and the PSD model, are not comprehensive. This can be caused through the fact that limited knowledge is available about how and which components contribute to the outcomes of eMental health and eHealth interventions (1, 20, 22, 23, 44, 45). Therefore, researchers and designers can only rely on existing models, such as the PSD model and the BCT Taxonomy. Another possible explanation can be that people only find what they are looking for. This means that when someone is interested in PSD features they probably miss other working mechanisms because they do not pay attention to these working mechanisms. Furthermore, the definitions and operationalisations of the working mechanisms are limited and this can be another reason why working mechanism are not identified in studies and eMental health interventions. A lack of operationalization can also cause difficulties while coding overlapping working mechanisms. This is the reason why definitions are important for researchers to identify and evaluate working mechanisms in eMental health interventions. Next to this, it is also important for designers which need a clear understanding on how to incorporate working mechanisms in the design. Therefore, the new identified working mechanisms are of added value for the design and evaluation of eMental health interventions to increase their effectiveness, adherence and engagement.

The PSD features seems to be more related to adherence and engagement than the BCTs

Another interesting finding is that the working mechanisms relate differently to effectiveness, adherence and engagement. The results showed that the PSD features are related more to adherence (n=10) and engagement (n=5) than the BCTs (n=0). In contrast, the BCTs are more investigated and related to effectiveness (n=3). The reason that might explain this is that PSD model and BCT Taxonomy are developed for different areas and therefore applied in different types of interventions (26, 27). First, the PSD features are aimed to increase the persuasiveness of technology (26). Persuading people to keep using the technology is in line with adherence, which is using the technology as intended (1). These PSD features are therefore only applied in technological interventions. Second, the BCTs are aimed to stimulate behaviour change and therefore can be applied in both traditional as digital behaviour change interventions (27). Behaviour change is closely related to the aim of the intervention and effectiveness, which refers to reaching the desired intervention effects (1, 27). Another possible explanation for the fact that the PSD features relate more to adherence and engagement than BCTs can be the heterogeneity of the outcome measurements used. In the literature, effectiveness, adherence and engagement are operationalized differently and used interchangeably. This causes that two reviews can both investigated adherence but both measure it differently, or operationalized engagement as program use, which is adherence. This heterogeneity of outcome measurements is also acknowledged in other studies in which efforts are made to generate an overall operationalization of engagement and adherence (17, 46-48). Therefore, it is important to pay attention to how working mechanisms contribute to outcomes, how these outcomes are defined, for which aim and for which types of interventions these mechanisms are developed, while evaluating and designing eMental health interventions.

The overlap between working mechanisms provides the opportunity to combine models

While there are differences between the aims of the PSD model and BCT Taxonomy, an overlap was found in how these frameworks operationalized working mechanisms to reach their aim. For example, the PSD feature self-monitoring, which is defined as 'Keeps track of the user's performance or status towards goal achievement', is according to the results of the current umbrella review and others studies increasing adherence with eMental Health interventions (40, 45). However, Self-monitoring is also part of the BCT Taxonomy, which operationalized Self-monitoring as: 'Establish a method for the person to monitor and record their behaviour(s) as part of a behaviour change strategy' (27). Therefore, it is also possible that Self-monitoring stimulate behaviour change (27). A possible explanation for this overlap can be the use of different names and definitions without comparing these with definitions of other available models (49). However, the overlap provides opportunities to combine existing models with their working mechanisms into one model and extent these with the new identified working mechanisms of the current study. In literature new models are proposed which combines PSD features and BCTs (49-51). This addresses that the need to revaluate and combine available frameworks is acknowledged. In addition, the existing PSD model and BCT taxonomy focus on persuasion and behaviour change. However, not on the relation with effectiveness, adherence and engagement. Therefore, a model which combines working mechanisms of different models and focus on their relation with effectiveness, adherence and engagement, is of added value for the design and evaluation of eMental health interventions.

4.2 Strengths and limitations

The current study has limitations that need to be considered when interpreting the results. First, due to a heterogeneity of how the outcome measurements were measured and the diversity in types of interventions it was not possible to compare the effects. Therefore, the results stating it had an effect is only about the effect how it was measured according to the specific review for the specific type of intervention and disorder and not for all the same working mechanisms examined in other reviews. However, since the aim was not providing an exhaustive overview of working mechanisms and their evidence, but a first step towards an overview, this is not from major influence on the added value of the results. Second, no risk of bias and methodological assessment of the included reviews was conducted instead, if available, the quality assessments of the reviews were used. An umbrella review can only rely on the conclusions of the included reviews and not on their primary studies. Specifically, if the conclusion of the specific review was not scientific correct, there was no possibility to check this. Therefore, it can be possible that not all evidence is correct which can influence the results. Third, the working mechanisms were deductive and inductively coded based on the interpretation of the involved researcher (AC). This can cause that the working mechanisms are interpreting differently by others, which limits the generalization of the results. However, this was done to identify as broad of possible and to provide a first overview of mechanisms.

Besides, the limitations the current umbrella review has also strengths. First, the use of the umbrella review method provides a domain specific overview of working mechanisms for a diversity of disorders and interventions. Another strength is the use of more than one model to identify working mechanisms. Both the PSD features and BCTs and their underlying theories as behaviour change and the theory of persuasion were used. Therefore, it was possible to identify working mechanisms as broad as possible. This increased the amount and relevance of the working mechanisms found. In addition, it also provides the possibility to compare the working mechanisms found with other studies using the same frameworks.

4.3 Recommendations future research and eMental health design

The current umbrella review is not providing an exhaustive list of all working mechanisms. Therefore, we propose recommendations for future research to extent the list of working mechanisms. First, more research is requested on what working mechanisms are and how the individual working mechanisms are operationalized in eMental health and eHealth interventions. By a better understanding new and existing working mechanisms can be identified in the available evidence and can be used in the design, evaluation and improvement of eMental health interventions. Second, the diversity in operationalization of outcome measurements make generalizing results difficult. Therefore, more attention should be paid to the operationalization of these outcome measurements to generate an overall understanding how the working mechanisms contribute to specific outcomes and to increase the generalization of results. For example, a systematic reviews can be conducted to gather all available definitions and develop based on these definitions one overall definition. Next to the research recommendations, design recommendations can also be given based on the results of the review. First, designers need to consider how the content of an eMental health intervention is delivered in order to design an engaging and effective eMental health intervention that fits the needs of the user. For example, the results showed that addressing the cognitive load of interventions by incorporating reduction and tunnelling is important (40). Secondly, an intervention with a competent look and feel which is providing content via engaging delivery strategies, such as video, is recommended and will increase the surface credibility (40). Third, self-monitoring is found to be helpful and increase the effectiveness of

eMental health interventions which is also acknowledged in other studies (40) (45). Therefore it is recommended to incorporate a self-monitoring component in the eMental health intervention. Fourth, the findings show that prompting the user with Reminders and Rewards helps in the engagement and adherence towards eMental health interventions (32, 38, 41, 45). Therefore, incorporating Rewards or Reminders will be recommended to increase the adherence and engagement with eMental health. In sum, the findings of the umbrella review provide valuable directions for design and evaluation of eMental health interventions.

4.4 Conclusion

eMental Health interventions can be of added value for the prevention and treatment of mental Health disorders. However, problems with effectiveness, adherence and engagement with these interventions limits this added value. Therefore, the current umbrella review identified working mechanisms and examined how these working mechanisms contributed to effectiveness, adherence and engagement with eMental health interventions. Resulting in a first overview of working mechanisms which can be used in the design and evaluation of eMental health interventions. Specifically, the review identified three types of working mechanisms within, PSD features and BCTs, and outside existing frameworks, such as Visualization. However, there was a lack of information on how these working mechanisms were defined and operationalized in eMental Health interventions and this needs attention in future research. In relation to the outcomes, the PSD features were studied more on adherence and engagement than BCTs. In contrast, BCTs were studied more on effectiveness. In addition, the results showed differences and overlap between the PSD features and BCTs such as Self-monitoring, which addresses a need to revaluate the existing models and offers the possibility to combine these into a model. All these findings are step forward in developing eMental health interventions to increase effectiveness, adherence and engagement.

References

1. Van Gemert-Pijnen JE, Kelders SM, Kip H, Sanderman R. eHealth Research, Theory and Development A Multidisciplinary Approach: Routledge 2018.
2. Lal S, Adair CE. E-mental health: a rapid review of the literature. Psychiatric services (Washington, DC). 2014;65(1):24-32.
3. Lal S. E-mental health: Promising advancements in policy, research, and practice. Healthcare Management Forum. 2019;32(2).
4. Basnet S, Tamminen M, Lathi T. The Feasibility of eHealth in Mental Health Care. Journal of Addiction Research & Therapy. 2014;5(4).
5. Huber M, Knottnerus J, Green L, van der Horst H, Jadad A, Kromhout D, et al. How should we define health? BMJ. 2011.
6. Huber M, van Vliet M, Giezenberg M, Winkens B, Heerkens Y, Dagnelie P, et al. Towards a 'patient-centred' operationalisation of the new dynamic concept of health: a mixed methods study. BMJ. 2016.
7. Andersson G, Cuijpers P. Internet-Based and Other Computerized Psychological Treatments for Adult Depression: A Meta-Analysis. Cognitive Behaviour Therapy 2009;38(4):196–205.
8. Christensen H, Mackinnon A, Batterham PJ, O'Dea B, Guastella A, Griffiths K, et al. The effectiveness of an online e-health application compared to attention placebo or Sertraline in the treatment of Generalised Anxiety Disorder. Internet interventions. 2014;1(4):169-74.
9. Lungu A, Jun JJ, Azarmanesh O, Leykin Y, Chen CE. Blended Care-Cognitive Behavioral Therapy for Depression and Anxiety in Real-World Settings: Pragmatic Retrospective Study. J Med Internet Res. 2020;22(7).
10. Park MJ, Kim DJ, Lee U, Na EJ, Jeon HJ. A Literature Overview of Virtual Reality (VR) in Treatment of Psychiatric Disorders: Recent Advances and Limitations. Frontiers in psychiatry. 2019.
11. Srivastana K, Das R, Chaudhury S. Virtual reality applications in mental health: Challenges and perspectives. Ind Psychiatry J. 2014;23(2):83-5.
12. Granja C, Janssen W, Johansen MA. Factors Determining the Success and Failure of eHealth Interventions: Systematic Review of the Literature. J Med Internet Res. 2018;20(5).
13. Schreiweis B, Pobiruchin M, Strotbaum V, Suleder J, Wiesner M, Bergh B. Barriers and Facilitators to the Implementation of eHealth Services: Systematic Literature Analysis. J Med Internet Res. 2019;21(11).
14. Kelders SM, Kok R, Ossebaard H, van Gemert-Pijnen JE. Persuasive System Design Does Matter: A Systemtatic Review of Adherence to Web-Based Interventions. J Med Internet Res. 2012;14(6).
15. Tremain H, McEnery C, Fletcher K, Murray G. The Therapeutic Alliance in Digital Mental Health Interventions for Serious Mental Illnesses: Narrative Review. JMIR Ment Health. 2020;7(8):e17204.
16. Garrido S, Millington C, Cheers D, Boydell K, Schubert E, Meade T, et al. What Works and What Doesn't Work? A Systematic Review of Digital Mental Health Interventions for Depression and Anxiety in Young People. Frontiers in psychiatry. 2019;10.
17. Kelders SM, van Zyl LE, Ludden GDS. The Concept and Components of Engagement in Different Domains Applied to eHealth: A Systematic Scoping Review. Front Psychol 2020.
18. Borghouts J, Eikey E, Mark G, De Leon C, Schueller SM, Schneider M, et al. Barriers to and Facilitators of User Engagement With Digital Mental Health Interventions: Systematic Review. J Med Internet Res 2021;23(3).
19. Cambon L, Terral P, Alla F. From intervention to interventional system: towards greater theorization in population health intervention research. BMC public health. 2019;19.
20. Holter MTS, Johansen AB, Ness O, Brinkmann S, Høybye MT, Brendryen H. Qualitative Interview Studies of Working Mechanisms in Electronic Health: Tools to Enhance Study Quality. J Med Internet Res. 2019;21(5).

21. Lacouture A, Breton E, Guichard A, Ridde V. The concept of mechanism from a realist approach: a scoping review to facilitate its operationalization in public health program evaluation. Implementation science : IS. 2015.
22. Sieverink F. Opening the Black Box of eHealth. A mixed methods approach for the evaluation of personal health record: University of Twente; 2017.
23. Kremer R. Black Box of eHealth 2016.
24. Poppe L, van der Mispel C, Crombez G, de Bourdeaudhuij I, Schroé H, Verloigne M. How Users Experience and Use an eHealth Intervention Based on Self-Regulation: Mixed-Methods Study. J Med Internet Res. 2018;20(10).
25. Steubl L, Sachser C, Baumeister H, Domhardt M. Intervention components, mediators, and mechanisms of change of Internet- and mobile-based interventions for post-traumatic stress disorder: protocol for a systematic review and meta-analysis. Systematic reviews. 2019;8(1).
26. Oinas-Kukkonen H, Harjumaa M. Persuasive Systems Design: Key Issues, Process Model, and System Features. Communications of the Association for Information Systems. 2009;24(1).
27. Michie S, Richardson M, Johnston M, Abraham C, Francis J, Hardeman W, et al. The behavior change technique taxonomy (v1) of 93 hierarchically clustered techniques: building an international consensus for the reporting of behavior change interventions. 2013.
28. Connor M, Norman P. Health behaviour: Current issues and challenges. Psychology and Health 2017;32(8):895-906.
29. Duff OM, Walsh DM, Furlong BA, O'Connor NE, Moran KA, Woods CB. Behavior change techniques in physical activity ehealth interventions for people with cardiovascular disease: Systematic review. J Med Internet Res. 2017;19(8):21-32.
30. Aromataris E, Fernandez R, Godfrey CM, Holly C, Khalil H, Tungpunkom P. Summarizing systematic reviews: methodological development, conduct and reporting of an umbrella review approach. International journal of evidence-based healthcare. 2015;13(3).
31. Melbye S, Kessing LV, Bardram JE, Faurholt-Jepsen M. Smartphone-Based Self-Monitoring, Treatment, and Automatically Generated Data in Children, Adolescents, and Young Adults With Psychiatric Disorders: Systematic Review. JMIR Ment Health. 2020;7(10):e17453.
32. Milward J, Drummond C, Fincham-Campbell S, Deluca P. What makes online substance-use interventions engaging? A systematic review and narrative synthesis. Digital health. 2018;4:2055207617743354.
33. Dogan E, er C, Wagner X, Hegerl U, Kohls E. Smartphone-based monitoring of objective and subjective data in affective disorders: Where are we and where are we going? Systematic review. J Med Internet Res. 2017;19(7):223-40.
34. Lehto T, Oinas-Kukkonen H. Persuasive features in web-based alcohol and smoking interventions: a systematic review of the literature. J Med Internet Res. 2011;13(3):e46.
35. Barakat S, Maguire S, Smith KE, Mason TB, Crosby RD, Touyz S. Evaluating the role of digital intervention design in treatment outcomes and adherence to eTherapy programs for eating disorders: A systematic review and meta-analysis. International Journal of Eating Disorders. 2019;52(10):1077-94.
36. Garnett CV, Crane D, Brown J, Kaner EFS, Beyer FR, Muirhead CR, et al. Behavior change techniques used in digital behavior change interventions to reduce excessive alcohol consumption: A meta-regression. Annals of Behavioral Medicine. 2018;52(6):530-43.
37. Domhardt M, Geßlein H, Rezori RE, Baumeister H. Internet- and mobile-based interventions for anxiety disorders: A meta-analytic review of intervention components. Depression and anxiety. 2019;36(3):213-24.
38. Wahle F, Bollhalder L, Kowatsch T, Fleisch E. Toward the Design of Evidence-Based Mental Health Information Systems for People With Depression: A Systematic Literature Review and Meta-Analysis. J Med Internet Res. 2017;19(5):e191.
39. Baumeister H, Reichler L, Munzinger M, Lin J. The impact of guidance on Internet-based mental health interventions - A systematic review. Internet Interventions. 2014;1(4):205-15.

40. Wozney L, Huguet A, Bennett K, Radomski AD, Hartling L, Dyson M, et al. How do eHealth Programs for Adolescents With Depression Work? A Realist Review of Persuasive System Design Components in Internet-Based Psychological Therapies. J Med Internet Res. 2017;19(8):e266.
41. Radomski AD, Wozney L, McGrath P, Huguet A, Hartling L, Dyson MP, et al. Design and Delivery Features That May Improve the Use of Internet-Based Cognitive Behavioral Therapy for Children and Adolescents With Anxiety: A Realist Literature Synthesis With a Persuasive Systems Design Perspective. J Med Internet Res. 2019;21(2):e11128.
42. Shim M, Mahaffey B, Bleidistel M, Gonzalez A. A scoping review of human-support factors in the context of Internet-based psychological interventions (IPIs) for depression and anxiety disorders. Clinical psychology review. 2017;57:129-40.
43. Lui JHL, Marcus DK, Barry CT. Evidence-based apps? A review of mental health mobile applications in a psychotherapy context. Professional Psychology: Research and Practice. 2017;48(3):199-210.
44. Collins LM, Trail JB, Kugler KC, Baker TB, Piper ME, Mermelstein RJ. Evaluating individual intervention components: making decisions based on the results of a factorial screening experiment. Translational behavioral medicine. 2014;4(3).
45. Whitton A, Proudfoot J, Clarke J, Birch M, Parker G, Manicavasagar V, et al. Breaking Open the Black Box: Isolating the Most Potent Features of a Web and Mobile Phone-Based Intervention for Depression, Anxiety, and Stress. JMIR Ment Health. 2015;2(1).
46. Donkin L, Christensen H, Naismith SL, Neal B, Hickie IB, Glozier N. A Systematic Review of the Impact of Adherence on the Effectiveness of e-Therapies. J Med Internet Res. 2011;13(3).
47. Perski O, Blandford A, West R, Michie S. Conceptualising engagement with digital behaviour change interventions: a systematic review using principles from critical interpretive synthesis. Translational behavioral medicine. 2017;7(2):254-67.
48. Sieverink F, Kelders SM, van Gemert-Pijnen JE. Clarifying the concept of adherence to eHealth technology: Systematic review on when usage becomes adherence. Journal of Medical Internet Research. 2017;19(12).
49. Wang Y, Fadhil A, Lange J, Reiterer H. Integrating Taxonomies Into Theory-Based Digital Health Interventions for Behavior Change: A Holistic Framework. JMIR Research Protocols. 2019;8(1).
50. Mohr DC, Schueller SM, Montague E, Burns MN, Rashidi P. The Behavioral Intervention Technology Model: An Integrated Conceptual and Technological Framework for eHealth and mHealth Interventions. J Med Internet Res. 2014;16(6).
51. Asbjørnsen RA, Smedsrød ML, Solberg Nes L, Wentzel J, Varsi C, Hjelmesæth J, et al. Persuasive System Design Principles and Behavior Change Techniques to Stimulate Motivation and Adherence in Electronic Health Interventions to Support Weight Loss Maintenance: Scoping Review. J Med Internet Res. 2019;21(6):e14265.
52. Weersing R, Rozenman M, Gonzalez A. Core Components of Therapy in Youth: Do We Know what to Disseminate? Behavior Modification. 2008;33(1):24-47.
53. Barakat S, Maguire S, Smith KE, Mason TB, Crosby RD, Touyz S. Evaluating the role of digital intervention design in treatment outcomes and adherence to eTherapy programs for eating disorders: A systematic review and meta-analysis. International Journal of Eating Disorders. 2019;52(10):1077-94.

Appendices

Appendix 1 Search strings used per database

Search string Scopus:
TITLE-ABS-KEY (mechanism* OR component* OR feature* OR technique*) AND TITLE-ABS-KEY (psychiat* OR psycholog* OR mental* OR DSM-5) W/3 (health* OR disorder* OR disease* OR illness* OR problem*) AND TITLE-ABS-KEY ("eMental health" OR "e-mental health" OR eHealth OR e-health OR mHealth OR m-health OR "mobile health" OR "web-based health" OR "digital health" OR "digital behaviour change intervention" OR telemedicine OR tele-medicine OR telehealth OR tele-health OR teleps*) AND TITLE-ABS-KEY (meta-anal* OR metaanal* OR review* OR "research integration" OR overview OR synthesis)

Filters: review
Result: 149

Search string PubMed:
(mechanism* OR component* OR feature* OR technique*) AND (psychiat* OR psycholog* OR mental* OR DSM-5) AND (health* OR disorder* OR disease* OR illness* OR problem*) AND ("eMental health" OR "e-mental health" OR eHealth OR e-health OR mHealth OR m-health OR "mobile health" OR "web-based health" OR "digital health" OR "digital behaviour change intervention" OR telemedicine OR tele-medicine OR telehealth OR tele-health OR teleps*) AND (meta-anal* OR metaanal* OR review* OR "research integration" OR overview OR synthesis)

Advanced options:	Search in all fields
Filters:	review and meta-analysis
Result:	347

Search string PsychInfo:
(mechanism* OR component* OR feature* OR technique*) AND (psychiat* OR psycholog* OR mental* OR DSM-5) AND (health* OR disorder* OR disease* OR illness* OR problem*) AND ("eMental health" OR "e-mental health" OR eHealth OR e-health OR mHealth OR m-health OR "mobile health" OR "web-based health" OR "digital health" OR "digital behaviour change intervention" OR telemedicine OR tele-medicine OR telehealth OR tele-health OR teleps*) AND (meta-anal* OR metaanal* OR review* OR "research integration" OR overview OR synthesis)

Filters:	Literature review + meta analysis, academic journals
Result:	236 literature reviews and 31 meta analyses a total of 267

Appendix 2 Data extraction form used to extract the data

Category	Name extracted data	Data Review 1,	Data Review 2
Review characteristics	Title		
	Year		
	Author		
	Type of review		
	Objective		
	Population		
	Intervention		
	Comparative		
	Outcome measurement		
	Amount of database used		
	Databases used		
	Time range search		
	Amount of studies		
	Study design included studies		
	Data range included studies		
	Method data synthesis		
	Quality assessment		
eMental health components	Category eMental health component		
	Name eMental health component		
	Definition eMental health component		
Relation with outcome	eMental health component		
	Qualitative and quantitative data stating a relation		
	Qualitative and quantitative data stating a relation		
	Qualitative and quantitative data stating a relation		
	Qualitative and quantitative data stating a relation		

Appendix 3 Coding schemes to identify PSD features, BCTs and other working mechanisms

Table 1 Coding scheme identified PSD features ([1]= review in which the specific PSD code was coded)

Category	Sub code	Definition sub code	Review[1]
Primary Task Support	Reduction	'Reduces complex behavior into simple tasks' (40)	(34, 40, 41)
	Tunnelling	'Guides a user through a process or experience' (40)	(32, 34, 40, 41)
	Tailoring	'Tailors the experience to the potential needs, interests, personality, or use context' (40)	(32, 34, 38, 40, 41)
	Personalization	'Personalizes content (eg, allows you to customize the interface or populates your name)' (40)	(34, 38, 40, 41)
	Self-monitoring	'Keeps track of the user's performance or status towards goal achievement' (40)	(31, 33, 34, 38, 40, 41, 43)
	Simulation	'Provides simulations to enable the user to observe link between cause and effect' (40)	(34, 40, 41)
	Rehearsal	'Provides a way for user to rehearse a skill or task' (26)	(34, 40, 41)
Dialogue support	Praise	'Offers praise as a form of feedback' (40)	(34, 38, 40, 41, 43)
	Rewards	'Rewards target behaviors' (40)	(34, 40, 41)
	Reminders	'Reminds the user of their target behavior' (26)	(32, 34, 35, 38, 40, 41)
	Suggestion	'Offers fitting suggestions' (40)	(34, 40, 41)
	Similarity	'Reminds the user of themselves in some meaningful way' (40)	(34, 40, 41)
	Liking	'Is visually attractive for the user' (40)	(34, 40, 41)
	Social Role	'Adopts a social role'(40)	(34, 40, 41)
Credibility Support	Trustworthiness	'Provide information that is truthful, fair, and unbiased' (40)	(34, 40, 41)
	Expertise	'Provides information showing knowledge, experience, and competence' (40)	(34, 40, 41)
	Surface credibility	'Has a competent look and feel' (40)	(34, 40, 41)
	Real-World Feel	'Provides information of the actual people behind its content and services' (40)	(34, 40, 41)
	Authority	'Refers to people in the role of authority' (40)	(34, 40, 41)
	Third-party endorsement	'Provides endorsements from other sources'(40)	(34, 40, 41)
	Verifiability	'Provides means to verify the accuracy of program via outside sources' (40)	(34, 40, 41)
Social support	Social Learning	' Can use the system to observe others performing tasks or behaviors' (40)	(34, 40, 41)
	Social Comparison	'Can use the system to compare their performance with the performance of others'(40)	(34, 40, 41)
	Normative influence	'Leverages normative influence or peer pressure' (40)	(34, 40, 41)
	Social facilitation	' User is able to discern via the system that others are performing the behavior along with them' (40)	(34, 40, 41)
	Cooperation	'Leverages drive to cooperate to complete tasks or behaviors' (40)	(34, 40, 41)
	Competition	'Leverages drive to compete against others in completing a task or action' (40)	(34, 40, 41)
	Recognition	'Offers public recognition for an individual or group'(40)	(34, 40, 41)

Table 2 Coding scheme identified BCTs ([1]= review in which the specific BCT code was coded)

BCT category	Sub code	Definition sub code	Review[1]
Goals and planning	Goal setting (behaviour)	'Set or agree on a goal defined in terms of the behavior to be achieved' (27)	(36, 40)
	Problem Solving	"Analyze, or prompt the person to analyze, factors influencing the behavior and generate or select strategies that include overcoming barriers and/or increasing facilitators" (27)	(36)
	Goal setting (outcome)	'Set or agree on a goal defined in terms of a positive outcome of wanted behavior' (27)	(36)
	Action planning	'Prompt detailed planning of performance of the behavior (must include at least one of context, frequency, duration and intensity). Context may be environmental (physical or social) or internal (physical, emotional or cognitive) (includes 'Implementation Intentions')' (27)	(36)
	Review behaviour goal(s)	'Review behavior goal(s) jointly with the person and consider modifying goal(s) or behavior change strategy in light of achievement. This may lead to re-setting the same goal, a small change in that goal or setting a new goal instead of (or in addition to) the first, or no change' (27)	(36)
	Discrepancy between current behaviour and goal	'Draw attention to discrepancies between a person's current behavior (in terms of the form, frequency, duration, or intensity of that behavior) and the person's previously set outcome goals, behavioral goals or action plans (goes beyond self-monitoring of behavior)' (27)	(36)
	Review outcome goal(s)	'Review outcome goal(s) jointly with the person and consider modifying goal(s) in light of achievement. This may lead to re-setting the same goal, a small change in that goal or setting a new goal instead of, or in addition to the first' (27)	(36)
	Behavioural contract	'Create a written specification of the behavior to be performed, agreed on by the person, and witnessed by another' (27)	(36)
Feedback and monitoring	Feedback on behaviour	'Monitor and provide informative or evaluative feedback on performance of the behavior (e.g. form, frequency, duration, intensity)' (27)	(36)
	Self-monitoring of behaviour	'Establish a method for the person to monitor and record their behavior(s) as part of a behavior change strategy' (27)	(36)
	Self-monitoring of outcome(s) of behaviour	'Establish a method for the person to monitor and record the outcome(s) of their behavior as part of a behavior change strategy' (27)	(36)
	Biofeedback	'Provide feedback about the body (e.g. physiological or biochemical state) using an external monitoring device as part of a behavior change strategy' (27)	(36)
	Feedback on outcome(s) of behaviour	'Monitor and provide feedback on the outcome of performance of the behavior' (27)	(36)
Social support	Social support (unspecified)	'Advise on, arrange or provide social support (e.g. from friends, relatives, colleagues,' buddies' or staff) or non-contingent praise or reward for performance of the behavior. It includes encouragement and counselling, but only when it is directed at the behavior' (27)	(36)
	Social support (practical)	'Advise on, arrange, or provide practical help (e.g. from friends, relatives, colleagues, 'buddies' or staff) for performance of the behavior' (27)	(36)
	Social support (emotional)	'Advise on, arrange, or provide emotional social support (e.g. from friends, relatives, colleagues, 'buddies' or staff) for performance of the behavior' (27)	(36)
Shaping knowledge	Instruction on how to perform the behaviour	'Advise or agree on how to perform the behavior (includes 'Skills training') ' (27)	(36)
	Information about antecedents	'Provide information about antecedents (e.g. social and environmental situations and events, emotions, cognitions) that reliably predict performance of the behaviour' (27)	(36)
	Behavioural experiments	'Advise on how to identify and test hypotheses about the behavior, its causes and consequences, by collecting and interpreting data' (27)	(36)
Natural consequence	Information about health consequences	'Provide information (e.g. written, verbal, visual) about health consequences of performing the behavior' (27)	(36)
	Salience of consequences	'Use methods specifically designed to emphasise the consequences of performing the behaviour with the aim of making them more memorable (goes beyond informing about consequences)' (27)	(36)

BCT category	Sub code	Definition sub code	Review[1]
	Information about social and environmental consequences	'Provide information (e.g. written, verbal, visual) about social and environmental consequences of performing the behavior' (27)	(36)
	Monitoring of emotional consequences	'Prompt assessment of feelings after attempts at performing the behavior' (27)	(36)
	Information about emotional consequences	'Provide information (e.g. written, verbal, visual) about emotional consequences of performing the behavior' (27)	(36)
Comparison of behaviour	Social comparison	'Draw attention to others' performance to allow comparison with the person's own performance' (27)	(36)
Associations	Prompts/cues	'Introduce or define environmental or social stimulus with the purpose of prompting or cueing the behavior. The prompt or cue would normally occur at the time or place of performance' (27)	(36)
Repetition and substitution	Behavioural practice/rehearsal	'Prompt practice or rehearsal of the performance of the behavior one or more times in a context or at a time when the performance may not be necessary, in order to increase habit and skill'(27)	(36)
	Behaviour substitution	"Prompt substitution of the unwanted behavior with a wanted or neutral behavior" (27)	(36)
	Habit reversal	'Prompt rehearsal and repetition of an alternative behavior to replace an unwanted habitual behavior' (27)	(36)
	Graded tasks	'Set easy-to-perform tasks, making them increasingly difficult, but achievable, until behavior is performed' (27)	(36)
Comparison of outcomes	Credible source	"Present verbal or visual communication from a credible source in favor of or against the behavior" (27)	(36)
	Pros and cons	'Advise the person to identify and compare reasons for wanting (pros) and not wanting to (cons) change the behavior (includes 'Decisional balance')' (27)	(36)
Reward and threat	Nonspecific reward	'Arrange delivery of a reward if and only if there has been effort and/or progress in performing the behavior (includes 'Positive reinforcement')' (27)	(36)
	Social-reward	'Arrange verbal or non-verbal reward if and only if there has been effort and/or progress in performing the behavior (includes 'Positive reinforcement')' (27)	(36)
	Nonspecific incentive	'Inform that a reward will be delivered if and only if there has been effort and/or progress in performing the behavior (includes 'Positive reinforcement')' (27)	(32, 36, 43)
	Self-reward	'Prompt self-praise or self-reward if and only if there has been effort and/or progress in performing the behavior' (27)	(36)
Regulation	Reduce negative emotions	'Advise on ways of reducing negative emotions to facilitate performance of the behavior (includes 'Stress Management' (27)	(36)
Antecedents	Restructuring the social environment	'Change, or advise to change the social environment in order to facilitate performance of the wanted behavior or create barriers to the unwanted behavior (other than prompts/cues, rewards and punishments)' (27)	(36)
	Avoidance/reducing exposure to cues for the behaviour	'Advise on how to avoid exposure to specific social and contextual/physical cues for the behavior, including changing daily or weekly routines' (27)	(36)
Identity	Framing/reframing	'Suggest the deliberate adoption of a perspective or new perspective on behavior (e.g. its purpose) in order to change cognitions or emotions about performing the behavior (includes 'Cognitive structuring')' (27)	(36)
Scheduled consequences	Punishment	'Arrange for aversive consequence contingent on the performance of the unwanted behavior' (27)	(36)
Self-belief	Verbal persuasion about capability	'Tell the person that they can successfully perform the wanted behavior, arguing against self-doubts and asserting that they can and will succeed' (27)	(36)
	Focus on past success	'Advise to think about or list previous successes in performing the behavior (or parts of it)' (27)	(36)
	Self-talk	'Prompt positive self-talk (aloud or silently) before and during the behavior' (27)	(36)

Table 3 Coding scheme other working mechanisms ([1]= review in which the mechanism was coded)

Category	Sub code	Definition sub code	Review[1]
Delivery support	Interactivity	'Interactive activities include features of the program where individuals are required to engage or participate within the program, for example self-monitoring tools, quizzes, self-assessment, or any activity, which helps individuals understand the content in a more personally relevant manner' (35)	(35, 38)
	Gamification	'Gamification is defined as the use of gaming components in non-gaming settings' (32).	(38, 43)
	Multimedia	'Multimedia choice refers to the way in which program content Is disseminated on the screen such as written text, pictures/graphics, animations, audio, and video' (35).	(32, 35, 38)
Therapeutic support	Cognitive restructuring	'Helping youngsters identify and alter their unrealistic, negative thoughts about themselves, others, and events' (52)	(40)
	Coping skills	N/A	(40)
	Behavioural activation	'Helping individuals engage in active behavior that can elevate mood and helping them to see the relation between their activity and mood'(52)	(40)
	Interpersonal skills	N/A	(40)
Knowledge support	Education	A system which provides education to increase the knowledge of the users that is relevant in the context of the intervention.	(38, 40, 43)
Guidance	Online Guidance	A system which provides supplementary guidance during the healthcare intervention/therapy/program	(32, 35, 37, 39, 40)
	Feedback	Providing feedback on behaviour, progress and results	(32, 53)

Appendix 4 Coding schemes to examine the effects of the working mechanisms

Table 1 Inductive coding scheme outcomes identified PSD features

PSD feature	Sub code	Definition
Reduction	Higher adherence	Reduction together with tunnelling increased the therapy adherence
	Unclear context effect	The effect in context was unclear due to a heterogeneity of therapies
	Increased engagement	By incorporating reduction the engagement increased
Tunnelling	Higher adherence	Tunnelling together with reduction increased the therapy adherence
	Improved engagement	Tunnelling significant improved engagement
	Unclear context effect	The effect in context was unclear due to a heterogeneity of therapies
Tailoring	Higher program use	Tailoring together with personalization increased program use
	Increased engagement	Tailoring significant increased the engagement
	Inconclusive results	The subtypes of tailoring had in some studies effect and in others not.
Personalization	Higher program use	Personalization combined with tunnelling increased program use
	Helpful for engagement	Personalization can help but had no established relation with engagement
	Significant adherence	Significant more adherence when the eMental health fit with preferences
Self-monitoring	Symptom improvement	Self-monitoring reduced clinical symptoms
	High adherence	The adherence towards self-monitoring systems was high (above 50%)
Praise	Promising results	Praise had promising results, however these results were not established yet
Rewards	Higher program use	Rewards encouraged the user to use the system more often
	Promising results	The use of rewards might be promising but the relation is not established
Reminders	Higher program use	The use of reminders encouraged the user to use the system more often
	Higher adherence	Reminders increased adherence such as the amount of visits or tool usage
	Increased engagement	When incorporating reminders the user was more engaged with the system
Similarity	Increased engagement	Led to adolescent engagement
Liking	Increased engagement	Led to adolescent engagement
Social Role	Higher program use	Through adding a social role the user used the program more often.
Trustworthiness	Higher program use	Through adding trustful information the user used the program more often.
	Crucial in engagement	The use of trustworthiness is crucial in website engagement
Expertise	Higher program use	Expertise lead to a greater program usage
Surface credibility	Increased engagement	Surface credibility led to a higher engagement
	Crucial in engagement	The use of trustworthiness is crucial in website engagement
Authority	Higher program use	Through adding an authority the user used the program more often.

Table 2 Inductive coding scheme outcomes identified BCTs

BCT	Sub code	Definition
Problem Solving	Alcohol reduction	Problem solving in online substance-use interventions reduced the amount of alcohol consumed and is therefore seen as effective
Credible source	Alcohol reduction	A credible source in online substance-use interventions reduced the amount of alcohol consumed and is therefore seen as effective
Behaviour substitution	Alcohol reduction	Behaviour substitution in online substance-use interventions reduced the amount of alcohol consumed and is therefore seen as effective
Incentives	Conflicting findings	The use of incentives was increasing in some studies but not in others Already engaged people increased however the engagement did not increased when the users were not engaged
		Increasing adherence
Nonspecific incentive	Conflicting findings	The engagement increased in already engaged people. The people which were not engaged yet had no increase in engagement
	Increase adherence	Incentives can be used to increase adherence

Table 3 Inductive coding scheme outcomes other identified working mechanisms

Mechanism	Sub code	Definition
Interactivity	Potential effective	Interactivity has the potential to improve clinical outcomes
	Might influence efficacy	Might influence treatment efficacy
	No symptom reduction	Interactivity did not decrease eating disorder symptoms
	No decrease in dropout	Interactivity did not significant decrease dropout
Visualization	Symptom reduction	Using multimedia decreased eating disorder symptoms
	Higher program use	Multimedia led to a higher usage of the intervention
	Increase engagement	Multimedia increased engagement with eMental health interventions
	No decrease in dropout	Multimedia did not significant decreased dropout
Feedback	No symptom reduction	Feedback did not significant decrease eating disorder symptoms
	No decrease in dropout	Interactivity did not decreased eating disorder symptoms
Guidance	Inconclusive results	Guidance was according to some studies effective and in other studies not
	More efficacious	Guidance was more efficacious compared the interventions without guidance
	No significant effect	There was no significant relation between human support and effectiveness
	Higher adherence	When human support was added the adherence increased
	No symptom reduction	Feedback did not significant decrease eating disorder symptoms
	No decrease in dropout	Interactivity did not decreased eating disorder symptoms

Appendix 5 Operationalization of the outcome measurements used per review

Review	Outcome	Operationalization outcome measurement
(31) Melbye et al., 2020.	Adherence	The percentage of participants reaching a predefined level of satisfactory completion or prompts/notifications the participants responded to (31).
(32) Milward et al., 2018.	Engagement	Number of logins, pages viewed, sessions completed, web-sessions opened, features used task achieved or time spent on intervention (32).
(33) Dogan et al., 2017	Adherence	Drop-out rates
	Effectiveness	Depressive symptoms or clinical outcomes
(34) Lehto & Oinas-Kukkonen et al, 2011	Effectiveness	Behavioural outcomes or program utilization
(35) Barakat et al., 2019	Effectiveness	Clinical outcomes: 'binge eating, purging, dietary restriction/restraint, compulsive exercise, laxative/diuretic use, global ED symptoms, weight/shape concerns or body dissatisfaction, eating concerns, weight or body mass index (BMI), comorbid stress, anxiety or depression, quality of life, and self-esteem' (35).
	Adherence	Treatment drop out
(36) Garnett et al., 2018	Effectiveness	'The mean difference in the quantity of alcohol consumed in a specified time period between intervention and control for each included trial' (36).
(37) Domhardt et al., 2018	Effectiveness	Anxiety symptom severity at post intervention and follow-up
	Adherence	Completed modules or completer rate according to Donkin et al.
(38) Wahle et al., 2017	Effectiveness	Depression symptom severity measured with the Beck Depression Inventory (BDI, BDI-1A, or BDI-II) or the Patient Health Questionnaire (PHQ, PHQ-9, or PHQ-2) (38).
(39) Baumeister et al., 2014	Effectiveness	Symptom severity
	Adherence	Completer rates and number of completed intervention modules
(40) Wozney et al., 2017	Effectiveness	Clinical outcomes: symptom reduction
	Adherence	N/A
	Engagement	N/A
(41) Radomski et al., 2019	Program use	Program use as reported in the included studies. The outcomes were converted into percentages and categorized into high use (≥75%), moderate use (50%-74%), low use (25%-49%), or very low use (≤24%).
(42) Shim et al., 2017	Effectiveness	Depression and anxiety symptoms
	Adherence	Treatment response
(43) Lui et al., 2017	Effectiveness	N/A