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Online Acceptance and Commitment Therapy (ACT) interventions for chronic pain: A systematic literature review

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ABSTRACT

Background: We systematically reviewed all literature concerning online Acceptance and Commitment Therapy (ACT) interventions for chronic pain to evaluate their (1) ACT content, (2) design characteristics, (3) design rationales, and (4) adherence.

Material and methods: A systematic search was performed on July 9th, 2020 in; PubMed, PsycINFO, CINAHL, and Web of Science. Search terms related to: Acceptance and Commitment Therapy, chronic pain, and eHealth. Extracted data concerned ACT content, design characteristics, adherence, and design rationales.

Results: 20 articles, in which 14 interventions were described, met all inclusion criteria. Adherence and design rationales were described to a limited extent in the included studies. In total, the majority provided an overview of the included ACT processes. In 10 articles it was described that the intervention was delivered via a dedicated website ($n = 10$), which was sometimes combined with an app ($n = 3$). Guidance was included in most studies ($n = 19$). Studies including RCT's ($n = 8$) reported online ACT interventions to be effective.

Conclusion: Online ACT interventions for chronic pain have been shown to be effective and have generally been constructed in line with ACT theory. However, the majority of studies does not provide information about the choices to optimize the fit between task, technology, and user. Considerations behind the choices for intervention features as well as design rationales could help to optimize future online ACT interventions. Additionally, consistent attention should be paid to measurement and operationalization of adherence, since this is a crucial link between content, design and effectiveness.

1. Introduction

Chronic pain is a prevalent, burdensome condition negatively affecting individuals' functioning, as well as socioeconomic factors (Breivik et al., 2006; Breivik et al., 2013). Unfortunately, effectiveness of biomedical treatment options for chronic pain are still not promising (Turk et al., 2011). Much like seen in many mental disorders (e.g., patients with anxiety disorders), chronic pain patients are characterized by high threat sensitivity, unbridled avoidance, and catastrophizing thinking styles (Claes, 2016; Claes et al., 2015; Harvie et al., 2017; Meulders et al., 2015; Vlaeyen et al., 2016). As such, classic psychotherapeutic interventions may aid in helping patients overcome these pain-related fears and avoidance behaviors that would otherwise lead to excessive activity disengagement. Cognitive behavioral therapies (CBT) like Acceptance and Commitment Therapy (ACT) may teach patients to adapt effectively to living with chronic pain (Hayes et al., 2006; Scott et al., 2016). Even more so than traditional CBT, ACT is highly suited to patients with chronic pain through its focus on pain acceptance as an alternative to ongoing, fruitless attempts at pain avoidance. Through this focus ACT can help chronic pain patients to form realistic expectations at pain relief, which are highly necessary given the currently modest effect sizes of existing biomedical and psychological treatment options for pain relief (Vlaeyen et al., 2016). In addition, the appropriateness of ACT has led to the development of many interventions in the last decade. Because it ran parallel to the developments in online interventions, the combination forms a very interesting case for chronic pain to look at in an independent review. ACT helps to shift focus towards performing personally valuable activities in the presence of chronic pain by increasing pain acceptance as an alternative to avoidance (i.e. psychological flexibility) (Hayes et al., 2006). In ACT,

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psychological flexibility is attained by increasing three different response styles, which are openness (i.e. acceptance and cognitive defusion), awareness (i.e. being present and self-as-context), and engagement (i.e. values and committed action) (Hayes et al., 2012). Earlier reviews described the effectiveness of ACT for chronic pain in improving anxiety, depression, pain intensity, functioning, and quality of life (Graham et al., 2016; Hughes et al., 2017; Simpson et al., 2017; Veehof et al., 2016).

Traditional *face-to-face* psychosocial therapies carry drawbacks, such as costs, accessibility, and psychological burden (e.g. reluctant towards *face-to-face* therapy due to the overwhelming nature of the diagnosis) (Børøsund et al., 2018; Knoerl et al., 2018). Additionally, there have been major developments in eHealth recent years (Børøsund et al., 2018; Gainsbury and Blaszczynski, 2011; Knoerl et al., 2018), increasingly more ACT interventions are being offered online (Buhrman et al., 2013). Thereby, patients can perform psychosocial therapy anytime, anywhere (Børøsund et al., 2018; Knoerl et al., 2018). Subsequently, more studies examining the effectiveness of online ACT interventions for chronic pain have been published. Several reviews assessed online interventions' effects. However, these reviews examined other behavioral interventions besides ACT (Bender et al., 2011; Buhrman et al., 2016; Eccleston et al., 2015; Macea et al., 2010) or assessed both offline and online ACT interventions (Graham et al., 2016; Hughes et al., 2017; Simpson et al., 2017; Veehof et al., 2016). Reviews in general included individuals with heterogeneous forms of chronic pain, some excluding headache (Eccleston et al., 2015; Graham et al., 2016; Hughes et al., 2017; Simpson et al., 2017) or malignant pain (Hughes et al., 2017; Simpson et al., 2017). This review focuses on online ACT interventions as it allows us to evaluate the content and design features of the online ACT interventions for chronic pain patients. An additional focus on the content and design characteristics of the intervention is informative when taking models such as the Technology Acceptance Model (TAM) and the Task-Technology Fit (TTF) model into account. TAM and TTF can be a good framework for optimal use of an online intervention. These models can serve as a guideline for research to maximize adherence and effectiveness, especially in the phase of usability testing. TAM shows that user acceptance is influenced by both perceived usefulness and perceived ease of use (Davis, 1989), and has become a crucial model describing users' acceptance of technology (Marangunić and Granić, 2015). However, the perception of technology varies per task, which is included in the TTF model (Lee et al., 2003). More specifically, TTF pictures the relationship between task requirement, individual abilities, and technology functionality (Goodhue and Thompson, 1995). In summary, adherence (i.e. "the extent to which individuals should experience the content to derive maximum benefit from the intervention, as defined or implied by its creators") (Kelders et al., 2012) and effectiveness of online interventions are determined by the ability to reach an optimal combination of task, technology, *and* user (Davis, 1989; Goodhue and Thompson, 1995). Especially in self-management interventions for chronic pain this can be of great importance, since such interventions are complex and require high user motivations (Laugesen, 2013). Although models such as TAM and TTF cannot be used to generate generic, measurable guidelines for eHealth intervention designs, the models show the importance of considering and substantiating the way in which user, task and technology are brought together for a specific intervention. Given the importance of optimizing TAM and TTF for online interventions for chronic pain, we will evaluate how existing online ACT interventions for chronic pain provided a rationale for, and designed, ACT content as based on the Psychological Flexibility Model (i.e. 'task' in TTF), and design characteristics (i.e. 'technology' in TTF). To our knowledge, this is the first review examining online ACT interventions for chronic pain through the lens of using TAM and TTF, which may provide new insights into the 'fit' of online ACT interventions. TAM and TTF were used here as frameworks or guidelines, rather than testable models. Summarized, the objective of this study is thus to evaluate online ACT interventions in terms of (1) design rationales, (2) ACT content, (3) design characteristics, and (4) adherence.

2. Method

This systematic review was performed using the PRISMA (Preferred Reported Items for Systematic Review and Meta-analysis) guidelines (Moher et al., 2009).

2.1. Search strategy

Databases PubMed, PsycINFO, CINAHL, and Web of Science were systematically searched on July 9, 2020. The main search terms included: Acceptance and Commitment Therapy; chronic pain; pain; Internet; online; telemedicine; telehealth; eHealth; mHealth; mobile health; Internet-based intervention; digital intervention; digital health intervention; web-based; web; mobile applications; mobile application; mobile app; mobile apps; app; apps. Medical Subject Headings (MeSH terms) were used if possible. Complete search strategies for each database are shown in Table 1. Removing duplicates was performed within Mendeley.

2.2. Inclusion and exclusion criteria

Studies were included if: (1) the publication described an online intervention that was based on ACT (i.e. ACT or acceptance-based) and designed for chronic pain (i.e. $\geq$3 months of pain), (2) the publication was an original article (e.g. no poster abstracts, editorials, reviews, letters to editor, etc.), (3) the article was published or in press in a peer-reviewed journal, and (4) the main article was written in English. Furthermore, all research designs were included, as long as it was related to the design or evaluation of an online ACT intervention. Studies were excluded if the intervention included participants under 18 years old or if the intervention concerned therapeutic sessions by telephone or video call only since these do not concern self-management activities. Publications were also excluded when chronic pain included headache (Rickardsson et al., 2020; Sullivan et al., 2018), since this is seen as a different type of pain compared to other chronic pain types and psychological therapies for headache are mainly focused at reducing pain characteristics instead of rehabilitation in the presence of persistent pain (Williams et al., 2019). This does not relate to adherence and design factors. Reference lists of excluded reviews were checked for other relevant publications.

2.3. Screening

Two authors (DG and FM) screened all titles and abstracts using Covidence. Subsequently, they screened all full texts of the remaining articles. Discrepancies were discussed and resolved in follow-up meetings. While discussing discrepancies, it was decided that therapeutic feedback by written text only did not fit, which is why this type of intervention was also excluded. Furthermore, two additional duplicates were found while screening full texts. Fig. 1 shows the flow-chart of the screening procedure.

2.4. Data extraction

One of the authors (DG) extracted all data using IBM SPSS Statistics 23 for tabulating the descriptive data out of all included articles. A top-down strategy was used in order to determine which data had to be extracted, based on TAM and TTF models (Davis, 1989; Goodhue and Thompson, 1995). Based on TAM and TTF, it is important to examine both the content of ACT and the design of the online intervention. Additionally, it has to be assessed whether the papers communicate a rationale based on a design theory that is the basis of the development of the online intervention. Information that was extracted out of the

Table 1
Search strategy.

Database	Keywords	Hits
PubMed	(((“Acceptance and Commitment Therapy”[MeSH Terms] OR “Acceptance and Commitment Therapy”[Title/Abstract])) AND ((“chronic pain”[MeSH Terms] OR “chronic pain”[Title/Abstract]) OR (“pain”[MeSH Terms] OR “pain”[Title/Abstract])) AND ((“Internet”[Mesh] OR “Internet”[Title/Abstract] OR “Online”[Title/Abstract]) OR (“Telemedicine”[MeSH Terms] OR “Telemedicine”[Title/Abstract] OR “Telehealth”[Title/Abstract] OR “eHealth”[Title/Abstract] OR “mHealth”[Title/Abstract] OR “mobile health”[Title/Abstract]) OR (“Internet-based intervention”[MeSH Terms] OR “internet-based intervention”[Title/Abstract] OR “digital intervention”[Title/Abstract] OR “digital health intervention”[Title/Abstract] OR “web-based”[Title/Abstract] OR “web”[Title/Abstract]) OR (“Mobile Applications”[MeSH Terms] OR “Mobile Applications”[Title/Abstract] OR “Mobile Application”[Title/Abstract] OR “Mobile App”[Title/Abstract] OR “Mobile Apps”[Title/Abstract] OR “App”[Title/Abstract] OR “Apps”[Title/Abstract]))))	36
PsycINFO	((DE “Acceptance and Commitment Therapy” OR TI “Acceptance and Commitment Therapy” OR AB “Acceptance and Commitment Therapy”)) AND ((DE “Chronic Pain” OR TI “Chronic Pain” OR AB “Chronic Pain”) OR (DE “Pain” OR TI “Pain” OR AB “Pain”)) AND ((DE “Internet” OR TI “Internet” OR AB “Internet” OR TI “Online” OR AB “Online”) OR (DE “Telemedicine” OR TI “Telemedicine” OR AB “Telemedicine” OR TI “Telehealth” OR AB “Telehealth” OR TI “eHealth” AB “eHealth” OR TI “mHealth” OR AB “mHealth” OR DE “Mobile Health” OR TI “Mobile Health” OR AB “Mobile Health”) OR (DE “Digital Interventions” OR TI “Digital Interventions” OR AB “Digital Interventions” OR TI “Digital Health Interventions” OR AB “Digital Health Interventions” OR TI “Internet-based interventions” OR AB “Internet-based interventions” OR TI “web-based” OR AB “web-based” OR TI “web” OR AB “web”) OR (DE “Mobile Applications” OR TI “Mobile Applications” OR AB “Mobile Applications” OR TI “Mobile Application” OR AB “Mobile Application” OR TI “Mobile App” OR AB “Mobile App” OR TI “Mobile Apps” OR AB “Mobile Apps” OR TI “App” OR AB “App” OR TI “Apps” OR AB “Apps”))	23
CINAHL	((MH “Acceptance and Commitment Therapy”) OR (TI “Acceptance and Commitment Therapy”) OR (AB “Acceptance and Commitment Therapy”)) AND ((MH “Chronic Pain”) OR (TI “Chronic Pain”) OR (AB “Chronic Pain”) OR (MH “Pain”) OR (TI “Pain”) OR (AB “Pain”)) AND ((MH “Internet”) OR (TI “Internet”) OR (AB “Internet”) OR (TI “Online”) OR (AB “Online”) OR (MH “Telehealth”) OR (TI “Telehealth”) OR (AB “Telehealth”) OR (TI “Telemedicine”) OR (AB “Telemedicine”) OR (TI “eHealth”) OR (AB “eHealth”) OR (TI “mHealth”) OR (AB “mHealth”) OR (TI “mobile health”) OR (AB “mobile health”) OR (TI “Internet-based Intervention”) OR (AB “Internet-based Intervention”) OR (TI “Digital Intervention”) OR (AB “Digital Intervention”) OR (TI “Digital Health Intervention”) OR (AB “Digital Health Intervention”) OR (TI “Web-based”) OR (AB “Web-based”) OR (TI “Web”) OR (AB “Web”) OR (MH “Mobile Applications”) OR (TI “Mobile Applications”) OR (AB “Mobile Applications”) OR (TI “Mobile Application”) OR (AB “Mobile Application”) OR (TI “Mobile App”) OR (AB “Mobile App”) OR (TI “Mobile Apps”) OR (AB “Mobile Apps”) OR (TI “App”) OR (AB “App”) OR (TI “Apps”) OR (AB “Apps”))	20
Web of Science	((TI = “Acceptance and Commitment Therapy”) OR (AB = “Acceptance and Commitment Therapy”)) AND ((TI = “Chronic Pain”) OR (AB = “Chronic Pain”) OR (TI = “Pain”) OR (AB = “Pain”)) AND ((TI = “Internet”) OR (AB = “Internet”) OR (TI = “Online”) OR (AB = “Online”) OR (TI = “Telemedicine”) OR (AB = “Telemedicine”) OR (TI = “Telehealth”) OR (AB = “Telehealth”) OR (TI = “eHealth”) OR (AB = “eHealth”) OR (TI = “mHealth”) OR (AB = “mHealth”) OR (TI = “mobile health”) OR (AB = “mobile health”) OR (TI = “Internet-based Intervention”) OR (AB = “Internet-based Intervention”) OR (TI = “Digital Intervention”) OR (AB = “Digital Intervention”) OR (TI = “Digital Health Intervention”) OR (AB = “Digital Health Intervention”) OR (TI = “Web-based”) OR (AB = “Web-based”) OR (TI = “Web”) OR (AB = “Web”) OR (TI = “Mobile Applications”) OR (AB = “Mobile Applications”) OR (TI = “Mobile Application”) OR (AB = “Mobile Application”) OR (TI = “Mobile App”) OR (AB = “Mobile App”) OR (TI = “Mobile Apps”) OR (AB = “Mobile Apps”) OR (TI = “App”) OR (AB = “App”) OR (TI = “Apps”) OR (AB = “Apps”))	35

included articles related to: (1) study characteristics (i.e. study title, authors, year of publication, origin of the sample, chronic pain type), (2) design rationales (i.e. rationale that is based on design theory), (3) ACT content (ACT overview, number of modules, duration of modules), (4) design characteristics (i.e. internet delivery type, software, multimedia type, tailoring, guidance, intervention duration, intervention features), and (5) adherence. Adherence was extracted from papers when adherence to the *intervention* was reported, and not adherence to the study. Our goal was to report on adherence as “the extent to which individuals should experience the content to derive maximum benefit from the intervention, as defined or implied by its creators” (Sieverink et al., 2017).

3. Results

3.1. Study characteristics

In total, 114 records were identified in the search (PubMed (36), PsycINFO (23), Cinahl (20), and Web of Science (35)), of which 20 were included in this review. Table 2 provides an overview of the relevant interventions and associated studies (Bell et al., 2020; Bendelin et al., 2020, 2018; Buhrman et al., 2013; Fledderus et al., 2015; Gentili et al., 2020; Hayes et al., 2014; Kioskli et al., 2020; Lin et al., 2018, 2017; Paganini et al., 2019; Probst et al., 2018; Scott et al., 2018; Simister et al., 2018; Slattery et al., 2019; Trompetter et al., 2016, 2015b, 2015a; Vilardaga et al., 2020; Yang et al., 2017). Articles were published between 2013 and 2020. Studies originated from Sweden ($n = 4$), the Netherlands ($n = 4$), Germany ($n = 4$), Canada ($n = 2$), Ireland ($n = 2$), United Kingdom ($n = 2$), Singapore ($n = 1$), and United States of America ($n = 1$). A total of eight studies focused on data of RCT's (Buhrman et al., 2013; Lin et al., 2018, 2017; Probst et al., 2018; Simister et al., 2018; Trompetter et al., 2016, 2015b, 2015a), 3 articles were protocols for (feasibility) RCT's (Bell et al., 2020; Hayes et al., 2014; Slattery et al., 2019), and two articles were development and feasibility studies (Gentili et al., 2020; Yang et al., 2017). Other studies related to development and pilot evaluation (Fledderus et al., 2015), feasibility RCT (Scott et al., 2018), health economic evaluation (Paganini et al., 2019), qualitative study (interviews) (Bendelin et al., 2020), qualitative feasibility study (Bendelin et al., 2018), design and theoretical basis (Vilardaga et al., 2020), and single-arm feasibility trial (Kioskli et al., 2020). Also in Table 2, it is shown that in total, eighteen articles studied general chronic pain (Bell et al., 2020; Bendelin et al., 2020, 2018; Buhrman et al., 2013; Fledderus et al., 2015; Gentili et al., 2020; Hayes et al., 2014; Lin et al., 2018, 2017; Paganini et al., 2019; Probst et al., 2018; Scott et al., 2018; Slattery et al., 2019; Trompetter et al., 2016, 2015b, 2015a; Vilardaga et al., 2020; Yang et al., 2017), one study focused on fibromyalgia (Simister et al., 2018), and one study assessed painful diabetic neuropathy (Kioskli et al., 2020). The twenty included articles described fourteen separate interventions, which are mentioned in Table 2.

3.2. Design rationales

Out of the twenty included papers, only three papers included a

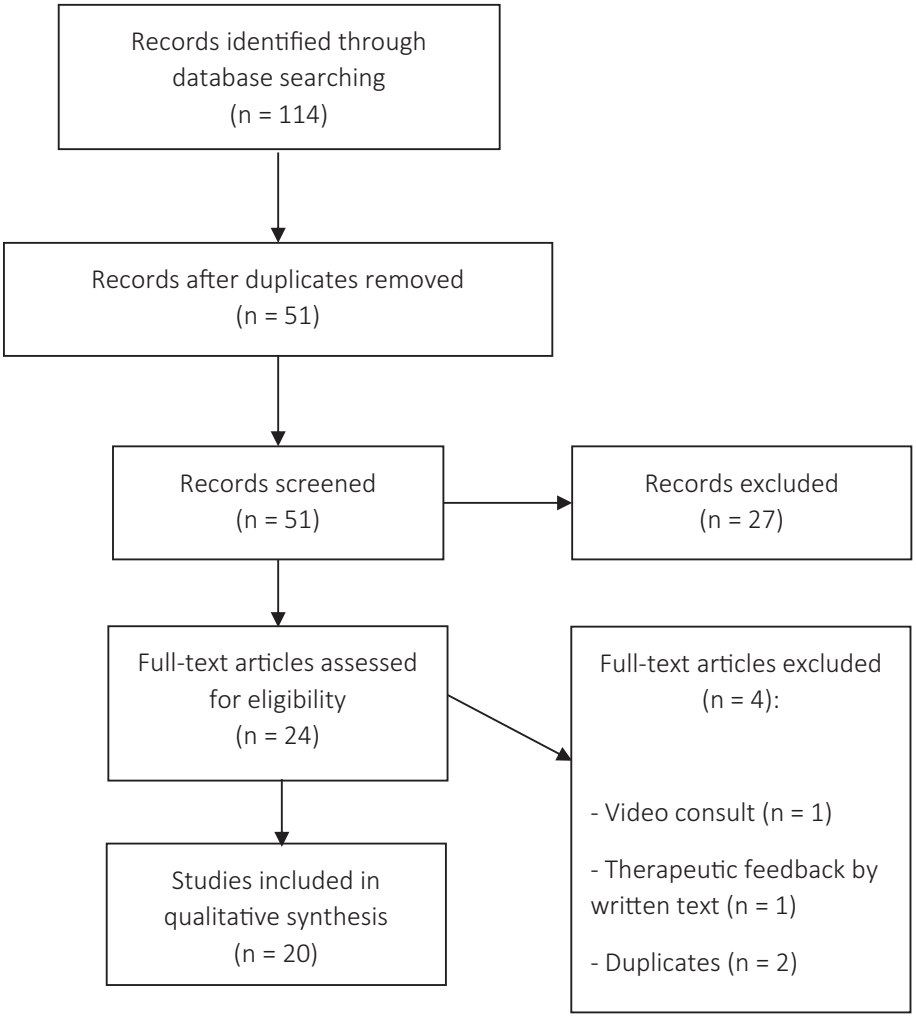

Fig. 1. PRISMA flow diagram.

description of their design rationale by means of a design theory. One paper mentioned the importance of a user-centered design, which is why their design process was based on the CeHRes roadmap (Fledderus et al., 2015). This was operationalized by conducting a focus group and several interviews regarding user needs, prototypes, and pilot evaluations. Another paper explained that the development of interventions need an approach including both the academic theory-driven and efficacy approach, as well as the industry's fast development process (Gentili et al., 2020). Therefore, the mHealth Agile Development & Evaluation Lifecycle was followed in this study, which is a framework for mHealth development, evaluation, and implementation. This involved alpha and beta testing, including both patients and expert interviews regarding user needs and experiences. Furthermore, a third study emphasized the importance of a theoretical rationale when designing an online intervention (Vilardaga et al., 2020). Therefore, a formative user-centered design was used, including user interviews and prototype testing.

3.3. ACT content

As shown in Table 2, the standard online ACT intervention is a standalone online course of 6-8 modules, based on ACT and the full underlying psychological flexibility model with its 6 therapeutic processes. Often, this is a 'fixed format' (i.e. continuing to the next one when a module is completed, or it is released in a fixed order through time) using regular mindfulness exercises and regular experimental exercises of the other ACT processes. This relates to metaphors (e.g. 'passengers on the bus') and exercises to achieve cognitive defusion (e.g. 'milk milk milk') (Bell et al., 2020; Bendelin et al., 2020; Buhrman et al., 2013; Fledderus et al., 2015; Hayes et al., 2014; Kioskli et al., 2020; Lin et al., 2018; Paganini et al., 2019; Probst et al., 2018; Scott et al., 2018; Simister et al., 2018; Slattery et al., 2019; Trompetter et al., 2016, 2015a, 2015b; Yang et al., 2017). The majority of interventions also offer psycho-education about chronic pain (Bell et al., 2020; Bendelin et al., 2020, 2018; Buhrman et al., 2013; Fledderus et al., 2015; Hayes et al., 2014; Kioskli et al., 2019; Lin et al., 2018; Paganini et al., 2019; Probst et al., 2018; Simister et al., 2018; Slattery et al., 2019; Trompetter et al., 2016, 2015a, 2015b; Yang et al., 2017), but this does not always apply. For most interventions, a detailed table was provided, including an explanation of the content of the intervention for each module (Bell et al., 2020; Bendelin et al., 2018; Hayes et al., 2014; Kioskli et al., 2020; Lin et al., 2018; Scott et al., 2018; Simister et al., 2018; Slattery et al., 2019; Trompetter et al., 2015b; Vilardaga et al., 2020; Yang et al., 2017).

On average, online ACT interventions included 7.47 modules (min = 4, max = 10). Eleven studies provided information on the duration of modules (Fledderus et al., 2015; Kioskli et al., 2020; Lin et al., 2018, 2017; Paganini et al., 2019; Probst et al., 2018; Scott et al., 2018; Trompetter et al., 2016, 2015b; Vilardaga et al., 2020; Yang et al., 2017), which varied greatly. Four studies described that each module lasted 60 min (Lin et al., 2018, 2017; Paganini et al., 2019; Probst et al., 2018). Other studies described daily use ranging from 5 to 45 min (Fledderus et al., 2015; Kioskli et al., 2020; Scott et al., 2018; Trompetter

Table 2
Online ACT intervention characteristics and related studies.

Title	Chronic pain type	Intervention delivery/ multimedia types	Duration/number of modules	Guidance/blended	ACT processes			Study: author (s) and year of publication	Study design	Adherence
					Openness	Awareness	Engagement			
ACT4PAIN	Painful diabetic neuropathy	Website/text, audio, video	12-35 min per module/5 weeks/8 modules	Guidance	✓	✓	✓	Kioskli et al. (2020)	Single-arm feasibility trial	
ACTonPain	General chronic pain	Website/text, audio, video	60 min per module/7-8 weeks/7 modules	Guidance	✓	✓	✓	Lin et al. (2017)	RCT	Adherence (based on drop-out rate): guided: 60%, and unguided: 39%. Modules completed: $M = 5.94$, $SD = 2.80$ (guided), $M = 4.74$, $SD = 2.89$ (unguided)
								Lin et al. (2018)	RCT	
								Paganini et al. (2019)	Health economic evaluation	
								Probst et al. (2018)	RCT	
ACTsmart	General chronic pain	Website, mobile application/ text, image, animation, audio, video		Guidance	✓	✓	✓	Gentili et al. (2020)	Development and feasibility study	Adherence (during pilot, based on criteria below): 90.3% Average completion of treatment content: 84%. Average of formulated values and reported behavior change: 84%
Get more out of your life	General chronic pain	Website, mobile application/ text	5-10 min per module (recommended) 8 weeks/8 modules	Guidance/blended (aftercare program)			✓	Fledderus et al. (2015)	Development and pilot evaluation	
iACT-CEL	General chronic pain	Website/text, audio, video	45 min minimum/ 5 weeks/5 modules	Guidance/(face-to-face sessions at pre and post intervention)	✓	✓	✓	Yang et al. (2017)	Development and feasibility trial	
Living with Pain	General chronic pain	Website/text Text Text	3 h per week or 30 min per day/9-12 weeks/9 modules	Guidance	✓	✓	✓	Trompetter et al. (2015a)	RCT	
								Trompetter et al. (2016)	RCT	
								Trompetter et al. (2015b)	RCT	Completion of at least 6-9 sessions: 72% completed 6-9 sessions. Of which completion of all sessions: 92%
The Pain Tracker Self Manager	General chronic pain	Website/text, image, audio, video	30-40 min/6 months/4 modules	Blended	✓	✓	✓	Vilardaga et al. (2020)	Design and theoretical basis	
Unknown	General chronic pain	Website/text, image, audio, video	7 weeks/7 modules	Guidance	✓	✓	✓	Bell et al. (2020)	Protocol for randomized controlled feasibility trial	
Unknown	General chronic pain	Website, mobile application/ text, audio	7 weeks/7 modules	Guidance	✓	✓	✓	Buhrman et al. (2013)	RCT	Completion of all sessions: 39.5%. Mean completed

(*continued on next page*)

Table 2 (*continued*)

Title	Chronic pain type	Intervention delivery/ multimedia types	Duration/number of modules	Guidance/blended	ACT processes			Study: author (s) and year of publication	Study design	Adherence
					Openness	Awareness	Engagement			
										modules: 4.2 (*SD* ¼ 2.7).
								Bendelin et al. (2018)	Qualitative feasibility study	
Unknown	General chronic pain	Text	20 weeks/8 modules	Guidance/blended (aftercare program after multidisciplinary rehabilitation)	✓	✓	✓	Bendelin et al. (2020)	Qualitative study (interviews)	
Unknown	General chronic pain	Website/text, image, animation, audio	8 weeks/8 modules	Guidance	✓	✓	✓	Hayes et al. (2014)	Protocol for RCT	
Unknown	General chronic pain	Text, video	8-12 min per module/10-12 weeks/10 modules	Guidance	✓	✓	✓	Scott et al. (2018)	Feasibility RCT	Completion of all sessions: 41.9%. Mean completed modules: 6.90 sessions (*SD* = 3.49).
Unknown	Fibromyalgia	Website/text, audio, video	8 weeks/7 modules	Guidance	✓	✓	✓	Simister et al. (2018)	RCT	
Unknown	General chronic pain	Website/text	8 weeks/8 modules	Guidance	✓	✓	✓	Slattery et al. (2019)	Protocol for RCT	

et al., 2015a, 2015b; Vilardaga et al., 2020; Yang et al., 2017). While most interventions took seven (Bell et al., 2020; Bendelin et al., 2020; Buhrman et al., 2013; Probst et al., 2018) or eight weeks (Fledderus et al., 2015; Hayes et al., 2014; Lin et al., 2018, 2017; Paganini et al., 2019; Simister et al., 2018; Slattery et al., 2019), the duration of interventions ranged from 5 weeks to 6 months in the overall sample (Bell et al., 2020; Bendelin et al., 2020, 2018; Buhrman et al., 2013; Fledderus et al., 2015; Gentili et al., 2020; Hayes et al., 2014; Kioskli et al., 2020; Lin et al., 2018, 2017; Paganini et al., 2019; Probst et al., 2018; Scott et al., 2018; Simister et al., 2018; Slattery et al., 2019; Trompetter et al., 2016, 2015b, 2015a; Yang et al., 2017). These results were also shown in Table 2.

3.4. Design characteristics

In ten studies, the online intervention was delivered via a website (Table 2) (Bendelin et al., 2020; Buhrman et al., 2013; Hayes et al., 2014; Kioskli et al., 2020; Lin et al., 2018; Simister et al., 2018; Slattery et al., 2019; Trompetter et al., 2015b; Vilardaga et al., 2020; Yang et al., 2017) and in 3 studies it was delivered via both website and mobile application (Bell et al., 2020; Fledderus et al., 2015; Gentili et al., 2020). The remaining studies did not mention anything about the way in which the intervention was delivered (Bendelin et al., 2018; Lin et al., 2017; Paganini et al., 2019; Probst et al., 2018; Scott et al., 2018; Trompetter et al., 2016, 2015a).

Six studies described that only text was used in the online intervention (Bendelin et al., 2018; Fledderus et al., 2015; Slattery et al., 2019; Trompetter et al., 2016, 2015a, 2015b). Four studies explained that the online intervention included text, audio, and video (Kioskli et al., 2020; Lin et al., 2018; Simister et al., 2018; Yang et al., 2017). In two studies text, images, audio, and video were used (Probst et al., 2018; Vilardaga et al., 2020) and in two studies both text and audio were included (Bendelin et al., 2020; Buhrman et al., 2013). The remaining studies described online interventions that included both text and video (Scott et al., 2018), text, images, animation and audio (Hayes et al., 2014) and text, images, animation, audio and video (Gentili et al., 2020).

Data regarding features of online interventions were also extracted. One study explained that it was possible to chat with a therapist within the online intervention (Gentili et al., 2020); six studies described that it was possible to receive reminders via mobile phone (Buhrman et al., 2013; Fledderus et al., 2015; Gentili et al., 2020; Lin et al., 2017; Paganini et al., 2019; Scott et al., 2018), and five studies via email (Fledderus et al., 2015; Hayes et al., 2014; Probst et al., 2018; Simister et al., 2018; Slattery et al., 2019). Four studies provided information about the possibility to keep a diary in the online intervention (Bell et al., 2020; Fledderus et al., 2015; Trompetter et al., 2016, 2015b). An interactive interface as a feature of the online intervention, like quizzes, was mentioned in two studies (Lin et al., 2018; Vilardaga et al., 2020). One study described the possibility to share tips with other users within the online intervention (Fledderus et al., 2015). Information about software, tailoring, and time spent participating, was not described in the included studies.

All studies, excluding one (Vilardaga et al., 2020), described that the online intervention did include guidance by a therapist, which is shown in Table 2. In three studies, users of the online interventions had the option to choose the way in which they wanted to have contact with the therapist, either between email and mobile phone (Fledderus et al., 2015; Slattery et al., 2019) or between face-to-face and mobile phone (Scott et al., 2018). In most studies, guidance took place via mobile phone (Bell et al., 2020; Bendelin et al., 2020; Buhrman et al., 2013; Gentili et al., 2020; Hayes et al., 2014) or email (Lin et al., 2018, 2017; Trompetter et al., 2015b, 2015a; Yang et al., 2017). Other interfaces used for guidance were chat (Gentili et al., 2020), Internet (Bendelin et al., 2020), and Skype (Kioskli et al., 2020). In 5 studies, no information was provided about the medium that was used for guidance (Bendelin et al., 2018; Paganini et al., 2019; Probst et al., 2018; Simister et al., 2018; Trompetter et al., 2016). Guidance could include weekly contact (Bell et al., 2020; Bendelin et al., 2020; Hayes et al., 2014; Kioskli et al., 2020; Lin et al., 2017; Trompetter et al., 2016, 2015b, 2015a), pre- or mid-intervention contact (Buhrman et al., 2013; Kioskli et al., 2020; Scott et al., 2018), contact in case of adherence problems only (Slattery et al., 2019), or in the first few weeks of the intervention only (Bendelin et al., 2018). Information regarding contact moments with therapist was unknown in 6 studies (Fledderus et al., 2015; Gentili et al., 2020; Lin et al., 2018; Probst et al., 2018; Simister et al., 2018;

Yang et al., 2017). Guidance appears to have the main purpose of motivating users (Bell et al., 2020; Bendelin et al., 2018; Buhrman et al., 2013; Hayes et al., 2014; Kioskli et al., 2020; Lin et al., 2018; Paganini et al., 2019; Probst et al., 2018; Simister et al., 2018; Slattery et al., 2019; Trompetter et al., 2015b, 2015a; Yang et al., 2017) and answering user questions (Bell et al., 2020; Buhrman et al., 2013; Hayes et al., 2014; Simister et al., 2018; Trompetter et al., 2015b, 2015a; Yang et al., 2017).

Also noteworthy is that there are some blended programs that include an aftercare program after a multidisciplinary treatment for chronic pain (Bendelin et al., 2018; Fledderus et al., 2015). In addition, some programs are not completely based on theory of ACT and psychological flexibility, but also on other theory (Bendelin et al., 2018; Vilardaga et al., 2020). These courses, which deviate from the above 'blueprint' (i.e. aftercare or other theoretical models), focus mainly on the engagement process of ACT, and try to achieve long-term behavioral change by adopting value-oriented behavior.

3.5. Adherence

As shown in Table 2, most studies ($n = 15$) did not include any measure of adherence to the intervention at all (Bell et al., 2020; Bendelin et al., 2020, 2018; Fledderus et al., 2015; Hayes et al., 2014; Kioskli et al., 2020; Lin et al., 2018; Paganini et al., 2019; Probst et al., 2018; Simister et al., 2018; Slattery et al., 2019; Trompetter et al., 2016, 2015a; Vilardaga et al., 2020; Yang et al., 2017). The five remaining studies operationalized adherence in various and sometimes multiple ways, which can be divided into adherence to the intervention (i.e. the percentage of people who adhered to the intended usage of the intervention) and completion of modules. Adherence was reported in four studies, and ranged from 39% to 90.3% (Buhrman et al., 2013; Gentili et al., 2020; Lin et al., 2017; Scott et al., 2018). Completion was reported in five studies (Buhrman et al., 2013; Gentili et al., 2020; Lin et al., 2017; Scott et al., 2018; Trompetter et al., 2015a). This could include a percentage of completed modules ranging from 84 to 92% (Gentili et al., 2020; Trompetter et al., 2015a) or average number of completed modules varying from 4.2 to 6.9 modules (Buhrman et al., 2013; Lin et al., 2017; Scott et al., 2018). Additionally, one study examined differences in number of modules completed between guidance and non-guidance, which showed that guided online interventions resulted in significantly more completed modules (Lin et al., 2018, 2017). In conclusion, adherence ranged from 39 to 90.3% in all studies, regardless of operationalization.

4. Discussion and conclusions

This study systematically reviewed all available literature regarding online ACT interventions for chronic pain, and evaluated ACT content, design characteristics, design rationales, and adherence. Most of the articles performed RCT's or studied development of online interventions and/or feasibility trials. A rationale behind the choices regarding the ACT content and design of the online intervention based on design theory was present in only a minority of papers. The majority of interventions were extensively described regarding ACT components using a table. Interventions were extensively described in terms of delivery, the use of multimedia types, as well as other features. Even though adherence is a crucial and problematic aspect in online interventions, it was not reported upon in the large majority of papers, In addition, online ACT interventions have been found to be effective for improving pain interference, acceptance, and fibromyalgia impact as chosen primary outcomes throughout RCTs.

As mentioned earlier, choices in online intervention development are determined by the extent to which these choices aid to optimize task-technology-user fit. There is no uniform answer to the question which choices regarding the design are most appropriate in developing online ACT interventions for chronic pain. In every new development situation, relevant context factors regarding the task (i.e., content), technology, and user must be considered. All factors should be balanced, so that use, acceptance, and adherence are positively influenced. These factors should be the basis during development and should subsequently be checked and improved during usability testing. Rather, it seems important that well-considered choices are made that are appropriate to the relevant TAM and TTF. Remarkably, only three papers used a design rationale for the intervention development (Fledderus et al., 2015; Gentili et al., 2020; Vilardaga et al., 2020). Some studies did explain consideration behind the design, such as Hayes et al. (2014). However, it is recommended to adopt an actual rationale by means of a design theory, in order to follow a fixed pattern of steps throughout the design process. Interestingly, only one study that adopted a design rationale additionally discussed considerations regarding ACT content (Vilardaga et al., 2020), since a combination like this is most desirable given the TAM and TTF. However, it can be concluded that design and feasibility studies are increasingly published, whereas previously RCT's were published directly, which shows an expansion in attention for the design process.

It is important in online interventions that the content (i.e. three response styles of ACT) is applied in line with the psychological flexibility model that underlies ACT, for example with the use of appropriate exercises and metaphors. It is most common for online ACT interventions to have 7 or 8 modules, and this number seems appropriate to allow the patient to go through all aspects of ACT. Interventions are mostly provided in a fixed-format using the underlying psychological flexibility model, including its therapeutic processes. Additionally, psychoeducation about pain is often provided. In most studies, a detailed overview of intervention content for each module was provided, which is indeed recommended since it informs readers about the content of the intervention and it facilitates replication.

The majority of online ACT interventions uses a combination of text, audio, video, animation and/or images to present information and exercises. Aspects of feedback speed, capacity of sending multiple cues simultaneously, natural language, and personal focus when developing has to be taken into account when deciding which multimedia will be used (Daft and Lengel, 1983). Next to that, in future online ACT interventions for chronic pain, guidance should be included since this positively affects outcomes in the online ACT interventions included in this review (Buhrman et al., 2013; Lin et al., 2018, 2017) as well as other online therapeutic interventions in the psychological domain (Bennett et al., 2019; Heber et al., 2017; Johansson and Andersson, 2012; Richards and Richardson, 2012; Spek et al., 2007; Spijkerman et al., 2016). Different methods can be chosen for delivering guidance (e.g. face-to-face, email, video call, mobile phone), depending on the TAM and TTF in question, which has been applied in the papers included in this review.

Adherence is a crucial aspect in online interventions (Donkin et al., 2011), and was early in the eHealth era recognized as one of the most difficult points in evaluating online interventions (Eysenbach, 2002). Since adherence affects physical and psychological outcomes (Donkin et al., 2011), it should be addressed in research examining online intervention effects. Nevertheless, this review has shown that adherence was scarcely examined in studies, since only five studies examined adherence. However, it is advisable to include adherence in studies because of its crucial link with effectiveness (Han, 2011). It should be measured in an objective and standardized manner (Kelders et al., 2012). Specifically, adherence should be measured on the basis of the intended usage of the intervention. The aim or the working mechanisms of the eHealth intervention must be leading when defining intended usage (Sieverink et al., 2017). This can be standardized, from which adherence percentages can be derived. As an example, actual usage statistics could be used to operationalize intervention adherence when comparing it with the technology's intended usage (e.g. number of logins, completion of module, completion of modules, duration of modules, total duration) (Kelders et al., 2012; Sieverink et al., 2017; Van

Den Berg et al., 2013). Subsequently, the percentage of people who adhered to the intervention can be calculated, which shows the overall adherence of the intervention.

Online ACT interventions have been shown to be effective for important primary outcomes in managing chronic pain in 8 articles describing five RCT's. This especially applies to online interventions with guidance and patients with high levels of psychological flexibility at baseline. A positive outcome is that the majority of these RCT's included pain interference as the primary outcome (5 out of 8). This is in line with a recommendation of Veehof et al. (2016), in response to a lack of inclusion of this outcome measure in previous RCT's on online ACT and mindfulness-based interventions for chronic pain.

Several potentially relevant intervention features that could be deliberated in future design of online ACT for chronic pain were not included or considered in the interventions described in the articles included in this review. First of all, an important aspect of online interventions is tailoring the technology. Tailoring is referred to as materials that: "are intended to reach one specific person, are based on characteristics that are unique to that person, are related to the outcome of interest, and have been derived from an individual assessment" (Wangberg et al., 2008, p. 276). This ties in nicely with TAM and TTF (Davis, 1989; Laugesen, 2013) and has also been shown to stimulate adherence (Kelders et al., 2012; Kerns et al., 2014). Only therapeutic guidance was often described as tailored to the user, by means of tailored feedback. Other examples of tailoring that could be considered include tailoring algorithms based on, for example, demographics by tailoring aspects such as images (e.g. show young female patients pictures of similar young female patients) and language (e.g. language level based on educational level) (Horvath and Bauermeister, 2017). Other examples relate to time investment (e.g., 2 or 4 h per week) and the extent to which the patient wants to improve his or her situation.

Another feature of online interventions which could be relevant for factors of TAM and TTF is social support (Stinson et al., 2014), which is defined as relationships that meet individuals' needs in daily life (Barker, 2003). It is based on the social learning theory (Bandura and Walters, 1977; Rotter, 1954) and serves patients' empowerment to self-manage their chronic pain and to improve their life (Polomano et al., 2007). Although this may influence effectiveness (Eccleston et al., 2009; Palermo et al., 2010), studies included in this review did not apply any aspect of social support (e.g. monitored discussion board (Stinson et al., 2014)). However, since incorporating social support features in online interventions may bring difficulties regarding privacy and appropriateness of peer feedback (Stinson et al., 2014), and it may thus deteriorate factors of TAM and TTF, it should be carefully considered whether the benefits outweigh the disadvantages.

Finally, no article elaborated on software features, while this could provide useful insights into the possibilities of online ACT interventions. A common and recommended way of delivering eHealth platforms is through the responsive design (Schmidt et al., 2020), in which a cross-platform is created that allows using the intervention on different media devices (e.g. smartphone, laptop, and tablet). This enlarges the TTF, since it is then accessible everywhere, every time, on every platform (Héroux et al., 2017; Schmidt et al., 2020).

Most online ACT interventions have been designed for chronic pain in general. However, neuropathic pain (e.g., low back pain) and nociceptive pain (e.g., chemotherapy-induced peripheral neuropathy) bring different sensations and, therefore, different daily limitations. This may result in disparate pain related thoughts, beliefs, and (dis)functional coping styles (Daniel et al., 2008; Nicholson, 2006). Neuropathic pain can be 'sharp', for which short-term distraction may be an appropriate strategy, while nociceptive pain is more likely to cause avoidance (Daniel et al., 2008). This should be addressed separately in online ACT interventions, which is why future studies should focus on specific types of chronic pain. In this way, the 'user' aspect of TAM and TTF is appropriately considered.

The main strength of this review is the inclusion of several study designs used in studies into online ACT interventions for chronic pain. In this way, aspects other than effectiveness could be described extensively to inform the future development of online ACT interventions. Unfortunately, it was not possible to use a quality assessment instrument in this review to rate all included studies, since there are no such instruments available that are appropriate to the current study. Next to that, another limitation relates to the inclusion of 20 papers describing only 14 studies. We chose to include all papers since this enabled us to address the research question and models of TAM and TTF appropriately. It may have been concluded that details were missing in some papers, while details may have been mentioned in the original papers. On the other hand, articles should be comprehensible on their own. Therefore, choices (e.g., multimedia, guidance, time investment) should always be explained in a paper, either concisely or comprehensively. Another limitation relates to including studies from a relatively large time span. Technology development and design have changed a lot from 2013 to 2020, which could have an impact on our results. Furthermore, it was only possible to describe whether the type of content was appropriate (e.g., number of lessons and ACT components), as the actual interventions were not publicly available, and we could therefore only use the information regarding the characteristics of the interventions as per how they were described in the papers.

In conclusion, online ACT interventions have been shown to be effective and are overall constructed in line with ACT theory. However, studies provide an insufficient amount of information on choices regarding TAM and TTF and why certain design choices are made. Formulating a rationale about how ACT content is structured and how the match between task, technology and user is expected to be achieved may contribute. Considering and, possibly, applying online intervention features may take online interventions to the next level, potentially increasing the effectiveness of online ACT interventions for chronic pain patients. It is recommended to uniformly examine and report adherence in studies into online ACT interventions, since this crucial aspect may contribute to achieving optimal effectiveness.

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CRediT authorship contribution statement

All authors contributed to the study conception, design, and material preparation. Data collection was performed by D.L. van de Graaf and F. Mols. Data analysis was performed by D.L. van de Graaf and H. Trompetter. The first draft was written by D.L. van de Graaf. All authors discussed the results and commented on previous versions of the manuscript. The final version was read and approved by all authors.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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