



Overcoming challenges in adherence and engagement digital interventions: The development of the ALGEApp for chronic pain management[☆]

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ABSTRACT

Despite the growing body of evidence for the effectiveness of clinic-based interventions in increasing daily functioning in individuals with chronic pain, many sufferers still remain untreated or inadequately treated. Digital psychological interventions have been proposed as a means to overcome many of the barriers to face-to-face treatment (e.g., access, mobility, transportation problems) with the aim to improve health care for persons with chronic conditions in the convenience of their own space and time (home care). The main challenge of digital interventions however, is low user engagement and adherence. Focusing on users' engagement during the design phase of a digital intervention development can increase adherence, effectiveness, and acceptability. The purpose of this paper is to illustrate how we leveraged a recently proposed four-dimensional framework with evidence-based best practices and recommendations to develop a new digital intervention for chronic pain management, called the ALGEApp. A detailed presentation of how ALGEApp was designed and developed to adopt the recommendations and how this can aid engagement within digital interventions is proposed.

1. Introduction

Chronic pain is one of the most prominent causes of disability worldwide (Vos et al., 2012) causing considerable burden to quality of life with a serious impact on physical, emotional and social functioning of sufferers (Kerns et al., 2011; Breivik et al., 2013). Despite the growing body of evidence that clinic-based interventions can be effectively used to treat pain-related interference in daily life, many individuals with chronic pain remain untreated or inadequately treated. This is partly a result of access, mobility, and transportation problems (Jerant et al., 2005); financial barriers; reluctance to seek treatment; and paucity of clinicians trained in evidence-based multidisciplinary treatments (Jamison et al., 2002; Breivik et al., 2013). In an attempt to overcome such barriers to treatment, an interest in home-based self-management support has emerged (Jerant et al., 2005). Particularly, digital interventions (used here as an umbrella term for e-health, m-health, internet based, text message, self-management interventions etc.) aiming to improve health care for persons with chronic conditions in the convenience of their own space and time (home-care) are emerging

(Bennett and Glasgow, 2009; Long and Palermo, 2009; Bender et al., 2011; Mcgeary et al., 2012).

1.1. The challenge of digital interventions: low adherence

Adherence, is a core health behavior and within the medication literature refers to the extent to which a person's behavior - for example taking medication, completing activities and/or carrying out lifestyle changes - corresponds with agreed upon recommendations for condition management (Sabate, 2003). Within digital interventions, adherence is the degree to which digital intervention users engage with the content of an intervention. Adherence is crucial since it directly relates to positive treatment outcomes (Donkin et al., 2011). On the contrary, low adherence constitutes a significant barrier that impacts' digital intervention efficacy (Leslie et al., 2005; Glasgow, 2007; Trompetter et al., 2015). Consequently, users who fail to engage with the intervention are less likely to adhere to the content and are more likely to dropout.

Accumulating evidence supports that almost twice as many individuals dropout from digital compared to traditional face-to-face

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interventions, suggesting that users possibly feel less engaged in these interventions (MacEa et al., 2010). Buhrman et al. (2016) reported considerable attrition levels in their systematic review of internet-based trials for chronic pain, ranging from 4 % to 54 %. Perhaps the most widely studied aspect related to disengagement and hence non-adherence or dropout are user-characteristics, such as poor digital literacy (Carlbring et al., 2001; Lange et al., 2003; Kenwright and Marks, 2004), longer duration of pain (Buhrman et al., 2004), less severe disease at baseline (Ström et al., 2000; Devineni and Blanchard, 2005), younger age (Ström et al., 2000; Lorig et al., 2008), higher levels of health distress and activity limitations (Lorig et al., 2006), and male gender (Batterham and Calear, 2017). Although it can be useful to identify users who might be at risk of feeling disengaged and address these characteristics, this has proven difficult, costly, requiring complex designs utilizing computer science algorithms and artificial intelligence, and there is no evidence that addressing user characteristics in this way would increase adherence (Wu et al., 2021). Also, very little is known about other factors contributing to low adherence (e.g., motivation for change, engaging and attractive content, “buying” into the intended message) and how to address them (Karekla et al., 2019). A recent review of qualitative telehealth studies in people with chronic pain suggested enablers (ability to engage at one's own time, space and place and being empowered) and barriers to engagement with telehealth to include impersonal interventions, technological difficulties and computer literacy problems, and irrelevant intervention content (Fernandes et al., 2022). Developing digital interventions focusing on improving adherence via increased user engagement and based on a research informed framework may enable augmenting effectiveness and utility.

Despite the opportunities and characteristics that modern technology can offer in terms of graphics, personalization and tailoring, enriched dynamic audiovisual interplay, gamification and more, with the potential to engage users to a treatment, few applications originating from psychological science and specifically that of chronic pain management using Acceptance and Commitment Therapy (ACT), utilize them. The couple of applications of ACT for chronic pain (e.g., Buhrman et al., 2013; Trompetter et al., 2015) tend to be heavily text based in the presentation of information and not build to consider how to engage users in the treatment.

1.2. Purpose of the present paper

A recent review examined research informed best practices in health-related digital intervention development and provided a recommendation framework guiding digital intervention developers to design programs that will improve users' treatment engagement (Karekla et al., 2019). This framework presents ten recommendations grouped into four-dimensional areas identified as important for adherence in digital interventions consisting of: 1) A-priori theoretical planning, 2) human-computer interaction factors, 3) tailoring and targeting to user groups, 4) active Assessment of usage. This framework uses persuasive technologies and gamification theories while it takes into account user characteristics found to predict dropouts in digital interventions (especially ones for chronic conditions such as chronic pain). Its aim is to drive the development of digital intervention while empowering the user to remain engaged. The purpose of this paper is to draw upon this four-dimensional evidence-based best practices and recommendations to describe and illustrate how we implemented these in designing a new digital intervention for chronic pain management, called the ALGEApp. The main objective of this app was to adapt for digital delivery the Algea Acceptance and Commitment Therapy for the management of Chronic pain protocol (Karekla et al., 2013). Specifically, it aimed to teach participants techniques to manage their pain and pain-associated stress via a digital self-paced intervention.

2. Methods

2.1. ALGEApp general description & digital interface

The development of the ALGEApp followed the aforementioned Four-Dimensional Adherence Framework (Karekla et al., 2019). Additionally, its psychotherapeutic content was adapted from the face-to-face ALGEA intervention for chronic pain management (Karekla et al., 2017; Vasiliou et al., 2021), and condensed into four 45-minute independent self-paced digital modules. Users are any individuals suffering from chronic pain who access the ALGEApp website (self-referred or referred by a provider). The therapeutic approach of Acceptance and Commitment therapy for pain management was utilized and its components of Acceptance, Contact with the Present Moment, Values Clarification, Committed Action, Self as Context and Cognitive Defusion (Hayes et al., 2012), were evenly distributed across the four modules (see Supplementary Table S1 for a description of session content).

The narratives of the intervention were adapted within a culturally congruent context. Two virtual human characters (Avatars; one male and one female presenting participants with a choice) were developed using UNITY real-time 3D development platform, to guide the user throughout the intervention, using prerecorded story-telling narratives. Audacity software, a free open-source easy-to-use multitrack audio editor and recorder application (www.audacityteam.org) was used to record and edit the Avatars' voices; while iMovie software was used to create and edit several clips. The two avatars were designed and presented themselves as a working-class person with a family (resembling an average chronic pain patient). The avatar was programmed to present limited head and mouth movements, and hand gestures, to match verbal information and consistent with a person suffering from arthritis. Familiar classic Greek movie segments and metaphors drawing upon ancient Greek mythology (e.g., Hercules stories) or familiar sceneries to the users (e.g., Santorini island sunset utilized during a mindfulness exercise) were incorporated for cultural familiarity and connection to users. Additionally, and in an attempt to make the application more interactive and interesting, we prepared a range of real-life video recorded vignettes of individuals suffering from chronic pain, role-plays between a therapist and a patient with chronic pain, animation clips in order to illustrate ACT concepts and metaphors etc. (See Supplementary materials for screenshots of audiovisual material used.) Multiple choice questions (via SurveyMonkey online survey development cloud-based software) were incorporated in different aspects of the program to engage the user with the taught content, enhance new learning and to ensure user's understanding of illustrated concepts. Overall, a dynamic interplay of images, videos and other interactive material, synchronized with the Avatar narratives were developed to make the digital experience interesting and captivating. MySQLWorkBench software was developed to track users' usage and engagement with the platform.

The idea of the development of a digital ACT-based intervention originated from oral feedback provided by participants of the ALGEA study group-based ACT intervention for chronic pain management (Karekla et al., 2017; Vasiliou et al., 2021). Also, feedback provided in that study from participants who prematurely discontinued the intervention included reports of mobility and transportation to the clinic difficulties, need for self-paced and self-guided intervention, and difficulty sitting still for the duration of the intervention. These difficulties contributing to dropout, pointed towards the need for developing a self-paced, guided digital intervention that would retain the main theorized processes of pain management. Ideas were discussed as part of the series of Algea group meetings with the multidisciplinary team of experts and researchers and resulted in the design of the ALGEApp as presented in this paper. Iterations of the ALGEApp program were pilot-tested with three potential end users (chronic pain patients) whose feedback on usability, user-friendliness, cultural adaptation, practicality, interest of and engagement with the content were incorporated into the creation of the ALGEApp prototype. These potential end users were patients

suffering from chronic musculoskeletal pain who participated in the Algea study group-based face-to-face intervention (Karekla et al., 2017). Final decisions regarding the apps' content were made in research team group meetings. A website URL (www.algeapp.com) was created and used to download on pdf the installation and usage instructions of the platform.

3. Program development

ALGEApp development based on the Four-Dimensional Adherence Framework (see Table 1).

3.1. Dimension I: a-priori theoretical planning

3.1.1. Recommendation 1: utilizing a digital theory-driven approach

A major problem with available digital interventions is that the majority lack grounding in a digital theory-driven approach (Christensen et al., 2009). Applying a theoretical design framework prior to designing the intervention may make the developed product more appealing while capitalizing on the capabilities of technology for the cultivation and maintenance of user engagement and motivation to adhere to the intervention as intended. Most digital interventions are reported to miss this theoretical grounding and even in cases where digital theory principles are included, they appear to be utilized as an afterthought (Kelders et al., 2012).

ALGEApp was developed based on the theories of Gamification (Deterding et al., 2011) and Persuasive Technology (Fogg, 2003). Basic tenets of these two theories were utilized to implement game design features (such as animations, videos and virtual rewards) and dialogue support facilitating features (e.g., frequent text reminders and suggestions) throughout the development of this intervention. Gamification integrates game design elements into therapeutic programs and many of

its features are grounded in behavior change theory and utilize operant learning principles with demonstrated behavior change effectiveness (e.g., reinforcement; Deterding et al., 2011). Gamification also includes the use of a storyline (Lieberman, 2006) which involves a compelling narrative with clear rules, challenging and achievable goals. In ALGEApp, a virtual human character (Avatar) was developed to guide the user throughout the intervention sessions using prerecorded narratives to present a story and guide the user through the various therapeutic components.

Persuasive technology theory proposes seven principles that digital programs should incorporate in order to be credible and engaging (Fogg, 2003): (1) trustworthiness (i.e., provide truthful, fair, and unbiased information); (2) expertise (i.e., provide information demonstrating knowledge, experience, and competence); (3) surface credibility (be face valid); (4) real-world feel (i.e., ability to communicate with the people behind its content); (5) authority (i.e., content originates or has been evaluated by an acknowledged authority); (6) third-party endorsements (i.e., endorsed from respected and renowned sources, such as a university); and (7) verifiability (i.e., provide information on external sources that verify the accuracy of the content such as peer-reviewed research articles). ALGEApp ensured that all seven principles were included. It presented that the program was based on the empirically supported ACT approach with references to external sites and research articles provided; presented clear information on the researchers/developers and the university hosting this program along with information of a real person to contact if needed; ensured face validity via a professional looking program and avatars' design (see Supplementary material pictures from the program and Dimension II for examples).

3.1.2. Recommendation 2: utilizing theory driven evidence-based psychological intervention content

Despite the availability of empirically-supported theoretically-driven

Table 1
ALGEApp development based on the Four-Dimensional Adherence Framework.

| Dimensions | Dimension I A-priori theoretical planning | | | Dimension II Human-Computer Interaction | | | Dimension III Tailoring and targeting to user groups | | Dimension IV Active assessment of usage | |
|-------------------------------------|---|---|--|--|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Recommendations | Use of digital theory-driven approaches | Use of theory driven evidence-based psychological intervention content | Ethical considerations | Theory-driven and empirically supported technological characteristics | Include human or a sense of human contact | Frequent content update | Take into account known user characteristics | Computer knowledge assessment & experience & provide easy tutorials and technical assistance | Instructions for use should be simple and direct | Utilize web-metrics to assess and monitor adherence of disengaged users |
| ALGEApp recommendation applications | <ul style="list-style-type: none"> Use of Gamification theory Use of Persuasive technology theory | <ul style="list-style-type: none"> Use of Acceptance & Commitment Therapy psychological theory and therapy | <ul style="list-style-type: none"> Developed in line with the International Society for Mental Health Online (47) and the European Group of Ethics (48) recommendations | <ul style="list-style-type: none"> Introduction of avatars as "co-travellers" Persuasive technology & gamification features embedded | <ul style="list-style-type: none"> Use brief telephone interview prior to program entry Provision of clear and explicit instructions Frequent interaction with the program Inbuilt easy way to contact researchers behind the ALGEApp | <ul style="list-style-type: none"> Each module released separately Bonus material | <ul style="list-style-type: none"> Included personalized and tailored content Offered choice of male or female avatar Avatar designed to resemble a middle-aged person suffering from chronic pain Use of illustrated examples (vignettes) of individuals suffering from chronic pain | <ul style="list-style-type: none"> Engaged end-users in development process Developed with versions for different operating systems Installation guide with download & app use illustrated instructions "Problem report" embedded followed by human contact to resolve issues | <ul style="list-style-type: none"> Material developed according to the Supportive Accountability model Clear, explicit and to the point instructions - provided both verbally (avatar) and in-writing (downloadables) | <ul style="list-style-type: none"> Utilization of web-metrics (use of MySQLWork Bench platform) & push notifications |

psychological interventions for management of chronic pain, there is a gap in their implementation and dissemination especially within digital interventions (Morrison, 2015). Theoretically-driven and empirically-supported psychological interventions such as Acceptance and Commitment Therapy (ACT) are examples of approaches that can be utilized as bases for digital intervention content. In the development of ALGEApp, we chose the ACT theoretical and treatment approach, given that ACT (Hayes et al., 2012) is classified as an empirically-supported treatment for general chronic pain conditions and has received great research support (APA, 2015; Hughes et al., 2017; Feliu-Soler et al., 2018; Gloster et al., 2020). It also presents with research support for chronic pain when adapted into a digital format (Lin et al., 2017, 2018; Rickardsson et al., 2020; Thompson et al., 2021). ACT purports to increase values-driven action in the presence of pain, aiming to change behavior and bring about improvements in functioning (Karekla et al., 2018). Psychological flexibility with its six interrelated components (acceptance, cognitive defusion, values clarification, contact with the present moment, self as context and committed action) is considered to be the mechanism of action in ACT (Hayes et al., 2012). Thus, ALGEApp development followed and adapted common methodologies and practices of ACT in its development (see Table S1).

3.1.3. Recommendation 3: ethical considerations

Consideration for a range of ethical and practical issues, especially those of privacy, confidentiality and emergency are of vital importance for any digital program development, given the limited face-to-face contact within them (Vayena et al., 2018; Karekla et al., 2019) and a lack of adequate regulation in these programs (Martinez-Martin and Kreitmair, 2018). Of special concern are users of such programs who may present with high harm or suicide risk potential (Bailey et al., 2020) and thus it is important for a-priori careful planning of how such risks and other ethical considerations will be minimized and dealt with in any digital program developed.

In order to address ethical considerations and ensure participant safety, ALGEApp was developed in line with the International Society for Mental Health Online (International, 2001) and the European Group of Ethics (Ethics, 2012) recommendations. All users were provided with a digital informed consent prior to entering the intervention, consisting of a detailed description of: 1) the study's purpose and process, 2) contact details of researchers, 3) potential participation benefits (e.g., convenience of time and space, low cost, anonymity, etc.), 4) potential risks that may arise from the use of the digital intervention (e.g., likelihood of technical difficulties, breach of confidentiality if the digital means are used in public areas or by others), and 5) safeguards taken to ensure confidentiality and privacy (e.g., use of encrypted platform of communication and data collection). Users were provided with transparent instructions and information (including provision of referrals for face-to-face services) and the right to withdraw from the study or have their data deleted at any point.

A mini-ADIS (Karekla and Panayiotou, 2011) assessment was incorporated into the program to screen for the following mental health problems (e.g., active suicidal ideation, psychosis, manic episodes, substance abuse) or at-risk populations (e.g., individuals who use drugs). Candidates who endorse any of these problems, are approached via telephone (brief consultation) by a clinical psychology trainee researcher following this first assessment session and assessed further for presence of psychological difficulties that would preclude the person from engaging in this self-paced digital intervention. Based on this assessment, a decision regarding inclusion to the program or further referral for assessment or treatment is made after a discussion between clinician researchers.

3.2. Dimension II: human-computer interaction

3.2.1. Recommendation 4: application of theory-driven technological characteristics

Gamification and Persuasive Technology, share a number of technological characteristics, which may facilitate engaging the user to the intervention or platform. Gamification principles of self-representation with avatars, three-dimensional environments, narrative context, feedback and levels achieved within a game, rewards and time pressure (Reeves and Read, 2009; Cobb and Poirier, 2014), as well as inclusion of a story line (Imamura et al., 2014) are proposed to be important for user engagement. The Persuasive System Design framework (PSD; Fogg, 2003) proposes 4 categories (task support, dialogue support, system credibility, and social support) of 28 technological characteristics that can guide digital intervention design so that is engaging and it promotes adherence (Oinas-Kukkonen, 2013). Kelders et al. (2012) in a meta-analysis of digital intervention program studies found evaluated programs to lack system credibility support considerations. Further, dialogue support emerged as the most important contributor to adherence, yet out of the seven dialogue support system features studies on average included only 1.5 of these features in their design. Reminders and suggestions were the features most employed whereas positive reinforcement (e.g., praise and rewards) was seldom used. This is surprising as positive reinforcement is among the most empirically supported and effective ways of achieving behavior change and establishing new behaviors (Abraham and Michie, 2008; Michie et al., 2013). This provides further support for the aforementioned claim that most digital programs are not based on basic psychology theories of change.

ALGEApp aimed to remedy this and ensure the use of both gamification and persuasive system design framework principles. Avatars were introduced as guides or "co-travelers" in the therapeutic journey within this digital intervention. Gamification aspects of narrative context along with a story line to follow the avatar were included. The seven dialogue support features of persuasive system design framework along with similar concepts from gamification were also considered and embedded into the program. Examples of how these were implemented include:

- 1) *Praise* involves rewarding an observed desired behavior by positive reinforcement. In the ALGEApp, the Avatar systematically and successively congratulates the user upon completing segments of each module or completing tasks and homework (e.g., "Congratulations, by signing up to the intervention, you have already completed a big step towards learning how to manage your pain").
- 2) *Rewards* aim to positively reinforce a person and provide a sense of achievement. In the ALGEApp, rewards were provided in the form of a bonus section with additional features such as extra information regarding pain and pain tracking sheets. Upon module completion, participants were granted access into respective "Bonus Section" modules as a reward.
- 3) *Reminders* are grounded in behavior theory and particularly aim to shape the desired behavior. Use of reminders, that is, prompting the user to behave in the targeted direction is an example of shaping. In ALGEApp, short pre-constructed reminders focusing on adherence and engagement with the intervention (target behavior) were carefully developed and forwarded to the users at specific time frames. For example, "Dear X, on behalf of the ALGEApp team we would like to remind you that Module 2 is now accessible and awaiting your visit". Given that too frequent reminders may lead to notification fatigue (Dennison et al., 2013), we chose to use primarily text messages (emails were only used if that was the preferred modality for the user) in the following fashion: i) within 24 h post completion of a module, a text was sent to congratulate participants for their time and effort and remind them to complete the homework, provide access to the bonus section and inform them that the next module will unlock after 72 h (3 days), and ii) a text when the next module unlocked.

- 4) *Suggestion* implies that an expert provides the user with a stance or a view about a specific behavior and its change. Similar to reminders, suggestions appear to be more directive and content-driven. In ALGEApp, they were grounded in data input such as a direct response to a question posed within the intervention through an activity, or an open-ended data response, such as a reaction towards an activity completed. For this purpose, the platform was designed to collect user responses from completed activities and these were monitored by a researcher. The researcher then responded via a text message in a tailored manner. For example, if a user who previously responded to a value-based activity in module 2 with the value “family is important for me” and the goal “I would like to take a walk in the park with my family more often”; a suggestion was strategically sent within 48 h upon completion of that exercise to suggest they take an action towards their valued goals with the following: “Dear X, the weather is great! Maybe it would be a good opportunity today if you took your family for a walk in the park!”
- 5) *Similarity* involves the effort to design visually familiar system components within the intervention. Within ALGEApp, a male and a female avatar were designed to visually resemble a typical chronic pain user in terms of age, gender, language spoken and health condition. The avatars were introduced as knowledgeable and experienced coaches who are themselves chronic pain sufferers of rheumatoid hand arthritis. The story was co-developed with the target patient group of sufferers with chronic pain. Their pain difficulty was visually made evident by depicting a slight deformation in the avatars’ hands (see Picture 2 in the Supplementary materials).
- 6) *Liking* refers to an aesthetically attractive system design, found to prolong web browsing (Geissler et al., 2006) and usage (Sonderegger and Sauer, 2010). To capitalize on aesthetics, the ALGEApp incorporated high quality images and backgrounds, as well as videos and audios to capture users’ interest and engage them in the intervention. Incorporating end users’ feedback in the development process aimed to ensure likeability of the designs and avatars.
- 7) *Social role* presents the medium through which all seven system credibility principles can be conveyed to the user. To implement this, ALGEApp used two virtual characters (avatars) “Odysseas” and “Aphrodite”, who were assigned the role of a “co-traveler and coach”. The two avatars introduced themselves as virtual personas with their own family, occupation and interests, who suffer from chronic pain themselves (real world feel). The two characters explain that their own journey with the University of Cyprus ACThealthy laboratory group (expertise) has provided them with helpful tools, and an opportunity to help others, like the user to obtain these tools themselves.

In order to transfer the rest of the seven system credibility principles (system credibility, trustworthiness and expertise, third party endorsements and verifiability) there was an introductory briefing prior to beginning module one. This stated that the system is based on an empirically-supported treatment, Acceptance and Commitment Therapy (system credibility, trustworthiness and expertise) with the purpose of helping the user. The only third-party endorsement was the University of Cyprus and in the case of questions users could contact the ACThealthy laboratory team through a provided email address (verifiability).

3.2.2. Recommendation 5: inclusion of human contact and user accountability

Human or a sense of human contact is a multi-layered endeavour and involves establishing therapeutic alliance, instigating a feeling of accountability on behalf of the participant, and opportunity to contact a real person if needed. Therapeutic alliance is a cornerstone for any effective therapy, found to significantly contribute and mediate treatment outcomes (Baier et al., 2020). In light of obstacles reported regarding achieving therapeutic alliance in digital interventions and barriers related to absence of direct human contact and limited

information on the digital “therapist” (Jasper et al., 2014), ALGEApp with the use of avatars, story line and information presented aimed to establish a good therapeutic alliance.

According to the model of supportive accountability (Mohr et al., 2011), accountability mediates an effective digital researcher/therapist-user interaction. Research suggests that when digital intervention users are accountable for their active participation and that what is expected of them is made clear via process oriented (step-by-step) expectations, they are more likely to adhere to the intervention and better outcomes are achieved (Mohr et al., 2011; Konow, 2016).

Concepts of human contact and user accountability were instilled in a variety of ways within ALGEApp. Prior to the intervention, researchers conducted a brief (5-minute) telephone interview with all users in order to introduce themselves and provide information regarding the program. Researchers responded to questions, set expectations regarding usage and provided information as to how they could be reached. Permission was then asked (consent form) to electronically interact with the users in order to provide feedback and reminders, which would improve their experience and enhance possible benefits from the intervention. All this information was reiterated by the avatar once the person enrolled in the digital program.

Examples of process-oriented expectations included clear and explicit instructions, regarding: i) completion of one module per week, ii) completion of the module without frequent or prolonged breaks (i.e., breaks that lasted longer than the duration of each session), iii) to avoid exiting the application halfway through a module since progress would be lost, and iv) to complete the questionnaire appearing at the start and end of each module. Interaction with the digital program was frequent (every 3 to 6 days), and users were provided with an inbuilt option of “problem report” to which they could communicate directly with the researchers, in case of technical difficulties.

3.2.3. Recommendation 6: frequent content update of digital interventions

In line with evidence suggesting that frequent updating of digital interventions improves user adherence (Kelders et al., 2012), ALGEApp content was released in four modules (and not all at once). In addition, ALGEApp was updated with a bonus section contingent upon module completion. Users were notified via text as to when the intervention was updated.

3.3. Dimension III: tailoring and targeting to user groups

3.3.1. Recommendation 7: consideration of user characteristics known to be associated with improved adherence and engagement

Examination of socio-demographic predictor variables linked to increased dropout risk in users (e.g., younger age, males, severity and duration of illness) may help researchers identify early “at risk” users for disengagement (Karekla et al., 2019). The ALGEApp development included personalized and tailored content to be engaging and relevant to both males and females. For example, participants were offered the choice of a male or a female avatar who would be their virtual coach. As aforementioned, the avatars were designed to resemble a middle-aged person suffering from chronic pain in order to appeal to both younger and older users. Also illustrated examples (vignettes) of individuals suffering from chronic pain included both male and female actors, who for example presented daily concerns of CP patients (see Picture 4 in the Supplementary materials).

3.3.2. Recommendation 8. Assessment of computer knowledge and provision of technical assistance

Users with insufficient computer knowledge often discontinue from digital interventions at an early stage (Kenwright and Marks, 2004). ALGEApp took several measures to tackle this issue. First, potential end-users were engaged in the designing process of the intervention and pilot testing occurred prior to finalizing the intervention, its design elements and components. This provided feedback regarding the user friendliness

of technical components as well as opportunity to redesign accordingly and resolve technical issues. Second, we developed a document (available upon request) with a short yet explicit description of the ALGEApp study, its methodology and requirements, which we provided via email to users. Third, we developed two different operating system versions of the application (Windows and Mac) in order to accommodate needs of both operating system users. Fourth, users were prompted to access the online step-by-step PDF manual, for the respective operating system, which explained with clear visual images and instructions how to download and install the program to their computer. Fifth, an option of “problem report” was embedded in each module in a visible position on the screen, where users could report technical issues, which were directly emailed to the ALGEApp team, who would respond within 24 h to provide a solution. Sixth, “TeamViewer” software was occasionally used with the participants’ oral consent, to resolve issues.

3.4. Dimension IV: active assessment of usage

3.4.1. Recommendation 9: provision of simple and direct instructions

Frequent explicitly informed intended usage is one of the most important contributors to digital intervention adherence (Kelders et al., 2012). For this purpose, we carefully designed all relevant information material (oral and electronic) according to the Supportive Accountability model (Mohr et al., 2011) whose purpose is to provide the user with a sense of accountability. As aforementioned we aimed for all instructions to be clear, explicit and to the point and provided where able both verbally (via the avatar scripts) and in writing (downloadable pdf). By “explicit”, we imply that the content of the instructions was developed with the purpose of transferring clear expectations such as “... complete one module per week but avoid exceeding the time frame of two weeks”. In addition, a reason was developed to justify for the users waiting at least three days to unlock the following session (“allowing for some time between sessions will give you a chance to practice what we have learned here today and then tell me how it worked”).

3.4.2. Recommendation 10: development of web-metrics to assess and monitor adherence of disengaged users

One of the main challenges of assessing adherence across varied digital interventions is the lack of uniform and subjective assessment measures across studies (Karekla et al., 2019). Additionally, weekly monitoring with reminders has been linked with reduced attrition (Christensen et al., 2009). For this purpose, reliable and unbiased assessment tools for adherence are paramount. The following web-metrics were recorded to assess ALGEApp usage: 1) number of logins, 2) number of modules completed, 3) number of exercises downloaded, 4) access to Bonus sections, and 5) total time spent on the intervention. These web-metrics were accessible through “MySQLWorkBench” computer platform, while push notifications were designed to inform researchers via email when a user: a) registered, b) begun a module, c) completed a module, or d) faced a problem.

4. Discussion

Despite digital health interventions flourishing over the past decade and the wide reach and access to technology, there is a large percentage of patients losing interest and feeling disengaged from digital interventions (Ebert et al., 2018; Karekla et al., 2019). This is partly due to a lack of digital interventions that are specifically developed to provide a theory-driven, evidence-based framework. This paper presented the development of a digital ACT-based intervention for chronic pain management with a focus on adherence and user engagement, utilizing the four-dimensional framework recommendations for digital health interventions (Karekla et al., 2019). This paper described a short rationale behind each recommendation as well as a description of how each recommendation was implemented within the ALGEApp.

Strengths of the development procedure followed for the digital ACT-

based intervention, include: 1) the adaptation of an empirically supported face-to-face intervention (ACT) to the digital medium incorporating users in the development process and taking into consideration reasons provided by participants who had dropped out of previous interventions, 2) the embodiment of culturally relevant content in the form of a wide range of dynamic audio-visual material such as animations, role-plays, mindfulness exercises and more, 3) the meticulous application of all four dimensions and 10 best recommendations with an emphasis on a-priori planning for improved user adherence, and 4) user-centered design and inclusion of patients with chronic pain as co-creators in the process of design and development. The limitation of this paper is that it does not provide any data on ALGEApps’ application, impact and effectiveness or whether it achieved all that it aimed to do via this process of development (e.g., whether the avatar presented a sense of “similarity” or human-like feel). We are presently in the process of testing the ALGEApp and hope to soon be able to present such information. First, the ALGEApp will be evaluated for its feasibility, usability, and engagement. Then we aim to launch a pilot randomized controlled trial to examine its effectiveness for the management of chronic pain, as well as evaluating its impact on engagement and adherence among users.

5. Conclusion

In conclusion, the design of the four-dimensional framework for adherence planning in digital interventions can be achieved with meticulous planning as demonstrated in this paper. Theoretical recommendations such as a-priori planning and ethical considerations, human-computer interaction facilitating factors such as reminders or frequent updates, tailoring the intervention to meet the target group characteristics as well as using web-metrics to assess for adherence can be utilized to design an adherence-focused digital intervention. A multidiscipline collaboration (psychologists-researchers, practitioners, developers, designers, coordinators, patients) is essential to implement all recommendations. Future researchers are strongly encouraged to use a holistic framework such as the one utilized here, to provide a thorough description of the development process of the digital intervention. Trials are now needed to examine whether this approach and intervention lives up to its potential and addresses the challenge of poor adherence and user engagement while effectively bringing about behavior change.

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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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