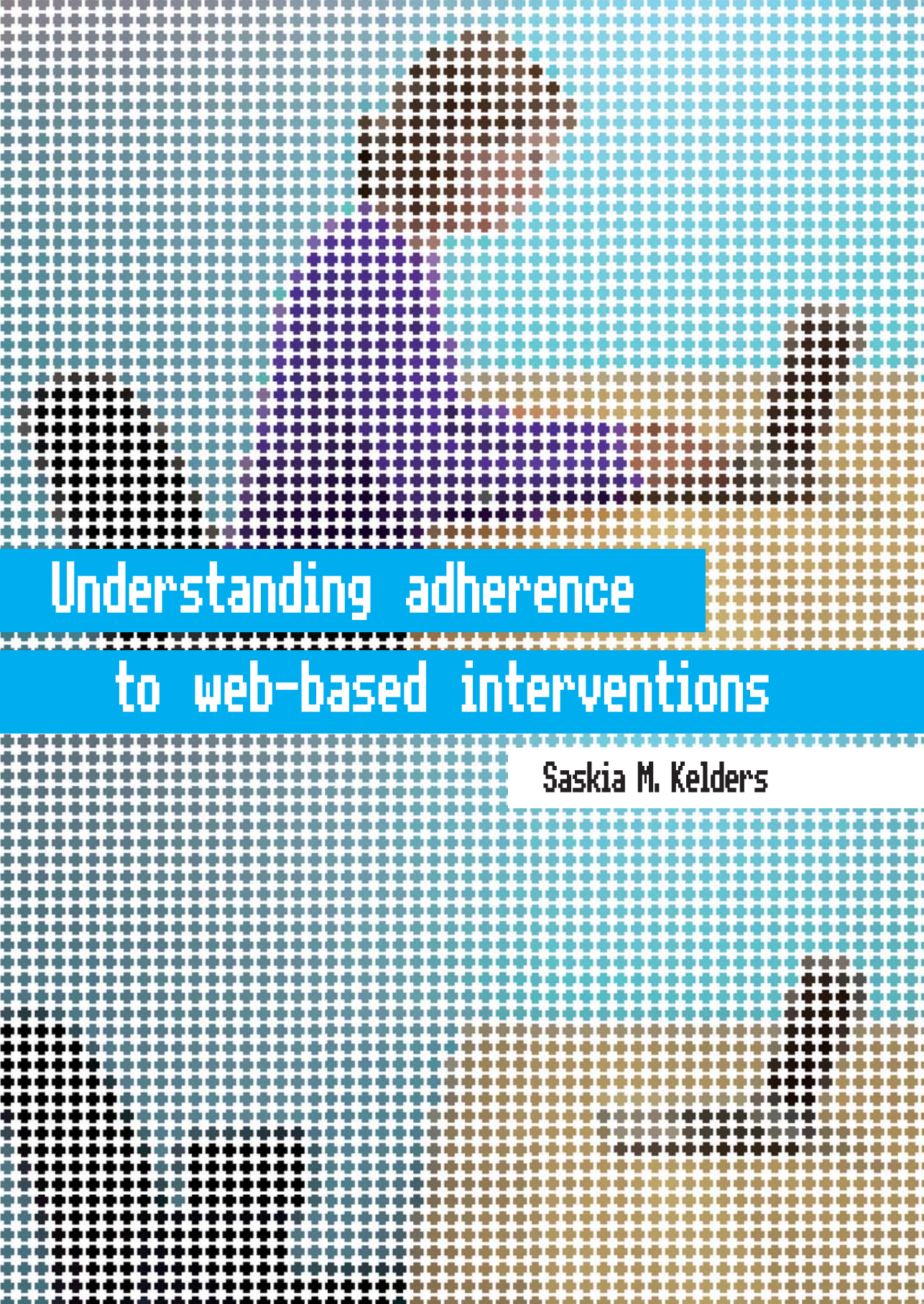

Understanding adherence to web-based interventions

Saskia M. Kelders

UNDERSTANDING ADHERENCE TO WEB-BASED INTERVENTIONS

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This thesis was funded by the Strategic Research Program of the Dutch National Institute for Public Health and the Environment (RIVM).

Kelders, S.M. Understanding adherence to web-based interventions. Enschede, the Netherlands: University of Twente; 2012

Cover design by Esther Ris, www.proefschriftomslag.nl
Printed by Gildeprint Drukkerijen, the Netherlands

Thesis, University of Twente, 2012
ISBN: 978-90-365-3417-8
DOI: 10.3990/1.9789036534178

UNDERSTANDING ADHERENCE TO WEB-BASED INTERVENTIONS

PROEFSCHRIFT

ter verkrijging van
de graad van doctor aan de Universiteit Twente,
op gezag van de rector magnificus,
prof. dr. H. Brinksma,
volgens besluit van het College van Promoties
in het openbaar te verdedigen
op vrijdag 12 oktober 2012 om 12.45 uur

door

Saskia Marion Kelders
geboren op 21 oktober 1982
te Eenrum

Dit proefschrift is goedgekeurd door de promotor prof. dr. E. T. Bohlmeijer en de assistent-promotor dr. J. E. W. C. van Gemert-Pijnen.

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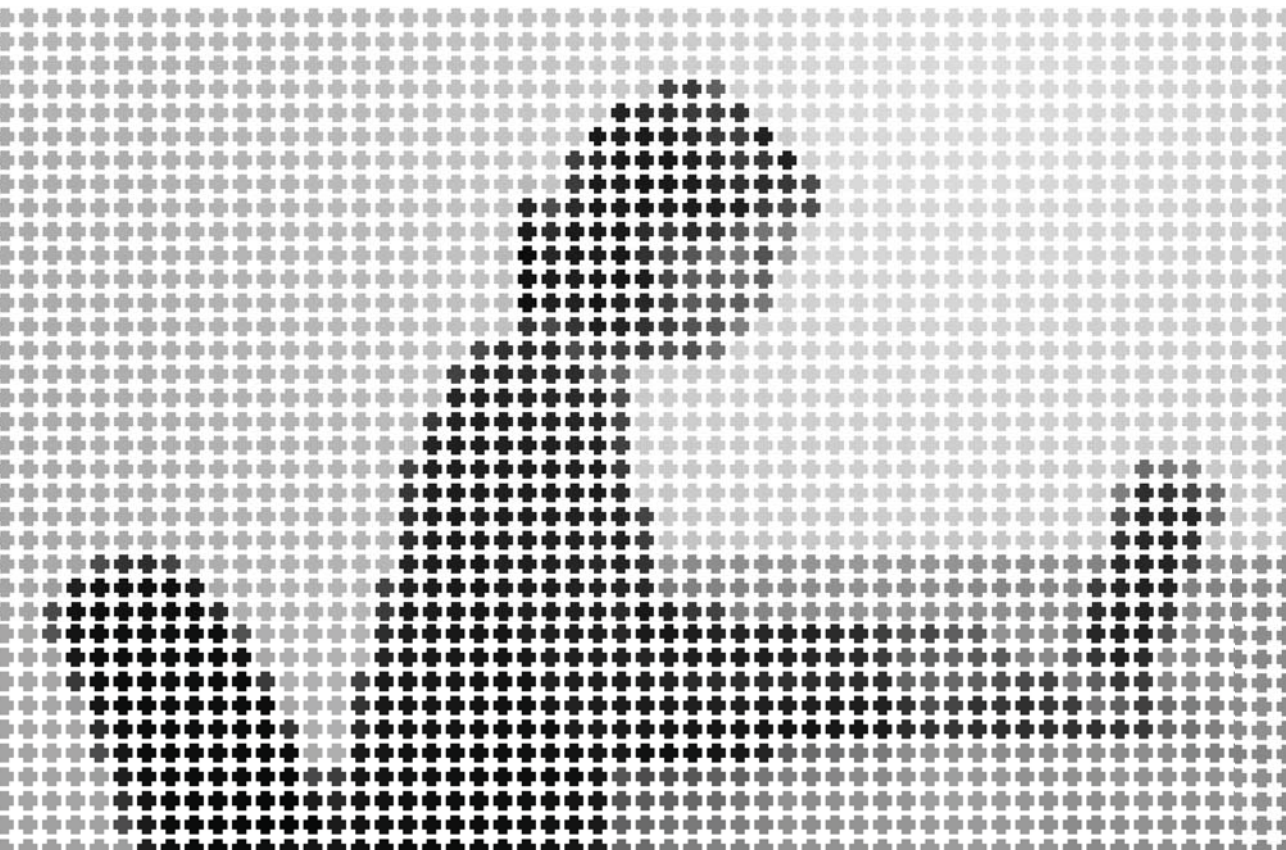

Preface

This thesis is the second thesis of the project 'gettingBetter.nl', a project on Consumer Health Informatics of the Dutch Institute for Public Health and the Environment (RIVM), funded by the strategic research program (2007-2011) of the RIVM. The project was carried out in collaboration with the IBR Institute for Social Sciences and Technology and the Center for eHealth Research and Disease Management at the University of Twente. Aims of the project were:

"to investigate two major informational issues relevant to societal and technological trends:
1) information behavior of Dutch citizens: information seeking/searching behavior, background variables, motivational variables, deployment of image and sound, consumer health vocabulary (e-) health literacy, the emerging on-demand health consumer;
2) information tools and services for citizens: support systems for a general public (idem for high risk and underserved populations; health disparities), evaluation methods, tailored health communication, search engines, integrating good examples, reaching the user (…)"

The investigation of the first aim resulted in the thesis 'iHealth – Supporting Health by Technology', which was successfully defended by dr. Hans Ossebaard in June 2012. The second line of research is the topic of this thesis. In 2007, the aim of this part of the project was specified as:

"to develop a virtual coach to support healthier behavior of populations at risk for chronic diseases. The system should be tailored to the needs of its users, to enable a "smooth flow of consumer-friendly information" and to encourage disease-management. Besides, the system should be consistent with high quality standards for electronic communication."

Specific focus points that were identified in the research plan were, for example: just-in-time preventive care; development of a virtual coach; an interactive system to support patient-system communication; and an adaptive system. The project started from a very broad point of view. Through advanced insights on the impact and uptake of eHealth technologies as seen, for example, in the work of Nijland presented in her thesis 'Grounding eHealth' and the study presented in Chapter 2 of this thesis, the focus has gradually become more specific towards the issue of non-adherence. Non-adherence (i.e. participants not following an intervention protocol) and, related, the gap in eHealth research on how to support patient-system interaction were seen in many eHealth interventions. More insight in, and ways to cope with these issues were considered a prerequisite to reach the aim of this part of the gettingBetter.nl project and therefore became the focus of this thesis.

Through the shifting and specification of the research goals, the intended target area of the research project (chronic disease) has been broadened to include lifestyle and mental

health. Nonetheless, many of the original goals are being addressed in the current thesis. For example, the web-based intervention "Living to the full", which is the case for Chapter 4-6, is a preventive intervention for people with mild to moderate depressive symptoms and is intended to provide 'just-in-time' care. Furthermore, the interactive system to support patient-system communication can be seen in the dialogue support category of the Persuasive System Design-model which has been found to be a main predictor of adherence in Chapter 3.

Chapter 1

General introduction

Introduction

For at least a decade, eHealth has been classified as 'promising' to reduce the costs of healthcare, to increase convenience and to enhance quality of healthcare. Eysenbach [1] defined eHealth in 2001 as:

"*e-health is an emerging field in the intersection of medical informatics, public health and business, referring to health services and information delivered or enhanced through the Internet and related technologies. In a broader sense, the term characterizes not only a technical development, but also a state-of-mind, a way of thinking, an attitude, and a commitment for networked, global thinking, to improve health care locally, regionally, and worldwide by using information and communication technology.*"

In this definition, it can be seen that eHealth refers not only to products or services, but also implies a process of innovation with a goal to improve health care. In his editorial, Eysenbach further elaborates on the many advantages and promises of eHealth including the aforementioned efficiency and enhancing quality, and adding empowerment and evidence based as important features [1].

However, to date, eHealth is not as ubiquitous as one would expect for such promising innovations. Of course, there are best practices of implemented eHealth technologies that have claimed a position within the regular healthcare system, as for example teledermatology [2], a virtual clinic targeted at empowering patients undergoing In Vitro Fertilisation (IVF) treatment [3], assistive technology for people with dementia [4], teleconsultation for diabetes care [5], and eMental Health interventions in The Netherlands [6, 7]. However, the overall impact of eHealth technology is small and implementation in the regular healthcare system is lacking [8, 9].

According to Nijland [8], reasons for the relatively low impact and uptake of eHealth technologies are a low level of exposure, regulatory restrictions and a disregard of the needs of patients and professionals, social-cultural habits and the complex nature of healthcare systems. In her thesis and in the following viewpoint paper by Van Gemert-Pijnen et al. [10], it has been argued that '*the development of eHealth technologies should be a process of value-creation to match the technology with needs, motivations, incentives, profiles and contexts*' [8, p. 157] to overcome these challenges. This is in line with an influential systematic review of systematic reviews by Black et al. [9], in which the authors conclude that empirical evidence for the beneficial impact of eHealth technology is modest at best. Furthermore, they underscore that there is still insufficient understanding of how and why eHealth interventions do or do not work. It seems that eHealth technology remains a 'black box': it has been assessed what goes in (e.g. baseline measures) and what comes out (e.g. post-intervention measures), but limited attention has been paid to what happens inside the box. This black box is observed in research (e.g. a lack of understanding how and why

interventions do or do not work) as well as in development (e.g. not achieving a match between technology and context).

An issue that has been recognized in the last few years is non-adherence [11, 12]; although many eHealth interventions reach a large group of participants, not all of these participants complete the intervention and may therefore not benefit as much from the intervention as they could. Open access interventions have been shown to have an adherence percentage as low as 1% [13]. This non-adherence has been proposed as a risk and as a reason for the limited impact of some eHealth technologies [11, 14, 15]. The black box issue is apparent here, because when it is unknown what happens when participants use an intervention, it is practically impossible to understand and intervene in this process of non-adherence.

Traditional research, with its focus on the content of interventions, seems to sustain the black box issue in eHealth technology. Numerous treatments, behavior change techniques and theories regarding behavior change have been extensively studied, whether or not in the context of eHealth. However, when introducing technology, not only a tool for delivery of treatment or behavior change techniques is introduced, the system itself also has its own values and implies a certain service that is given by the intervention as a whole [8, 10]. Understanding how the content, system and service of an intervention are used and experienced, may be the key to understanding why eHealth technologies suffer from large non-adherence rates.

Another sustaining factor for the black box issue lies in the development process of eHealth interventions. Many eHealth interventions are developed in an ad-hoc manner, although authors have advocated more user involvement and a more structured development process [10, 16-18]. Often, the development of the technology is engineering driven and the development of system and content is done separately instead of intertwined, which can lead to stand alone applications where there is no fit between content, system and service [19]. This ad hoc design with insufficient user, or stakeholder, involvement has been proposed to be one of the causes of interventions with a lacking match between the system and the users in their context [10] and may well contribute to non-adherence [20].

From a research point of view, the first step towards understanding and influencing non-adherence, lies in opening the black box of eHealth interventions. First, data on who the adherers and non-adherers are, is crucial to be able to view adherence in its context. Furthermore, it is important to know why and to what ends participants want to use eHealth technologies, in order to achieve a fit between the technology and the user. Additionally, the technology itself may play a role in the process of adherence, for example by being persuasive [21], so the technology itself should not be neglected either. Lastly, knowledge on how eHealth interventions are used is needed, to see whether participants use these technologies as we (designers, researchers, care providers) think and expect

them to use them. Only then it is possible to open the black box and to intervene when necessary.

To investigate these different aspects, it has been proposed that researchers should adopt more practical eHealth trials 'that use rigorous but creative designs compatible with eHealth interventions and theory' [16]. Pre-posttest research designs, with or without control group, are likely not able to answer all the questions regarding the understanding of adherence and a match between the system and users in their context. Although effectiveness studies are important, they should be complemented by, for example, qualitative methods or measures of the usage of eHealth interventions to be able to understand why and how these interventions do or do not achieve the desired effects.

To summarize, it seems that there certainly are benefits to be gained from innovating health care through the use of eHealth technologies. However, at the moment, many of these technologies lack impact because of inadequate implementation and too little understanding of how and why eHealth technologies do or do not work. Non-adherence is an issue that seems to be fostered through eHealth technologies being a black box. This black box seems to be maintained by research that is focused only on the content of interventions and development that is ad hoc and lacks stakeholder involvement. Gaining more insight in the 'black-box' of eHealth interventions is a first step towards understanding non-adherence. Possible solutions for this issue may be found in structured development and the employment of aspects from persuasive technology. In the following section, this context with the issues and possible solutions will be specified for this thesis.

Web-based interventions

eHealth technology comes in many forms. Eysenbach's definition [1] mentioned at the start of this introduction, states that eHealth refers to '*health services and information delivered or enhanced through the Internet and related technologies*' which shows the breadth of the forms which this technology can take. In 2009, Barak et al. [22] published a paper where they define '*internet-supported therapeutic interventions*', with the goal of unifying the terminology used in the field of eHealth. They define four categories: web-based interventions; online counseling and therapy; Internet operated therapeutic software; and other online activities. This thesis is focused on the first of the four categories: web-based interventions. According to Barak et al. [22] a web-based intervention is:

"*…a primarily self-guided intervention program that is executed by means of a prescriptive online program operated through a website and used by consumers seeking health- and mental health-related assistance. The intervention program itself attempts to create positive change and or improve/enhance knowledge, awareness, and understanding via the provision of sound health-related material and use of interactive web-based components.*"

A web-based intervention can involve therapy that lasts for a pre-determined, fixed period of time. However, it can also be a continuous program with no specific end-date that supports self-management among patients with a chronic condition. It is made up of different, inseparable aspects which, according to Barak et al. [22], are: program content, multimedia choices, interactive online activities, and guidance and supportive feedback. It is stressed that these categories are not mutually exclusive and are interdependent and that is, in the context of this thesis, the most important aspect of web-based interventions. Multimedia choices, for example, can be part of interactive online activities and interactive online activities can be a valuable way to provide guidance and supportive feedback. Furthermore, this division implies that interaction is only part of online activities and is separate from feedback. Moreover, the aspects seem to differ in their conceptual level: program content is an overall aspect that runs through the whole intervention; multimedia choices and interactive online activities are specific features of the system; guidance and support seem to be part of the service the system intends to provide. In this thesis, a web-based intervention is viewed as the whole of the content, system and the service it provides, following Van Gemert-Pijnen et al. [10]. Content corresponds with Barak's program content; system refers to the technology, with the features the intervention contains, the persuasiveness and user friendliness; service refers to the process of care given through the intervention. In this conceptualization, interaction is neither content, system or service, rather it is an integral part of web-based intervention. Depending on the viewpoint, it can be regarded as belonging to either category (e.g. the accuracy of a response to a question of a participant can be seen as 'content', the way the question is send and the response is read can be seen as 'system', and the timeliness of the response can be seen as belonging to the 'service').

Web-based interventions have been the object of research for some time and have been shown to be effective in different areas of health care [23-28], although not all of these interventions have shown positive effects [29, 30].

Adherence

An issue that has gained considerable attention since Eysenbach coined the 'Law of attrition' in 2005 [12], is the problem of non-adherence [11, 12, 31-33], which refers to the fact that not all participants use or keep using the intervention in the desired way. Research suggests that non-optimal exposure to the intervention lessens the effect of these interventions [14, 34]. Gaining insight into the factors that influence adherence should therefore be one of the main focus areas in any study into web-based interventions. Important, in this context, is to stress the difference between the terms 'adherence' or 'non-usage attrition' and 'drop-out'. Drop-out, or drop-out attrition, refers to participants in a study who do not fulfill the research protocol (e.g. filling out questionnaires). This is not a

focus area of this thesis. Adherence, or non-usage attrition, refers to the extent to which individuals experience the content of an intervention [11, 12]: this is the focus of this thesis.

When looking at literature about adherence to a therapeutic regimen [35, 36], adherence is seen as the extent to which the patient's behavior matches the recommendations that have been agreed upon with the prescriber. The term is often seen as a reaction to the term 'compliance', which has a more coercive connotation. Consequently, in adherence, the patient plays an active role in achieving this behavior [35]. At the same time, there is a norm or recommendation from a prescriber, which the patient tries to match. This recommendation is missing from both the definition of adherence and that of non-usage attrition [11, 12] and can be added by introducing the concept of 'intended usage'. Intended usage is the extent to which individuals *should* experience the content (of the intervention) in order to derive maximum benefit from the intervention, as defined or implied by its creators. By comparing the observed usage of an individual to the intended usage of the web-based intervention, it can be established whether or not this individual adheres to the intervention. In this context, adherence is a process which cannot be assessed solely by measuring usage at the beginning and end of the intervention; rather it has to be assessed throughout the entire process to establish whether or not an individual adheres to the intervention at each and every step of the way. Finally, by comparing the observed usage of each individual to the intended usage of the web-based intervention, the percentage of individuals that adheres to the intervention can be calculated. This results in an adherence measurement from objective data that is comparable between interventions, even if the intended usage is different.

Adherence to web-based interventions has been the subject of research for some time. Many studies focus on whether and which participants' characteristics can explain variations in adherence [11, 32, 37]. Whether intervention or technology characteristics influence adherence has gained less attention, although there have been reviews that have explored this possibility [38, 39]. These studies give insight into adherence as an outcome measure, but adherence can also be seen as a process. Adherence as a process relates to what participants actually do when interacting with a web-based intervention. It involves data on usage patterns, preferably on the level of the individual participant, because that allows studying how individuals interact with the system and whether there are differences between adherers and non-adherers. From usage data, design recommendations and 'recommended' use patterns to increase the likelihood of adhering to the intervention can be extracted. Usage and use patterns of web-based interventions have been studied [13, 40-48]. However, these studies are mainly done on the overall usage of an intervention and not on how individuals use a web-based intervention or on differences between adherers and non-adherers.

Development of web-based interventions

Web-based interventions are developed at a startling rate, but there is no scientifically underpinned agreement on how to best develop these applications [21]. Many web-based interventions seem to be designed ad hoc; there is a presumed problem for which technology is supposed to be the solution, or the technology is used as a starting point and is developed because of the technological possibility, not because of the needs of the target group. In many cases, the content of these web-based interventions has been the subject of research and consists of evidence-based therapies, but when creating a web-based intervention based on this content, the technology is seen as a given. This ad hoc design and a lack of a holistic overview, in which the human and technological context is given a prominent place, seems to be one of the main reasons that web-based interventions do not reach their full potential in terms of adherence and outcomes [13, 21, 22].

A possible solution for this issue can be found in a smarter way of developing eHealth interventions and through this smarter development create better designed eHealth interventions. The CeHRes (Center for eHealth Research and Disease Management) Roadmap for the development of eHealth technologies provides a practical guideline to achieve such a smarter development process [10]. The holistic approach is based on persuasive technology theories, human centered design approaches and business modeling. Persuasive technology refers to the capacity of technology to influence behavior and is used in eHealth research to understand the role of technology in changing behavior [21, 49]. Human centered design advocates the systematic, continuous consultation of potential users during the whole design process [50] and has been shown to have a positive effect especially on user satisfaction and on fitting to user needs [51]. Business modeling stems from commercial strategic management [52] and focusses on value creation with stakeholders. In eHealth, this approach can be used to make the development of eHealth technology value-driven, i.e. creating technology that matches the values of and makes sense to the different stakeholders [53].

Six working principles that underlie the CeHRes roadmap are that eHealth technology development: is a participatory process; involves continuous evaluation cycles; is intertwined with implementation; changes the organization of health care; should involve persuasive design techniques; and needs advanced methods to assess impact. The roadmap itself (figure 1) consists of six research and development activities. Before the actual start of the development process, a multidisciplinary project management team should be established that facilitates between the creators and the users of the system. In short, the following steps are as follows. In the contextual inquiry, information is gathered from the intended users and their environment to see whether there is a need for technology and how this technology may fit into the daily routines of the intended users. The value specification builds on the results of the contextual inquiry and here the key stakeholders determine and rank their values. These values are cooperatively translated into

requirements of the technology. In the design step, (a prototypical version of) the technology is developed, based on the requirements. The framework states that the quality of the design can be assessed at the levels of content quality (providing meaningful and persuasive information), system quality (user friendly application that matches the end-users' roles and tasks) and service quality (providing an adequate and feasible service that fits the context) [29]. The operationalization phase concerns the introduction, adoption and employment of the technology in practice and involves, for example, training and education of health care workers. The last stage is summative evaluation, in which the actual uptake and impact of the technology, regarding clinical, organizational and behavioral effects, is assessed. As a whole, the roadmap provides a comprehensive development and evaluation strategy and is intended to improve the uptake and impact of eHealth technologies.

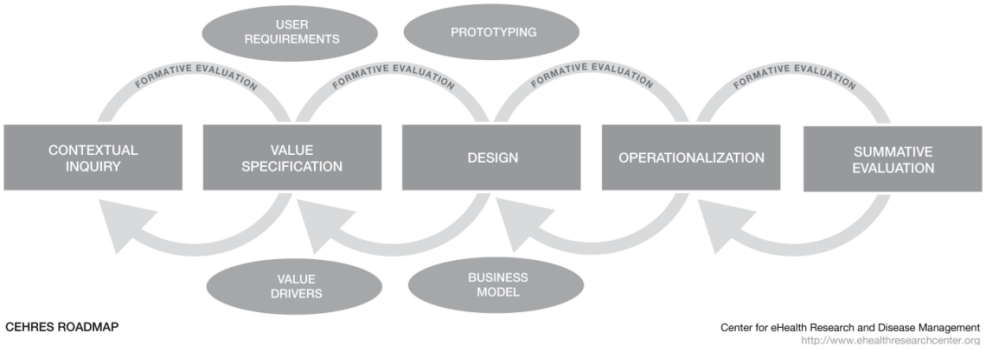

Figure 1. CeHRes Roadmap for eHealth development

Persuasive technology

From the field of persuasive technology we learn that technology has the capacity to be persuasive through its role as a tool, a medium, and a creator of experiences [21]. Fogg's definition of persuasive technology (exemplified in the title of his thesis 'Charismatic computers' [54]) limits this field to human-computer interaction and does not include computer-mediated communication (i.e. including interaction with a person). However, it seems unnecessary and undesirable to separate these two aspects of technology, particularly in the area of health care, because a web-based intervention is made up of different, inseparable aspects. Therefore, a broader application of the term 'persuasive technology' is proposed, which includes both human-computer interaction and computer-mediated communication. This is more in line with the view of Oinas-Kukkonen [55], where persuasive technology is the field of research and Behavior Change Support Systems (BCSSs) are an object of study with as research interests, among others, both human-computer interaction and computer-mediated communication. A BCSS is defined as:

'an information system designed to form, alter or reinforce attitudes, behaviors or an act of complying without using deception, coercion or inducements.'

Although the term 'information system' has a static connotation, in his paper Oinas-Kukkonen [55] stresses the importance of both human-computer interaction and computer-mediated communication, which may make a BCSS more of a 'communication system' than an 'information system'. The definition of a BCSS can be seen as complementary to the definition of web-based interventions by Barak et al.[22] in that it elaborates on the way that '*the intervention program itself attempts to create positive change and or improve/enhance knowledge, awareness, and understanding via the provision of sound health-related material and use of interactive web-based components'* by focusing on the persuasion that can emanate from technology. There are many ways that technology can persuade and can influence the behavior of its users. Following Fogg's work [21, 56], Oinas-Kukkonen and Harjumaa introduce a framework to classify technology in its persuasive functions [49]. This Persuasive System Design-model (PSD-model), classifies features of the technology in the categories: primary task support, dialogue support, social support and credibility support. This model provides a means to systematically look at how persuasive system design elements and their broader categories are used in current web-based interventions, and provide ideas on how to design web-based interventions to be more persuasive.

The elements of the PSD-model are not new but stem, for a large part, from persuasive communication (see for an overview [57]) and many elements have been studied in 'offline' as well as in web-based interventions. Tailoring, for example, has gained substantial attention and has been shown to be positively related to the effectiveness of interventions in print [58] and seems to be potentially effective for computer tailored interventions aimed at promoting a healthy diet [59]. Furthermore, review studies have shown that web-based interventions which include text messages are more effective than interventions which do not include text messages [28] and that reminders increase the effect and adherence of web-based interventions [60]. However, current knowledge focusses mainly on the separate elements; it is not known which elements work best for whom in what way and it is not known whether it is important to include elements from all categories of the PSD-model or whether multiple elements from one category are sufficient [55].

Outline of the thesis

The main focus of this thesis is adherence to web-based interventions. The five studies described in the thesis approach adherence from a different perspective to gain more insight in adherence as an outcome and as a process. As introduced, this may be achieved by opening the black box of web-based interventions by gaining insight into (1) differences

between adherers and non-adherers; (2) the goals and needs of participants related to web-based interventions; (3) the role technology plays in adherence; and (4) usage and usage patterns of participants within web-based interventions.

The first study (Chapter 2) is a randomized controlled trial on a web-based intervention aimed at healthy dietary and physical activity behavior and explores differences between users and non-users of this intervention which showed a very low adherence percentage (3%). This was done by investigating the value of a framework (including social and economic factors, condition-related factors, patient-related factors, reasons for use, and satisfaction) to predict which participants were users and which participants were non-users. This chapter focusses mainly on the 1st and 2nd aims: gaining insight in differences between adherers and non-adherers; and to what ends participants use web-based interventions.

To gain insight in the 3th aim (the role technology plays in adherence), a systematic review was conducted to explore whether intervention characteristics and persuasive design affect adherence (Chapter 3). In this study, 83 web-based interventions on lifestyle, chronic conditions and mental health were included. Of each intervention, the adherence percentage was extracted and intervention characteristics, such as intended usage, duration, frequency and mode of interaction, and employed persuasive technology elements, were coded. Consequently, the relationship between intervention characteristics, persuasive design and adherence was investigated.

Chapter 4 presents the development process of 'Living to the full', a web-based intervention for the prevention of depression. This study was done to gain insight in to what ends participants want to use web-based interventions. In this chapter, an example is given of how a structured development process can be performed, using the CeHRes Roadmap [10] as a guideline. It demonstrates practical development methods and shows that it is possible to design a web-based intervention by taking into account the expected needs of stakeholders, especially of future participants. Moreover, it has been investigated whether specific features that may influence adherence or the effect of the intervention were regarded useful to the target audience. By developing the web-based intervention in this structured and theory guided manner, pitfalls that would probably have led to decreased adherence and effect of the intervention have been avoided and thereby, the first step towards creating a successful web-based intervention for the prevention of depression has been taken.

The following study (Chapter 5) explored the adherence to the developed intervention and assessed whether it was effective. This study was set up as a fractional factorial experimental RCT, to investigate the effects of variations in the technology on adherence and clinical effectiveness, and to gain more insight in the role technology plays in adherence. This was done because standard RCT-studies are not able to untangle the active ingredients of an intervention, as they investigate whether a specific combination of

content, system and service has an effect compared to a control condition. The variations that were investigated were human versus automated support; text-messages versus no text-messages; high versus low experience through technology; high- versus low-tailored success stories; and high versus low personalization.

Where Chapter 5 assessed adherence to the web-based intervention 'Living to the full' as an outcome measure, the study presented in Chapter 6 approaches adherence as a process to gain more insight into the differences between adherers and non-adherers and into the use patterns of participants (the 1st and 4th aim of this thesis). This study presents analyses of log data of the 206 participants of the study in Chapter 5 that started the first lesson of the web-based intervention. As many web-based interventions, 'Living to the full' comprises of different features such as lessons with exercises, feedback messages and success stories. This chapter investigated whether and to what extent these features were used. Moreover, possible differences between adherers and non-adherers in the usage of these features were explored, to see whether it was possible to identify non-adherers before they actually become non-adherers. The same is done for use patterns; individual use patterns of 20 participants were investigated to gain insight into the way participants use this web-based intervention and to explore differences between adherers and non-adherers.

The last chapter of this thesis (Chapter 7) contains a general discussion of the results, methods and implications of the studies presented in this thesis. Furthermore, future research directions are explored.

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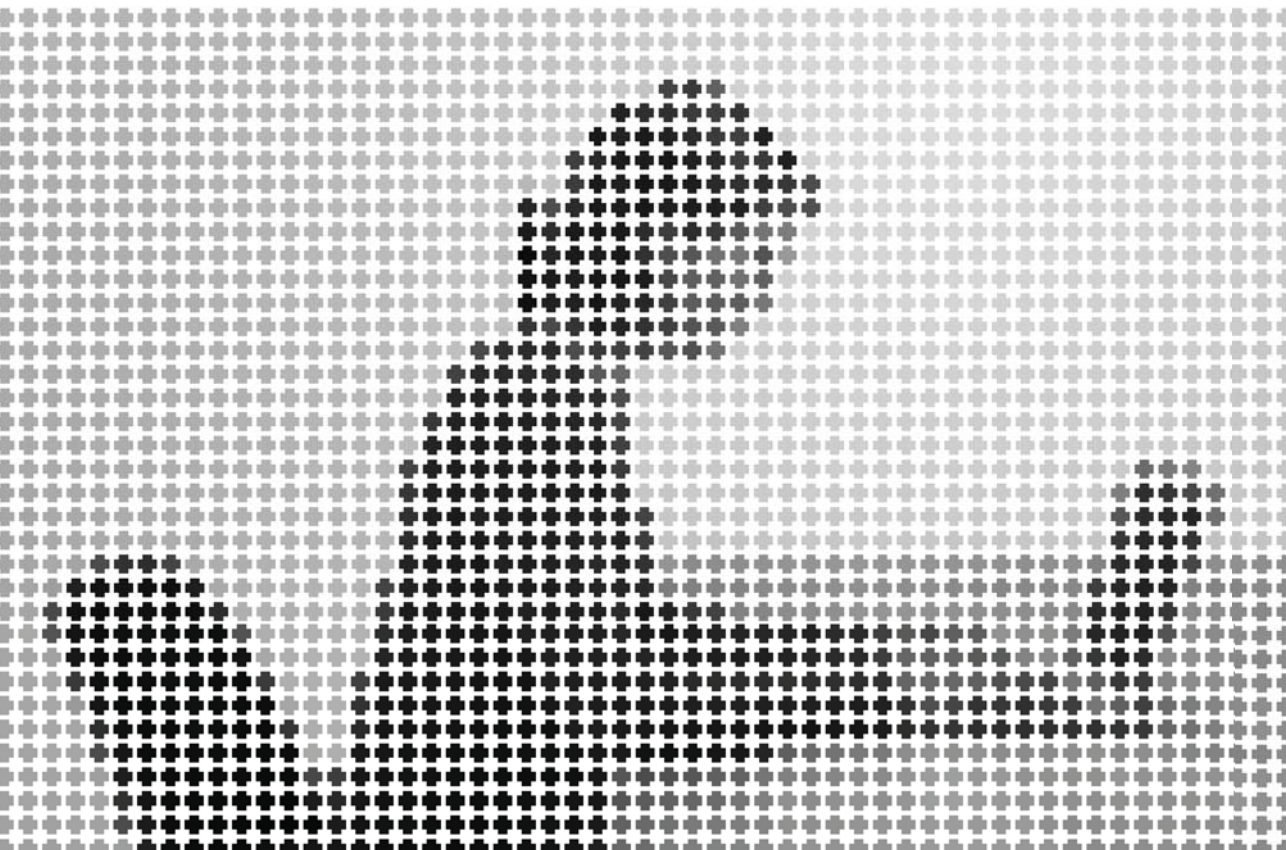
Chapter 2

Effectiveness of a web-based intervention aimed at healthy dietary and physical activity behavior: a randomized controlled trial about users and usage

Kelders SM, Van Gemert-Pijnen JEWC, Werkman A, Nijland N, Seydel ER.
Effectiveness of a Web-based Intervention Aimed at Healthy Dietary and Physical Activity Behavior: A Randomized Controlled Trial About Users and Usage.
J Med Internet Res 2011;13(2):e32



Abstract

Background: Recent studies have shown the potential of Web-based interventions for changing dietary and physical activity (PA) behavior. However, the pathways of these changes are not clear. In addition, nonusage poses a threat to these interventions. Little is known of characteristics of participants that predict usage.

Objective: In this study we investigated the users and effect of the Healthy Weight Assistant (HWA), a Web-based intervention aimed at healthy dietary and PA behavior. We investigated the value of a proposed framework (including social and economic factors, condition-related factors, patient-related factors, reasons for use, and satisfaction) to predict which participants are users and which participants are nonusers. Additionally, we investigated the effectiveness of the HWA on the primary outcomes, self-reported dietary and physical activity behavior.

Methods: Our design was a two-armed randomized controlled trial that compared the HWA with a waiting list control condition. A total of 150 participants were allocated to the waiting list group, and 147 participants were allocated to the intervention group. Online questionnaires were filled out before the intervention period started and after the intervention period of 12 weeks. After the intervention period, respondents in the waiting list group could use the intervention. Objective usage data was obtained from the application itself.

Results: In the intervention group, 64% (81/147) of respondents used the HWA at least once and were categorized as "users." Of these, 49% (40/81) used the application only once. Increased age and not having a chronic condition increased the odds of having used the HWA (age: beta = 0.04, P = .02; chronic condition: beta = 2.24, P = .003). Within the intervention group, users scored better on dietary behavior and on knowledge about healthy behavior than nonusers (self-reported diet: $\chi 2\ 2$ = 8.4, P = .02; knowledge: F1,125 = 4.194, P = .04). Furthermore, users underestimated their behavior more often than nonusers, and nonusers overestimated their behavior more often than users (insight into dietary behavior: $\chi 2\ 2$ = 8.2, P = .02). Intention-to-treat analyses showed no meaningful significant effects of the intervention. Exploratory analyses of differences between pretest and posttest scores of users, nonusers, and the control group showed that on dietary behavior only the nonusers significantly improved (effect size r = –.23, P = .03), while on physical activity behavior only the users significantly improved (effect size r = –.17, P = .03).

Conclusions: Respondents did not use the application as intended. From the proposed framework, a social and economic factor (age) and a condition-related factor (chronic condition) predicted usage. Moreover, users were healthier and more knowledgeable about healthy behavior than nonusers. We found no apparent effects of the intervention, although exploratory analyses showed that choosing to use or not to use the intervention led to different outcomes. Combined with the differences between groups at baseline, this

seems to imply that these groups are truly different and should be treated as separate entities.
Trial registration: Trial ID number: ISRCTN42687923; http://www.controlled-trials.com/ISRCTN42687923/ (Archived by WebCite at http://www.webcitation.org/5xnGmvQ9Y)

Keywords

Randomized controlled trial; usage; eHealth; intervention; attrition; Internet; adherence; retention

Introduction

The increasing prevalence of overweight is a problem in modern society. It is closely related to a number of chronic conditions such as type 2 diabetes mellitus and places a great burden on the health care system. Losing weight and especially preventing weight regain is challenging. It might be more cost-efficient to prevent people from becoming overweight by focusing on healthy dietary and physical activity (PA) behavior [1-3]. To achieve this goal, interventions aimed at the general public are needed that must not only inform people about the risks of unhealthy dietary and physical activity habits but must also stimulate people to adopt healthier behaviors related to diet and physical activity [2,4]. Previous research has shown that tailored and interactive interventions can achieve this goal [2,4-7]. The Internet provides an opportunity for these interventions to reach a broad population. Besides, by using a Web-based application, the content of the intervention can be tailored to the users, and the intensity can be varied according to the needs and wishes of these users [8-9]. Research has already shown the potential of these applications for the achievement of weight loss and weight management [6,10-14]. However, most studies are focused on applications aimed at treatment or secondary prevention. Many questions remain about the users and the effectiveness of Web-based applications for the prevention of health problems by stimulating healthy behaviors.

The problem of attrition [15] poses a threat to most eHealth interventions but might pose an even bigger threat to Web-based interventions for prevention, considering that people who do not experience an urgent health problem might be less internally motivated to change their behavior [16]. Until recently, the characteristics of the users and nonusers of Web-based applications have gained only very limited attention [17-19]. It is important to know who the users of these interventions are. This knowledge helps us identify important factors in the dissemination of these interventions and the characteristics of intended users who are not reached [20]. Moreover, recent studies indicate that people react differently to motivational and persuasive strategies, which might make the need for examining user characteristics even more essential [21]. A recent review by Christensen and colleagues [22] emphasized the need for a theoretical framework to increase our understanding of attrition. They proposed using the framework adopted by the World Health Organization (WHO) [16] (ie, five dimensions of adherence: health system factors, social and economical factors, therapy-related factors, condition-related factors, and patient-related factors) and mention the possible potential of behavior theories. Furthermore, research into the reasons for use of Web-based eHealth applications can give us valuable information on what the users hope to accomplish and how the application can assist them. In addition, usability and satisfaction with an application can play an important role in the extent to which such applications are ultimately used [15,23].

We incorporated the WHO framework and behavior theories in a study of use of the Healthy Weight Assistant (HWA), a Web-based lifestyle intervention. We considered the

influence of social and economic factors (demographics), condition-related factors (ie, general practitioner [GP] visits, having a chronic condition, and self-reported and self-rated dietary and PA behavior), patient-related factors or constructs identified by behavior change theories (ie, knowledge, attitude, and self-efficacy) [24-25], and reasons for use and satisfaction with the intervention.

Additionally in this study, we assessed the effectiveness of the intervention using self-reported dietary and PA behavior as primary outcome measures because the intervention was aimed at improving health behavior. We included secondary outcome measures that are known determinants of behavior change. We also chose to include measures of knowledge, attitude, and self-efficacy [24-25]. Self-rated behavior and insight into behavior were included as secondary outcome measures because one of the goals of the intervention was to improve insight into one's own behavior.

Consequently, our research questions were: What characteristics of participants are related to the use of the HWA intervention? What effects does the HWA intervention have on the primary and secondary outcome measures?

Method

Recruitment and design

Participants were recruited through advertisements about an online lifestyle intervention in local newspapers, supermarkets, and on health-related websites. Permission of an ethics review board for the study was not required because, according to the Dutch law, nonintrusive interventions conducted with healthy adults do not require approval from an ethics board. In total, 297 respondents expressed interest in using an online lifestyle intervention and satisfied our inclusion criteria (body mass index [BMI] 18.5 - 28.0 kg/m2, Dutch-speaking). The inclusion criterion for BMI was chosen to reflect the target group of the intervention under investigation. The sample used in this study was a self-selected convenience sample. Enrollment took place beginning November 1, 2008, and ending December 31, 2008. All participants were randomly assigned to either the Web-based lifestyle coach or a waiting list. A total of 150 participants were allocated to the waiting list group, and 147 participants were allocated to the intervention group. Participants filled out online questionnaires before the 12-week intervention period started and again after the intervention period ended. The posttest questionnaire was available for all respondents for a period of 3 weeks beginning February 27 and ending April 16. After the intervention period, respondents in the waiting list group could use the intervention. The flowchart of the study can be found in Figure 1.

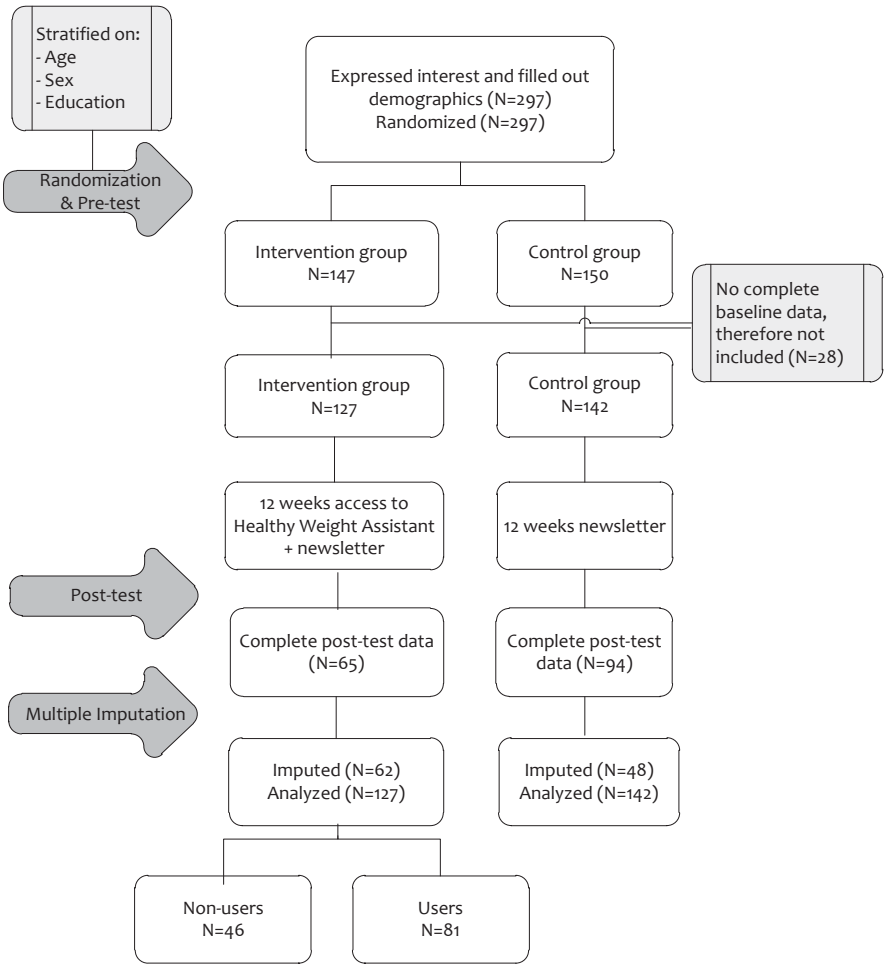


Figure 1. Flowchart of the study

Randomization

Randomization took place 1 week before the start of the intervention period. We used block randomization with blocks of 4 participants, stratified on age, sex, and education. The randomization scheme was created by a computer application and carried out by a member of the research team. Participants who filled out demographic information were randomized. Only respondents who completed the pretest questionnaire were included; therefore, 28 respondents were excluded. Participants were not blinded to randomization outcome but received an email with information on when and how they were able to access the Healthy Weight Assistant (HWA) after filling out the pretest questionnaire.

Intervention

The Healthy Weight Assistant (HWA) is a Web-based lifestyle intervention developed by the Netherlands Nutrition Centre, which is a government-funded organization focusing on increasing the knowledge of consumers about the quality of food and encouraging consumers to eat healthily and safely. The goal of the HWA is to support people with a healthy weight and people who are slightly overweight (ie, BMI 18.5-28.0 kg/m2) to maintain and achieve a healthy weight. The aim is not to achieve a given weight loss, but to support the achievement of healthy dietary and PA behavior. Therefore, the focus was broader than only energy balance-related behavior. The target group was selected by the Netherlands Nutrition Centre according to their BMI classification. The theoretical basis for behavior change via the HWA is the transtheoretical model [26], which entails that the participants are addressed according to the stage of change in which they find themselves when starting the application. The researchers were not the leading party in the design of the HWA but have done earlier research on the application. This previous study employed user-centered evaluation methods and has led to slight alterations in the design of the application in order to increase users' motivation to keep using the HWA and their motivation to change behavior [27].

The HWA consists of 4 steps, which are marked in the application by a "to-do list" and tabs in the "diary" (Figure 2). When users enter the program for the first time, they start by assessing their baseline status. In this step, users answer questions about their body weight, dietary behavior, physical activity behavior, and emotions concerning these behaviors. This results in tailored advice that can be applied in the next steps of the application. The second step is motivation. Users are asked about their motivation to change behavior, and the application assists them in making these motivations clear to themselves, thereby also focusing on clarifying their emotions related to behavior. The third step is called *difficult moments*. Users are encouraged to reflect on their difficult moments (i.e., moments at which it is tempting to engage in unhealthy behavior) and to provide solutions for these moments. The HWA coaches the user throughout this step by giving automated tailored feedback based on input of the users. The final step is goal setting and monitoring achievement of goals. Users are coached to set useful and realistic goals and can opt to receive a weekly email reminder on these goals. Additionally, users can give feedback on the achievement of their own goals and access an overview of previous goals. The news section of the HWA is regularly updated, and when users exit the application, random hints are displayed. Other content is static. The HWA is designed to be used at regular intervals. The intended use is one or multiple visits within a short period of time to complete the first 3 steps. For the last step, the intended use is once a week to once a fortnight over a longer period of time. For the research period, the HWA was only available to the participants. After this period, the application was made openly accessible through a website.

Figure 2. The Healthy Weight Assistant

Waiting list

We made use of a waiting list control group. Participants randomized in this group received an email newsletter every 3 weeks, but no access to the HWA during the intervention period. The newsletter contained general information about the study and about the University of Twente. Furthermore, it contained leisure tips, but it contained no information on healthy lifestyle. After the intervention period, participants in the waiting list group received access to the HWA. Participants in the intervention group also received the newsletter every 3 weeks.

Research instruments

Online questionnaires were used to assess pretest and posttest values. Education was self-reported and recoded into the following three categories: low (primary and lower vocational education), moderate (secondary and middle vocational education), and high (higher vocational and university education). BMI (kg/m2) was calculated using self-reported weight and length. Dietary behavior was measured using a 14-item self-report

questionnaire of the Netherlands Nutrition Centre, based on the Netherlands classification model [28]. This questionnaire has not been validated but was used because of the applicability to the standards used by the Netherlands Nutrition Centre [29]. These standards are based on a report of the Health Council of the Netherlands, which is the basis of nutritional education in the Netherlands [30]. This questionnaire classifies respondents as *unhealthy* (not complying to the standards on all aspects), *improvable* (complying with the standards on some aspects), and *healthy* (complying with the standards on all aspects). This classification entails that respondents in the healthy category have limited room for improvement because they already comply with all of the standards. We have included a translation of this questionnaire in Multimedia Appendix 1. Physical activity behavior was measured according to the Dutch Standard for Healthy Physical Activity, using a validated 4-item self-report questionnaire [31]. This questionnaire classifies respondents into two categories, *unhealthy* (not complying with the standards) and *healthy* (complying with the standards). Again, this classification entails that respondents in the healthy category have limited room for improvement because they already comply with the standards. We have included a translation of this questionnaire in Multimedia Appendix 2. Self-efficacy for diet and PA were both measured using a 3-item questionnaire with a 5-point Likert scale ranging from 1 (very high) to 5 (very low) [32]. Knowledge was assessed using a 10-item true/false questionnaire based on the Netherlands classification model [28] for diet and a 10-item true/false questionnaire for physical activity based on the Dutch Standard for Healthy Physical Activity [33]. The total scores of these questionnaires range from 1 (very poor) to 10 (excellent). Attitude was measured using a 5-item questionnaire on health consciousness attitude and a 6-item questionnaire on health-oriented beliefs; all questions used a 5-point Likert-scale ranging from 1 (very unfavorable) to 5 (very favorable). These questionnaires were based on the research of Dutta-Bergman [34] and adapted to the Dutch situation. Self-rated behavior (henceforth self-rating) was assessed by 2 items, 1 on self-rated diet and 1 on self-rated PA, both using a scale from 1 (very poor) to 10 (excellent). Insight into behavior was calculated by comparing self-reported and self-rated diet and PA based on the classification used by Ronda et al. [35]. Self-rating was recoded into categories to match the categories of self-reported behavior. Therefore, self-rated diet was recoded into three categories (1-4: unhealthy; 5-7: improvable; 8-10: healthy) and self-rated PA was recoded into two categories (1-5: unhealthy; 6-10: healthy). Respondents who did not meet the criteria for recommended healthy behavior but rated their own behavior as healthy were classified as overestimators. Respondents who did meet the criteria for healthy behavior but rated their behavior as unhealthy were classified as underestimators. The remaining respondents were considered to have had realistic insight into their behavior. Pretest and posttest questionnaires were identical except for the following additional items at posttest: the number of newsletters received and opened (waiting list group) and satisfaction with the HWA (intervention group). Satisfaction was measured using 4 items with a 5-point Likert

scale ranging from 1 (very negative) to 5 (very positive) on user friendliness, usefulness, recommending to others, and willingness to continue using the HWA [36]. In addition to the online questionnaires, the HWA stored every log-on by a participant. These log files were used to attain the usage of the HWA, that is, the number of times each respondent logged on to the HWA within the intervention period.

Electronic surveys

SurveyMonkey was used for the electronic data collection [37]. The first page of the survey consisted of an informed consent. By agreeing to participate, participants were led to the actual questionnaire. Data was protected following the security measures of SurveyMonkey [38]. Moreover, no personal identifying information apart from an email address was collected. Our survey was pretested using 5 nonparticipants comparable to the participants of the study. Feedback from the pretest was implemented in the final survey. Our format of data collection was an "open survey" [39] posted on a website. The survey was only accessible through our research website for respondents who satisfied our inclusion criteria. The initial contact mode was through online and offline advertisements for research into an online lifestyle coach. It was mandatory for participants to fill out the questionnaire to be included in the study. We offered no incentives to participate other than the use of the lifestyle coach. The pretest questionnaire was available for 8 weeks; the posttest questionnaire was available for 3 weeks. We used randomization of items for Likert-type questions with no specific order. The number of items was 42, divided over 5 screens. All questions were mandatory except comment boxes. Respondents were able to review and, if necessary, change previous answers until they had submitted the completed questionnaire. We were not able to record unique site visitors or survey visitors. The completion rate was 90% (269/297). To prevent multiple entries from the same person we used cookies that were stored when visiting the first page and were valid for 14 days. Also, we checked IP addresses. Entries from the same address with identical sex and birth date were checked for completeness. The most complete entry was saved, or, in case of equal completeness, the first entry was saved.

Participants

Previous research on the HWA using the same research instrument on self-reported dietary behavior yielded information on the mean and standard deviation of this primary outcome measure (mean 62.9, SD 8.43) [27]. To be able to measure a meaningful difference (3.5 points) we needed a detectable effect size of 0.4. When testing at the .05 level, and, using a power of 80%, we calculated that we needed a sample size of 200 (100 per group).

Analyses

Statistical analyses were performed using SPSS Statistics 17.0 (IBM Corporation, Somers, NY, USA). We used the multiple imputation (MI) feature of SPSS Statistics 17.0 to handle

missing data of posttest nonrespondents. Demographic variables and baseline outcome measures were used as predictors in the imputation model. We used an iterative Markov chain Monte Carlo method, which is the fully conditional specification. In addition, five imputed datasets were generated on which the effectiveness analyses were performed. When possible, pooled outcomes were used for the analyses; otherwise, the five estimates were combined into a single overall estimate following the MI inference rules of Rubin [40]. Differences between users and nonusers within the intervention group were assessed using Pearson's chi-square and analysis of variance testing. Furthermore, regression analysis was used to see whether characteristics predicted use of the intervention. Effectiveness of the intervention was assessed by intention-to-treat (ITT) using effect sizes and odds ratios. Additionally, exploratory analyses were performed on pretest and posttest scores of all participants combined and separately for the control group, the users, and the nonusers of the intervention using regression analyses and effect sizes. All reported *P* values are 2-tailed. We used no statistical measures to correct for multiple testing. Effect sizes for differences in means are presented as Cohen's d and effect sizes for nonparametric variables are presented as r, calculated from the *z* scores of the Wilcoxon signed rank test [41].

Results

Response rates

Of the 269 enrolled respondents (those who completed the pretest questionnaire), 159 respondents filled out the posttest questionnaire (response rate = 59%, 159/269). The response was significantly lower in the intervention group (51%, 65/127) than in the control group (66%, 94/142) ($P = .01$). There were baseline differences between responders (ie, respondents who filled out the posttest questionnaire) and research dropouts on outcome variables. As shown in Table 1, dropouts scored significantly lower on attitude and self-rating. In addition, within the intervention group, only 48% (30/62) of dropouts used the HWA as opposed to 78% (51/65) of responders ($\chi 2\ 1 = 12.424$, $P < .001$).

Descriptive analyses of baseline variables

As shown in Table 2, most of the respondents in this study were female (177/269, 66%) and in the highest education category (143/269, 53%). Mean age was 41.5 years (SD 13.5). There were no significant differences between the intervention and control group on demographic variables and reasons for use. On outcome variables, there was one significant difference at baseline, that is, respondents in the intervention group scored significantly higher on self-efficacy than respondents in the control group. Mean scores were respectively 2.2 (SD 0.6) versus 2.1 (SD 0.6) ($F1,267 = 4.109$, $P = .044$). The most frequently mentioned reason by respondents for wanting to use the application was to gain more insight into their own lifestyle.

Table 1. Baseline differences on outcome variables between responders and dropouts

Variable	Responders (n=159)	Dropouts (n=110)	*P*
BMI (kg/m2), mean (SD)	24.0 (2.5)	23.9 (2.5)	.83
Diet, n (%)			.18
Healthy	48 (30)	26 (24)	
Improvable	99 (62)	69 (63)	
Unhealthy	12 (8)	15 (14)	
Healthy PA, n (%)	64 (42)	41 (37)	.46
Knowledge, mean (SD)[a]	7.9 (1.1)	7.7 (1.2)	.19
Attitude, mean (SD)[b]	4.1 (0.4)	3.9 (0.5)	.001
Self-efficacy, mean (SD)[c]	2.1 (0.6)	2.2 (0.6)	.55
Self-rating, mean (SD)[d]	6.8 (1.1)	6.4 (1.5)	.02
Realistic insight, Diet, n (%)	92 (60)	69 (63)	.35
Realistic insight, Physical Activity (PA), n (%)	88 (58)	70 (64)	.60

[a] Scale from 1 (very poor) to 10 (excellent) [b] Scale from 1 (very unfavorable) to 5 (very favorable) [c] Scale from 1 (very high) to 5 (very low) [d] Scale from 1 (very poor) to 10 (excellent)

Table 2. Baseline demographics and reasons for use

Variable	Total (N = 269)	Intervention (n = 127)	Control (n = 142)	*P*
Age (years), mean (SD)	41.5 (13.5)	41.2 (13.5)	41.7 (13.6)	.73
Sex, n female (%)	177 (66)	85 (67)	92 (65)	.80
Education				.71
High, n (%)	143 (53)	69 (54)	74 (52)	
Moderate, n (%)	87 (32)	42 (33)	45 (32)	
Low, n (%)	39 (15)	16 (13)	23 (16)	
Chronic condition, n (%)	48 (18)	19 (15)	29 (20)	.27
Reasons for use[a]				
Insight into lifestyle, n (%)	161 (60)	80 (63)	81 (57)	.38
Living healthier, n (%)	120 (45)	61 (48)	59 (42)	.33
Fun, n (%)	112 (42)	55 (43)	57 (40)	.62
Lose weight, n (%)	107 (40)	56 (44)	51 (36)	.21

[a] Multiple answers possible so cumulative percentages do not equal 100%

Users and nonusers

Respondents in the waiting list (control) condition reported to have opened a mean of 3.4 (SD 1.2) out of 5 newsletters. From the log files of the HWA, we know that 81 of the 127 (64%) respondents in the intervention group used the HWA at least once, while 49% (40/81) of these used the application only once. The respondent that used the HWA most frequently used it 13 times during the intervention period of 12 weeks. The median number of times HWA was used was 1.0. Of the 127 respondents in the intervention group, 4 (3%) used the application at least the intended number of times within the intervention period (i.e., once a fortnight or 6 times during the 12-week period). Satisfaction with the

application was assessed within the posttest questionnaire. We used only the data provided by 50 respondents who filled out the posttest questionnaire and who had accessed the HWA at least once in the intervention period. These results are depicted in Table 3. The overall mean satisfaction score for these 50 respondents was 3.0 (SD 0.74) on the 5-point scales where 1 = very negative and 5 = very positive. A score of 3.0 lies within the neutral category.

Table 3. Satisfaction with the Healthy Weight Assistant (n = 50)

Item	Mean (SD)	Disagree, n (%)	Neutral, n (%)	Agree, n (%)
Easy to use	3.3 (0.83)	8 (16)	22 (44)	20 (40)
Useful	2.9 (0.87)	13 (26)	25 (50)	12 (24)
Recommend to others	3.0 (0.90)	12 (24)	22 (44)	16 (32)
Keep using	2.7 (0.89)	20 (40)	22 (44)	8 (16)

Baseline differences between respondents in the intervention group who used the application (users) and the respondents in this group who did not use the HWA at least once (nonusers) are depicted in Table 4.

Overall, at baseline, users were healthier (scored better on dietary behavior and had a chronic condition less often) and were more knowledgeable about healthy behavior. Furthermore, users seemed to underestimate their behavior more often than nonusers, and nonusers seemed to overestimate their behavior more often than users. To assess whether variables of the framework proposed in the introduction could be used to predict if respondents were going to use the HWA, we performed an exploratory logistic regression using the factors from the framework (social and economic, condition-related, patient-related or constructs from behavior change theories, and reasons for use). Results of this logistic regression (Table 5) showed that one variable within the social and economic factor (i.e., age) and one variable within the condition-related factor (i.e., chronic health condition) significantly contributed to the model. The model showed that increased age and not having a chronic condition increased the odds of having used the application (Cox & Snell $R2 = .24$, Nagelkerke $R2 = .32$, Model $\chi2\ 18 = 34.15$, $P = .01$).

Furthermore, we performed a linear regression to investigate whether satisfaction with the intervention HWA predicted the number of logins (Table 6). The model showed that satisfaction did not predict frequency of use ($R2 = .05$, adjusted $R2 = .04$).

Table 4. Baseline differences between users and nonusers in the intervention group

Variable	Users (n=81)	Nonusers (n=46)	F or χ^2	*P*
Age (years), mean (SD)	42.6 (13.2)	38.8 (13.8)	$F_{1,125}$= 2.307	.13
Sex, n female (%)	58 (72)	27 (59)	χ^2_1 = 2.2	.17
Education			χ^2_2 = 0.7	.70
High, n (%)	46 (57)	23 (50)		
Moderate, n (%)	26 (32)	16 (35)		
Low, n (%)	9 (11)	7 (15)		
Chronic condition, n (%)	8 (10)	11 (24)	χ^2_1 = 4.5	.04
BMI (kg/m2), mean (SD)	24.2 (2.5)	23.7 (2.3)	$F_{1,125}$= 0.900	.35
Diet, N (%)			χ^2 = 8.4	.015
Healthy, n (%)	28 (35)	6 (13)		
Improvable, n (%)	46 (57)	31 (67)		
Unhealthy, n (%)	7 (9)	9 (20)		
Healthy PA level, n (%)	28 (37)	19 (41)	χ^2_1 = 0.2	.70
Knowledge, mean (SD)	7.9 (1.1)	7.4 (1.4)	$F_{1,125}$ = 4.194	.04
Attitude, mean (SD)	4.0 (0.4)	3.9 (0.5)	$F_{1,125}$ = 2.665	.11
Self-efficacy, mean (SD)	2.3 (0.6)	2.2 (0.6)	$F_{1,125}$ = 0.274	.60
Self-rating, mean (SD)	6.6 (1.4)	6.5 (1.5)	$F_{1,125}$= 0.037	.85
Insight, Diet			χ^2_2 = 8.2	.02
Underestimation, n (%)	17 (21)	2 (4)		
Realistic insight, n (%)	52 (64)	31 (67)		
Insight, PA			χ^2_2 = 2.1	.36
Underestimation, n (%)	1 (1)	1 (2)		
Realistic insight, n (%)	47 (58)	32 (70)		

Table 5. Logistic regression model to predict usage of the HWA

Included		Coefficient B (Standard Error [SE])	*P*	Odds Ratio (OR) (95% Confidence Interval [CI])
Constant		-12.63 (4.013)	.002	
Factor	*Variable*			
Social and	Age	0.04 (0.018)	.02	1.04 (1.00 - 1.08)
economic	Internet use	0.18 (0.131)	.17	1.20 (0.93 - 1.55)
	Sex	0.50 (0.504)	.32	1.65 (0.62 - 4.44)
	Education	0.13 (0.353)	.71	1.14 (0.57 - 2.28)
Condition-	Self-rating	−0.35 (0.379)	.36	0.71 (0.34 - 1.49)
related	GP visits	1.19 (0.647)	.07	3.30 (0.93 - 11.72)
	Chronic condition	2.24 (0.749)	.003	9.40 (2.17 - 40.82)
	Diet	0.71 (0.688)	.31	2.03 (0.53 - 7.80)
	PA	0.80 (0.948)	.40	2.22 (0.35 - 14.26)
	Insight, diet	0.56 (0.667)	.40	1.76 (0.48 - 6.48)
Patient-	Insight, PA	−1.00 (0.818)	.22	0.37 (0.07 - 1.83)
related	Knowledge	0.03 (0.213)	.91	1.03 (0.68 - 1.56)
	Attitude	0.57 (0.681)	.41	1.76 (0.46 - 6.69)
	Self-efficacy	0.26 (0.458)	.57	1.30 (0.53 - 3.18)
Reasons for	Insight into lifestyle	0.47 (0.531)	.37	1.60 (0.57 - 4.55)
use	Live healthier	−0.03 (0.281)	.93	0.98 (0.56 - 1.69)
	Fun	0.13 (0.165)	.44	1.14 (0.82 - 1.57)
	Lose weight	0.16 (0.122)	.18	1.18 (0.93 - 1.50)

Table 6. Linear regression on satisfaction predicting number of log-ins to the HWA

	B (SE)	Beta
Constant	−2.61 (1.17)	
Satisfaction	0.70 (0.38)	0.23[a]

[a] *P* = .07

Effectiveness

In addition, ITT analyses were performed on all outcome variables (Table 6). We found a significant but very small effect on attitude (d = 0.08) favoring the intervention group. None of the other variables showed a significant effect of the intervention. Complementary to the ITT analyses, we performed analyses comparing the differences of the control group with the differences of the users (results not shown). These analyses did not yield any significant effects and were comparable to the results of the ITT analyses, although the effect sizes were generally larger.

Table 7. Intention-to-treat (ITT) analyses

Variable	Intervention (n=127)		Control (n=142)		Effect Size[a] (ES) or OR (95% CI)
	Pretest	*Posttest*	*Pretest*	*Posttest*	
BMI, mean (SD)	24.0 (2.4)	24.1 (2.5)	23.9 (2.5)	24.0 (2.5)	ES: 0.07 (-0.10 – 0.24)
Diet, n (%)					OR: 0.84
Healthy	34 (27)	45 (35)	40 (28)	46 (32)	(0.44 – 1.58)
Improvable	77 (61)	73 (58)	91 (64)	89 (63)	
Unhealthy	16 (13)	9 (7)	11 (8)	7 (5)	
Healthy PA, n (%)	49 (38.6)	58 (46)	58 (41)	69 (49)	OR: 1.10 (0.60 – 2.01)
Knowledge, mean (SD)	7.7 (1.2)	7.7 (1.3)	7.9 (1.1)	7.7 (1.3)	ES: 0.15 (–0.13 to 0.42)
Attitude, mean (SD)	4.00 (0.45)	4.03 (0.45)	4.01 (0.44)	4.02 (0.45)	ES: 0.08 (0.00 – 0.16)
Self-efficacy, mean (SD)	2.2 (0.61)	2.3 (0.70)	2.1 (0.59)	2.2 (0.64)	ES: 0.04 (–0.01 to 0.17)
Self-rating, mean (SD)	6.5 (1.4)	6.9 (1.2)	6.8 (1.2)	6.9 (1.2)	ES: 0.18 (–0.04 to 0.40)
Realistic insight, diet, n (%)	83 (65)	71 (56)	83 (59)	87 (61)	OR: 0.74 (0.35 – 1.56)
Realistic insight, PA, n (%)	79 (62)	83 (65)	84 (59)	88 (62)	OR: 0.78 (0.35 – 1.74)

[a] Effect size for ratio variables presented as Cohen's d, that is, the number of standard deviations the intervention group (I) improved more than the control group (C) (mean improvement I – mean improvement C)/pooled SD of improvement. Effect size for ordinal variables is presented as the odds ratio.

For the group as whole (independent of randomized condition), there were significant differences between pretest and posttest scores. With respect to diet (effect size r = –0.12), physical activity (effect size r = –0.09), and self-rating (effect size d = 0.21) the study seemed to have had a positive influence, although the effect was small (data not shown). These differences could not be attributed to the intervention according to the ITT analyses. As mentioned in the previous paragraph, our results showed differences between users and nonusers at baseline. Therefore, we performed exploratory analyses on these groups to investigate whether choosing to use or not to use the application led to different outcomes. Tables 8 and 9 show that we found significant differences in some groups but not in others. Contrary to what we expected, only the nonusers showed a significant improvement on diet (r = –0.23). Examining the data more closely revealed that the control group and, to a larger extent, the users also showed improvement, although this difference was not significant. The data showed that only the users significantly improved with respect to PA behavior (effect size r = –0.17). The control group showed a nonsignificant improvement,

while PA behavior of the nonusers deteriorated, but the change was nonsignificant. With respect to attitude, the nonusers showed a significant improvement with a medium effect size (d = 0.28), although the absolute difference was small. With respect to self-efficacy, the control group and the nonusers showed deterioration (effect sizes respectively d = 0.14 and d = 0.33), again with small absolute differences. Lastly, the data showed that users' self-rated behavior was more favorable at posttest than at pretest. The size of this effect was small to medium (d = 0.27).

Table 8. Pretest and posttest values on outcome variables for control group, nonusers, and users

Variable	**Control (n=142)**		**Nonusers (n=46)**		**Users (n=81)**	
	Pretest	*Posttest*	*Pretest*	*Posttest*	*Pretest*	*Posttest*
BMI, mean (SD)	23.9 (2.5)	24.0 (2.5)	23.7 (2.3)	23.9 (2.5)	24.2 (2.5)	24.2 (2.5)
Diet, n (%)						
Healthy	40 (28)	46 (32)	6 (13)	11 (24)	28 (35)	34 (42)
Improvable	91 (64)	89 (63)	31 (68)	30 (65)	46 (57)	43 (53)
Unhealthy	11 (8)	7 (5)	9 (20)	5 (11)	7 (9)	4 (5)
Healthy PA, n (%)	58 (41)	69 (49)	19 (41)	16 (35)	30 (37)	42 (52)
Knowledge, mean (SD)	7.9 (1.1)	7.7 (1.3)	7.4 (1.4)	7.3 (1.4)	7.9 (1.1)	7.9 (1.2)
Attitude, mean (SD)	4.0 (0.44)	4.0 (0.45)	3.9 (0.46)	4.0 (0.45)	4.0 (0.44)	4.0 (0.44)
Self-efficacy, mean (SD)	2.1 (0.59)	2.2 (0.64)	2.2 (0.62)	2.4 (0.77)	2.3 (0.61)	2.3 (0.65)
Self-rating, mean (SD)	6.8 (1.2)	6.9 (1.2)	6.5 (1.5)	6.9 (1.4)	6.6 (1.4)	6.9 (1.1)
Realistic insight, diet, n (%)	83 (59)	87 (61)	31 (67.4)	25 (54.3)	52 (64.2)	46 (56.8)
Realistic insight, PA, n (%)	84 (59)	88 (62)	32 (69.6)	27 (58.7)	47 (58.0)	56 (69.1)

Table 9. Effect size (ES) of the differences between pretest and posttest values on outcome variables for control group, nonusers, and users

Variable	Control (n=142)		Nonusers (n=46)		Users (n=81)	
	ES[a]	*z (P)d/ 95% CI ES*[e]	*ES*[a]	*z (P)d/ 95% CI ES*[e]	*ES*[a]	*z (P)d/ 95% CI ES*[e]
BMI	0.02[b]	CI: −0.39 to 0.44	0.06[a]	CI: -0.64 – 0.77	0.03[a]	CI: -0.51 to 0.57
Diet	−0.09[c]	*z* = −1.45 (.15)	−0.23[b]	*z* = −2.22 (.03)	−0.13[b]	*z* = −1.62 (.11)
PA	−0.10[c]	*z* = −1.65 (.10)	−0.07[b]	*z* = −0.71 (.48)	−0.17[b]	*z* = −2.12 (.03)
Knowledge	−0.15[b]	CI: −0.35 to 0.04	−0.08[a]	CI: −0.49 to 0.34	0.04[a]	CI: −0.20 to 0.29
Attitude	0.01[b]	CI: −0.06 to 0.08	0.28[a]	CI: 0.15 – 0.41	−0.05[a]	CI: −0.15 to 0.05
Self-efficacy	0.14[b]	CI: 0.03 – 0.24	0.33[a]	CI: 0.13 – 0.53	0.05[a]	CI: −0.09 to 0.19
Self-rating	0.15[b]	CI: −0.05 to 0.35	0.25[a]	CI: −0.18 to 0.68	0.27[a]	CI: 0.00 – 0.54
Insight, diet	−0.03[c]	*z* = −0.51 (.61)	−0.13[b]	*z* = −1.27 (.21)	−0.07[b]	*z* = −0.90 (.37)
Insight, PA	−0.01[c]	*z* = −0.49 (.62)	−0.13[b]	*z* = −1.21 (.23)	−0.11[b]	*z* = −1.42 (.16)

[a] Effect sizes for ratio variables are presented as Cohen's d, while effect sizes for ordinal variables are presented as *r*. [b] Effect size (ES) presented as Cohen's d: $(mean_{post} - mean_{pre})/SD_{pooled}$ [c] Effect size presented as *r*: $z/\sqrt{(n)}$. [d] Wilcoxon signed-rank test. [e] In this column the reliability of the effect size is presented as the confidence interval for Cohen's d for ratio variables and as *z* statistic with *P* value for ordinal variables.

Discussion

The results showed that the HWA was not used as often as intended. Increased age and not having a chronic condition increased the odds of having used the application at least once. Moreover, users were healthier and more knowledgeable about healthy behavior than nonusers. The ITT analyses showed no apparent effects of the intervention; however, there were differences in the effect of the intervention on users and nonusers. With respect to dietary behavior and attitude, nonusers improved more than users, while with respect to physical activity and self-rated behavior the users improved more than nonusers. On self-efficacy, the control group and the nonusers showed deterioration from baseline to posttest.

Only 64% (81 out of 127) of the participants who received access to the HWA actually used the application. This finding is not unique to this study; for example, see [6,15,20,42]. This stresses an important aspect of Web-based interventions, that is, of the respondents who agree to participate in a study on a Web-based intervention, we can expect that a substantial percentage does not use the intervention at all. In addition, we saw that the HWA is not used as often as intended in the design of the application. Of the included social and economic factors of the proposed framework, only increased age increased the odds of having used the application. This finding might seem counterintuitive, but it concurs with recent findings on the motivation to use e-consultation [43], which showed that older

people were more motivated to use e-consultation than younger people. With respect to the condition-related factors, the regression analysis showed that having a chronic condition decreased the odds of using the application. An explanation might be that the HWA was not developed for people with chronic conditions and no special attention is paid to the needs of people with chronic conditions. Therefore, these people might feel that the HWA does not suit their needs. Significant differences between users and nonusers on condition-related factors showed that users were healthier. A reason for this might be that people like to be rewarded for their healthy behavior and not confronted with their unhealthy behavior.

Additionally, users more often underestimated their dietary behavior (respondents who did meet the criteria for healthy behavior but who rated their behavior as unhealthy were classified as underestimators), while nonusers more often overestimated their behavior. This shows that the people who could have benefited most from the HWA were less likely to use the application. Of the patient-related factors or constructs from behavior change theories, only knowledge showed a significant difference between users and nonusers. Users knew more about healthy behavior, which supports the notion that the people who could have benefited most from the HWA were least likely to use the application.

There were no differences related to the reasons for use between users and nonusers, and the different reasons do not explain whether respondents used the HWA or not. However, the reasons for use might play a role in the frequency of use. The most frequently mentioned reason for wanting to use the intervention was to gain insight into one's own behavior (60%). It might be that this goal was reached after using the HWA once, and participants might not have felt the need to use the HWA again.

Interestingly, the intervention was specifically not made to help people lose weight, but this goal was mentioned by 40% of respondents. Respondents seemed to want a quick and short-term effect (to gain insight) and might not have been willing to use the intervention frequently to work on a long-term goal (e.g., a healthier lifestyle). Satisfaction with the HWA was not associated with the frequency of use. However, overall, participants were not very satisfied with the HWA, which might have contributed to the relative low usage rates. To summarize, one of the social and economic factors (i.e., age), condition related factors (i.e., chronic condition, self-reported behavior, and insight into behavior), and one of the patient-related factors (i.e., knowledge) were related to use of the system. Satisfaction and reasons for use provided more in-depth information related to the causes of the lack of adherence to the intervention.

At baseline, the intervention and control groups showed a significant difference in attitude. The absolute value of the difference was small, however, and we don't consider it to be a meaningful difference. Therefore, we can argue that the groups were comparable at baseline. We found no meaningful significant effects of the intervention using ITT analyses.

We did find that both the waiting list group and the intervention group showed significant improvement on behavior and a significantly more favorable self-rated behavior. This well-known Hawthorne effect [44] (i.e., the effect on outcome through participation in research) might be explained by the increased attention participants paid to healthy behavior due to completing questionnaires on behavior and by increased awareness of current and desired behavior. Another explanation for the improvement in all respondents might be social desirability. Thinking of the intended behavior might have influenced the responses given in the posttest questionnaire. Considering the control group, the users, and the nonusers separately showed that only nonusers significantly improved on dietary behavior. This might be due to the large differences between users and nonusers at baseline. Users were already much healthier, and both groups improved, although at posttest, the nonusers were still less healthy than the users. It seems that a ceiling effect prevented the users from improving significantly while the nonusers had much room for improvement and, for that reason, showed significant improvement. On PA, we found that only the users of the intervention improved significantly, although the effect size was not very large ($r = -0.17$). The nonusers, who chose not to use the intervention, showed a decline in behavior while the control group showed improvement. Although these differences were not significant, this does point toward a difference between choosing not to use an intervention and not being able to use an intervention. However, these differences might also reflect social desirability because of the focus on PA in the intervention. Lastly, users judged their own behavior significantly more positively after the intervention period than before. None of the other groups showed this significant improvement. Summarizing, we found no apparent effects of the HWA, but it seems that having chosen to use or not to use the intervention led to different outcomes. Combined with the differences between groups at baseline, this seems to imply that these groups are truly different and should be treated as separate entities.

In this study, we were faced with substantial dropout and nonusage rates. High dropout rates are not uncommon in this field of research and have been said to be a major challenge [45,46]. Additionally, the reduction of nonusage rates is also a major challenge [15,47]. Faced with these challenges, it is important to note that in this study the groups of dropouts and nonusers overlapped, but were not the same. Almost half of the dropouts had been users, and there were also nonusers that were responders. Consequently, it is very important keep these two concepts apart.

Our results showed that the users of the HWA were healthier than nonusers, which is an unfortunate finding not unique to this study [18]. The group for which the intervention seemed to have been most useful, namely people who had room for improvement on both diet and physical activity, were less likely to have used the HWA. This tells us that we need to try different ways to entice potential users who could benefit from the HWA to become active users. More effort should be made to tempt the nonusers of the intervention to

become users. One way to do this might be to make it as easy as possible to start using the application. The moment people are interested, they should be able to use the application. In our study, there was considerable time between expressing interest and being able to use the application. Moreover, participants had to check their email, click on a link, and create a profile. All these steps require effort and could thereby decrease the odds of using the intervention. Once participants become users, the application itself can stimulate adherence. This might be done by regularly providing new content, by including reminders (through email or text messaging), or by explicitly telling participants what is expected of them in terms of usage. In our view, including these aspects would have improved the HWA.

In this study, the frameworks used to predict usage and to study effectiveness seem to have been insufficient. From the WHO framework [16], some factors, especially condition-related, seem to have explanatory power but not enough to fully explain why participants choose whether to use an intervention. This might be due to the fact that the goal of the model is adherence to treatment and not adherence to technology. Moreover, attitude, self-efficacy, and knowledge do not contribute to a better understanding of the effects of the intervention. These variables from classic behavior change theories might not discriminate enough. To gain more insight into how online interventions can support people in changing their behavior, we should try to take into account the specific barriers and opportunities of eHealth interventions and integrate them into a comprehensive conceptual framework.

Limitations

A limitation of this study is the use of self-reported behaviors. Although we used questionnaires used in previous studies, there is a chance of biased results due to social desirability or lack of insight into behavior. As a consequence, a possible change in insight into behavior might not be reflected in our results. It could be that at baseline, participants provided optimistic self-reported behavior. Due to the intervention, the users might have provided more realistic self-reported behavior at posttest. Unfortunately, this potentially positive effect of the HWA could not be tested in this study. A second limitation is related to the participants in this study. Most respondents were female and highly educated. Various studies have reported overrepresentation of this group [6,18,48,49]. Nevertheless, the question remains whether these results can be generalized to the broader target population of the HWA. Another limitation of this study is that we measured the usage of the system as the number of log-ons per participant. What participants did while logged on and for how long they were logged on, we do not know. As more and more eHealth research takes the usage of the applications into account, it might be beneficial to standardize the assessment of usage. Furthermore, a limitation of this study is related to the response rate. Our overall response rate was quite low (59%), and we found significant differences between responders and nonresponders. We accounted for this bias by using multiple imputation procedures. However, imputing 41% of the data might have yielded

unreliable estimates, although research has shown that imputing up to 58% can be more reliable than listwise deletion [40,50]. In our view, this study has provided valuable insights into the users of a Web-based intervention. However, had we been able to conduct this study again, we would have changed the way we dealt with several issues. First of all, we would have included a larger number of respondents to certify a sample size large enough to account for the high dropout and nonusage rates. Second, we would have tested and adapted the application during development so that we could have chosen the outcome measures and study period to better reflect the goals and expected effects of the application. Unfortunately, this was not possible in the current study, and this stresses the importance of a close collaboration between researchers and developers of eHealth interventions.

Future work

Usage is a major issue in research into the effects of eHealth applications. More research is needed into transforming potential users into actual users and into keeping them engaged with the application and, thereby, stimulating them to keep using the intervention. Moreover, long-term research on the use of eHealth applications is needed to provide insight into the way usage fluctuates over time. From this study, we have gained insight into differences between users and nonusers, which can be seen as a first step to decreasing attrition. The next step might be found when looking at the opportunities technology has to offer. For example, several recent studies have shown beneficial effects of adding mobile technology [51-53] and devices that provide automated tailored feedback [54]. Additionally, the field of persuasive technology might provide us with insight into how technology as a medium can persuade and motivate users to change behavior [55,56].

Appendixes

Appendix 1. Translated questionnaire dietary behavior

Appendix 2. Translated questionnaire physical activity behavior

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Appendix 1. Questionnaire Dietary Behaviour

Werkman A, Hammink A, Netherlands Nutrition Centre. Vragenlijst & Scoreberekening voor gezonde versus ongezonde voeding. 2008

Translated from Dutch

1. How many times in the past four weeks have you eaten vegetables?
Never
Almost never
Less than once a week
1 or 2 times a week
3 or 4 times a week
5 or 6 times a week
Every day

2. How many times in the past four weeks have you eaten fruits?
Same answering categories as question 1

3. How many times in the past four weeks have you drunk/eaten milk and/or milk products?
Never => go to question 5
Almost never => go to question 5
Less than once a week
1 or 2 times a week
3 or 4 times a week
5 or 6 times a week
Every day

4. What kind of milk and/or milk products did you usually drink/eat?
Skimmed milk and/or milk products, like skimmed milk, skimmed yoghurt, buttermilk and/or skimmed custard
Low-fat milk and/or milk products, like low-fat milk, low-fat yoghurt and/or low-fat custard
Whole milk and/or milk products, like whole milk, whole yoghurt and/or whole custard
Varying low-fat and skimmed
Varying low-fat and whole
Varying skimmed, low-fat and whole

5. How many times in the past four weeks have you eaten bread?
Never => go to question 8

Almost never => go to question 8
Less than once a week
1 or 2 times a week
3 or 4 times a week
5 or 6 times a week
Every day

6. What kind of bread did you usually eat?
Brown, whole wheat and/or rye bread
White bread
Varying

7. What kind of butter did you usually use on your bread?
(low-fat) margarine
Butter
Varying
I do not use butter on bread

8. How many times in the past four weeks have you used fat or (olive)oil when preparing a meal?
Never => go to question 10
Almost never => go to question 10
Less than once a week
1 or 2 times a week
3 or 4 times a week
5 or 6 times a week
Every day

9. What kind of fat did you usually use?
Margarine from a tub and/or squeeze-bottle, (olive)oil and/or liquid frying fat
A packet of margarine and/or solid baking, frying or deep frying fat
Butter

10. How many times in the past four weeks have you eaten meat, fish or chicken with your hot meal?
Never => go to question 12
Almost never => go to question 12
Less than once a week
1 or 2 times a week

3 or 4 times a week
5 or 6 times a week
Every day

11. What kind of meat, fish or chicken did you usually eat with your hot meal?
Lean kinds (like steak tartare, pork tenderloin, (pork) steak, chicken breast, roast beef, ham, loin chop, tilapia, pike perch and the like)
Fatter kinds (like minced meat, hamburger, sausage, shoulder chop, bacon, mackerel, salmon and the like)
Varying

12. How many times in the past four weeks have you drunk regular soda, sports drinks and/or juices (not LIGHT soda)?
Same answering categories as question 1

13. How many times in the past four weeks have you consumed alcoholic beverages?
Same answering categories as question 1

14. How many times in the past four weeks have you eaten large biscuits, cake, candy bars, snacks, candy and/or crisps in between meals?
Same answering categories as question 1

Appendix 2. Questionnaire Physical Activity

Douwes M, Hildebrandt VH. Vragen naar de mate van lichamelijke activiteit. Geneeskd Sport 2000;33(1):9-16.

Translated from Dutch

The following questions are about physical activity, such as walking, biking, gardening, sporting or moving at work or at school.

1. How many days a week have you performed this kind of physical activity for at least 30 minutes a day during SUMMER? It is about the average number of days in a regular week.
Less than 1 day a week; 1 day a week; 2 days a week; 3 days a week; 4 days a week; 5 days a week; 6 days a week; 7 days a week

2. How many days a week have you performed this kind of physical activity for at least 30 minutes a day during WINTER? It is about the average number of days in a regular week.
Less than 1 day a week; 1 day a week; 2 days a week; 3 days a week; 4 days a week; 5 days a week; 6 days a week; 7 days a week

The following questions are about strenuous activities in your free time.

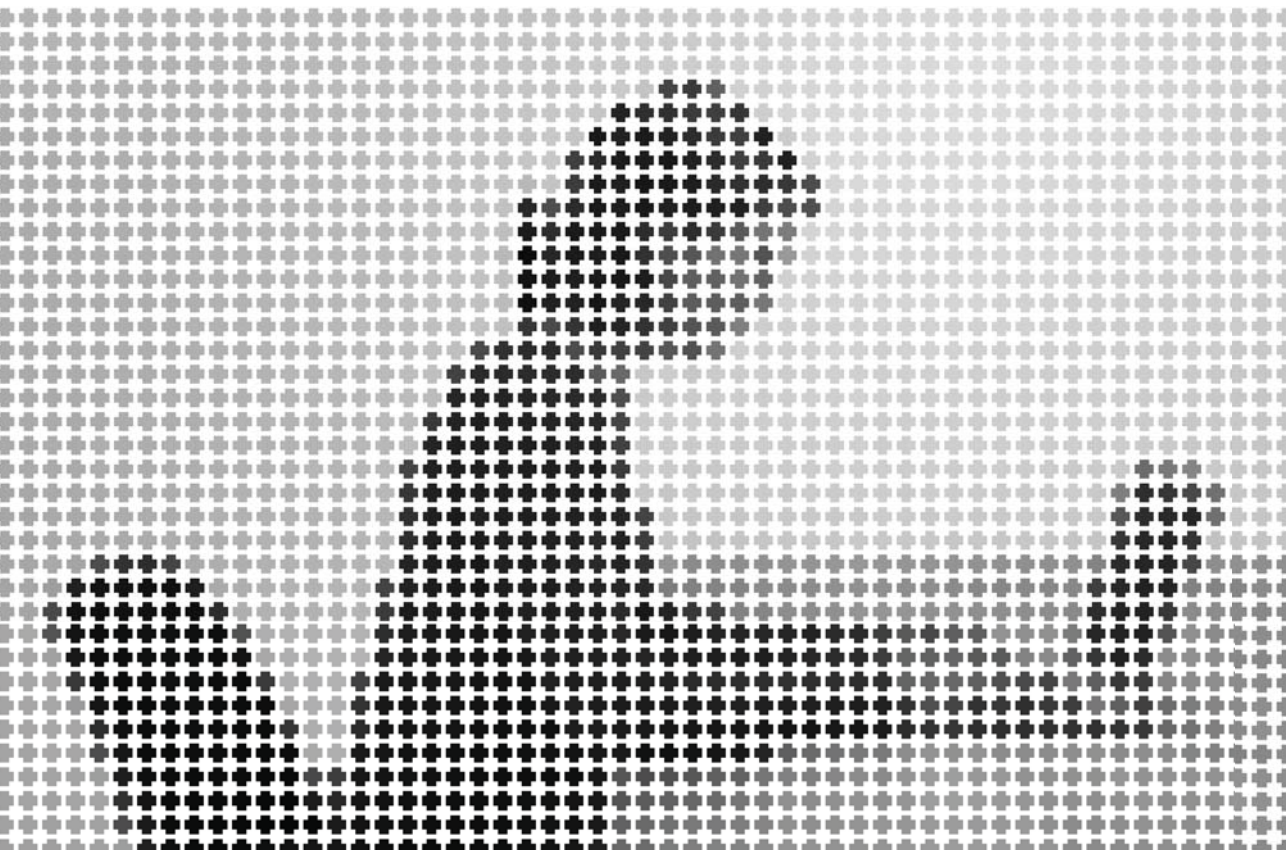
3. In your free time during summer, how many times do you carry out strenuous sports or physical activities that take long enough to become sweaty? It is about strenuous physical activity that lasts at least 20 minutes each time.
Less than 1 day a month; 1 day a month; 2 days a month; 3 days a month; 4 days a month
2 days a week; 3 days a week; 4 days a week; 5 days a week; 6 days a week; 7 days a week

4. In your free time during winter, how many times do you carry out strenuous sports or physical activities that take long enough to become sweaty? It is about strenuous physical activity that lasts at least 20 minutes each time.
Less than 1 day a month; 1 day a month; 2 days a month; 3 days a month; 4 days a month
2 days a week; 3 days a week; 4 days a week; 5 days a week; 6 days a week; 7 days a week

Chapter 3

Persuasive system design does matter: a systematic review of adherence to web-based interventions

Kelders SM, Kok RN, Ossebaard HC, Van Gemert-Pijnen JEWC.
Persuasive system design does matter: a systematic review of adherence to web-based interventions.
J Med Internet Res; in press. DOI: 10.2196/jmir.2104



Abstract

Background: Although web-based interventions for the promotion of health and health related behavior can be effective, poor adherence is a common issue that needs to be addressed. Technology as a means to communicate the content in web-based interventions has been neglected in research. Indeed, this technology is often seen as a black-box, a mere tool that has no effect or value and serves merely as a vehicle for the delivery of intervention content. In this paper we examine the technology from a holistic perspective and see it as a vital and inseparable aspect of the web-based intervention to help explain and understand adherence.

Objective: This study aims to review the literature on web-based health interventions to investigate whether intervention characteristics and persuasive design affect adherence to a web-based intervention.

Methods: A systematic review of studies into web-based health interventions was conducted. Per intervention, intervention characteristics, persuasive technology elements and adherence were coded. A multiple regression analysis was performed to investigate whether these variables could predict adherence.

Results: We included 101 articles on 83 interventions. The typical web-based intervention is meant to be used once a week, is modular in set-up, is updated once a week, lasts for ten weeks, includes interaction with the system, a counselor and peers on the web, includes some persuasive technology elements, and circa 50% of the participants adhere to the intervention. Regarding persuasive technology, we see that primary task support elements are most commonly employed (mean 2.9 out of a possible 7). Dialogue support and social support are less commonly employed (mean 1.5 and 1.2 out of a possible 7, respectively). When comparing the interventions of the different health care areas, we find significant differences on intended usage ($p=.004$), set-up ($p<.001$), updates ($p<.001$), frequency of interaction with a counselor ($p<.001$), the system ($p=.003$) and peers ($p=.017$), duration ($F=6.068$, $p=.004$), adherence ($F=4.833$, $p=.010$) and the number of primary task support elements ($F=5.631$, $p=.005$). Our final regression model explained 55% of the variance in adherence. In this model, a RCT study opposed to an observational study, increased interaction with a counselor, more frequent intended usage, more frequent updates and more extensive employment of dialogue support significantly predicted better adherence.

Conclusions: Using intervention characteristics and persuasive technology categories, a substantial amount of variance in adherence can be explained. Although there are differences between health care areas on intervention characteristics, health care area *per se* does not predict adherence, rather the differences on technology and interaction predict adherence. The results of this study can be used to make an informed decision on how to design a web-based intervention that has a greater likelihood of being adhered to.

Keywords

Systematic review, web-based interventions, adherence, persuasive technology, behavior change

Introduction

Web-based interventions for the promotion of health and health-related behaviors are seen in many variations and health care areas. According to Barak et al.[1] a web-based intervention is:

"*…a primarily self-guided intervention program that is executed by means of a prescriptive online program operated through a website and used by consumers seeking health- and mental health-related assistance. The intervention program itself attempts to create positive change and or improve/enhance knowledge, awareness, and understanding via the provision of sound health-related material and use of interactive web-based components.*"

A web-based intervention can involve therapy that lasts for a pre-determined, fixed period of time. However, it can also be a continuous program with no specific end-date that supports self-management among patients with a chronic condition. It is made up of different, inseparable aspects which, according to Barak et al. [1], are as follows: program content, multimedia choices, interactive online activities, and guidance and supportive feedback.

Evidence exists to support the effectiveness of web-based interventions. These interventions have been shown to be effective in different areas of health care [2-7]. However, many evaluations of eHealth interventions report either no positive effects at all or only limited ones [8-12]. One of the issues that is frequently addressed is the problem of non-adherence [11, 13-17], which refers to the fact that not all participants use or keep using the intervention in the desired way. Research suggests that non-optimal exposure to the intervention lessens the effect of these interventions [18, 19]. Gaining an insight into those factors that influence adherence should therefore be one of the main focus areas in any research study into web-based interventions. Important in this context is to stress the difference between the terms 'adherence' or 'non-usage attrition' and 'drop-out'. Drop-out, or drop-out attrition, refers to participants in a study who do not fulfill the research protocol (e.g. filling out questionnaires). This is not a focus area of this study. Adherence, or non-usage attrition, refers to the extent to which individuals experience the content of an intervention [13, 15]: this is the focus of our study.

When looking at literature about adherence to a therapeutic regimen [20, 21], adherence is seen as the extent to which the patient's behavior matches the recommendations that have been agreed upon with the prescriber. The term is often seen as a reaction to the term 'compliance', which has a more coercive connotation. Consequently, in adherence, the patient plays an active role in achieving this behavior [21]. At the same time, there is also a norm or recommendation from a prescriber, which the patient tries to match. This recommendation is missing from both the definition of

adherence and that of non-usage attrition [13, 15]. In this study, we elaborate on the definition by introducing the concept of 'intended usage'. Intended usage is the extent to which individuals *should* experience the content (of the intervention) in order to derive maximum benefit from the intervention, as defined or implied by its creators. This matches the norm or recommendation from the definition of adherence to a therapeutic regimen. By comparing the observed usage of an individual to the intended usage of a web-based intervention, we can establish whether or not this individual adheres to the intervention. In this context, adherence is a process which cannot be assessed solely by measuring usage at the beginning and end of the intervention; rather it has to be assessed throughout the entire process to establish whether or not an individual adheres to the intervention at each and every step of the way. Finally, by comparing the observed usage of each individual to the intended usage of the web-based intervention, the percentage of individuals that adheres to the intervention can be calculated. This results in a more objective measurement of adherence which can then be compared to other interventions, even if the intended usage is different.

Adherence to web-based interventions has been the subject of research for some time. Many studies focus on whether and which respondents' characteristics can explain variations in adherence [11, 13, 16, 22]. Although this is a very important line of study, it seems to take the technology of web-based interventions for granted. Technology as a means to communicate the content has been neglected in research. Indeed, this technology is often seen as a black-box, a mere tool that has no effect or value and serves merely as a vehicle for the delivery of intervention content. In line with a recent viewpoint paper, we propose to examine the technology from a holistic perspective and see it as a vital and inseparable aspect of the web-based intervention [12]. This approach has been recommended in recent literature [10, 11, 13, 23] and has been the key point in the field of persuasive technology [24], where there are examples of studies on the persuasive capacities of technology to support web-based interventions in the health care domain [25-28].

Recently, two systematic reviews on the influence of intervention factors on adherence to web-based interventions were published [29, 30]. Although both reviews provide valuable insights, we feel that there are shortcomings that limit the applicability of these results for our objectives. First, with regard to adherence, the study of Brouwer [29] takes exposure to interventions delivered via the internet as the outcome measure. Exposure is seen as the number of times the user/patient logged on, the time spent on site, page views etc., but these are static measurements which are unrelated to the usage intended by these interventions. This gives limited insights into the process of usage and adherence, which makes it difficult to compare different interventions and specify how 'well' certain interventions are doing. A review by Schubart [30] fails to distinguish between drop-out and adherence, which limits the applicability of the results, because in real-life

implementation of web-based interventions, there is no research protocol to adhere to, only the intervention. The results of Schubart's review [30] cannot be generalized to these situations because we do not know whether engagement is due to the research or the intervention.

Furthermore, regarding the intervention factors, both studies use an ad hoc classification of these factors without a theoretical foundation which makes it difficult to generalize and explain the results. As described earlier, we consider a web-based intervention as consisting of content, interaction and technology. And, although these aspects are inseparable, they can be looked at in a structured manner. Both earlier reviews use a classification which, in our opinion, has substantial overlap in the goals that are to be achieved with these aspects. For example, in the review by Brouwer [29], a distinction is made between interactive behavior change strategies and interactive elements. It is stated that the goal of interactive elements is to "improve the attractiveness of the intervention or to provide the option for more information", but this is not mutually exclusive with interactive behavior change strategies. For example, a quiz is seen as an interactive element, but in our opinion it can also be used as a means of receiving tailored feedback or as a way to self-monitor your knowledge or behavior. Allocating a quiz to one of these categories is therefore problematic. The categorization of intervention factors in the review by Schubart [30] lacks depth and tries to encompass in one single categorization both modality (i.e. the channel through which content is delivered; for example, e-mail or telephone) and strategy (e.g. feedback). The current study attempts to overcome these shortcomings by employing a more objective and comparable measurement of adherence to web-based interventions and a classification of technology based on persuasive technology literature.

From the field of persuasive technology we learn that technology has the capacity to be persuasive through its role as a tool, a medium, and a creator of experiences [24]. Fogg's definition of persuasive technology limits this field to human-computer interaction and does not include computer-mediated communication (i.e. including interaction with a person). However, we feel that it is unnecessary and undesirable to separate these two aspects of technology, particularly in the area of health care, because a web-based intervention is made up of different, inseparable aspects. We therefore propose a broader application of the term 'persuasive technology' to include both human-computer interaction and computer-mediated communication. Accordingly, regarding the aspects of a web-based intervention, we propose a more pragmatic conceptual division between technology (i.e. all the features of the web-based intervention, including multimedia and online activities) and interaction (i.e. all interactions between the user/patient and the intervention, a counselor and/or peers) which is slightly different from the aspects proposed by Barak et al. Following Fogg's work, Oinas-Kukkonen and Harjumaa introduce a framework to classify technology in its persuasive functions [31]. This Persuasive System Design-model (PSD-model), which is

used, for example, in a study by Lehto and colleagues [32], classifies features of the technology as primary task support, dialogue support, social support and credibility support. By applying this model to web-based interventions, we can systematically look at how persuasive system design categories are used and investigate their possible influence on adherence.

This study investigates whether intervention characteristics and persuasive design affect adherence to a web-based intervention. Web-based interventions are applied in various health care domains and intuitively it seems that there are differences between web-based interventions aimed at people with a chronic condition, at lifestyle change and mental health, because of the target group, involvement with a health care professional, and duration of the interventions. However, the underlying principles may well be the same. Therefore, from an intervention perspective, there is no absolute need to see these areas as being so different from each other that they cannot be compared. Consequently, it is interesting to see whether the preconceptions about the differences can be confirmed and whether there is added value for researchers and designers in one area to look at interventions from a different area.

Our systematic review aims to answer the following research questions: (1)What are the key characteristics of web-based interventions in terms of technology and interaction? (2) Are there any differences in intervention characteristics between web-based interventions aimed at chronic conditions, lifestyle and mental health? (3) What percentage of participants adhere to web-based interventions? (4) Which characteristics of web-based interventions relating to technology and interaction are linked to better adherence? These insights can help us understand and reduce the impact of the problem of non-adherence.

Method

Search strategy

A comprehensive literature search was conducted using the following bibliographic databases: Web of Knowledge, EBSCOHOST, Picarta, SciVerse Scopus and ScienceDirect. These were queried for a combination of the constructs 'web-based', 'intervention', 'adherence' and 'health'. For each construct, several keywords were used (see Multimedia Appendix 1) to ensure a broad coverage of published studies in our review. Following this search strategy, we identified 14,264 articles until 26 October 2011 (see Figure 1 for the full flow diagram of article selection).

Eligibility criteria

The review is limited to studies of web-based interventions in the health care domain. The criteria used for including a study were that: (1) it involved a web-based intervention for promoting health through behavioral change, (2) the web-based intervention was intended

to be visited and used on more than one occasion, (3) the research included an assessment of the effect of the intervention, (4) the study reported objective, quantifiable measurements of usage for the intervention and (5) the study was published in either English or Dutch. Exclusion criteria were as follows, namely that: (1) drop-out attrition and non-adherence were indistinguishable, (2) the intervention was aimed at care-providers or relatives of the 'patient', (3) from the description of the intervention no information could be gathered on the applied persuasive features of the technology and (4) the web-based intervention was not primarily intended to be used through a computer or laptop situated at the user's/patient's home. In addition, we only included peer-reviewed, published articles.

Study selection and data collection

The study selection was done in three steps. First, the titles of all retrieved articles were screened for eligibility by two authors (SK and RK). Second, the abstracts of all initially relevant articles were screened for eligibility by the same authors. Finally, the full text of all remaining publications were checked for inclusion by two authors (SK and RK or SK and JvG). In cases where the suitability of a study came into question during one of the steps, it was included in the next step. Disagreements about including the full text publication were discussed until agreement was reached. To check whether any eligible publications had been overlooked during the initial search process, the reference lists of all systematic reviews which were identified in the original search were checked to find additional publications that met our inclusion criteria.

The characteristics of all of the interventions that were included were coded by two researchers (SK and RK) using a data extraction form based on a protocol for the systematic review of eHealth technologies [33]. Where possible, data was extracted using the CONSORT eHealth checklist [12]. For the extraction we relied on information that was available in the published literature. The basis of the data extraction was the intervention, not the study itself. This meant that for some interventions, data from more than one article was used. Furthermore, when a study described more than one web-based intervention (e.g. a comparison of two web-based interventions), all web-based interventions were coded separately.

Data items

The following characteristics were coded:

Intervention name

The name of the intervention was recorded. If the intervention had no name, the intervention was named after the first author of the primary article about the intervention.

Behavior/Condition

The targeted behavior or condition of each intervention was recorded. Furthermore, the area of health care targeted by the intervention (chronic condition, lifestyle or mental health) was recorded.

Studies and study design

For each intervention, the studies that were used to code the characteristics of the intervention were recorded. Furthermore, whether these studies were randomized controlled trials (RCTs) or observational studies without randomized control groups was also recorded.

Intended usage

Intended usage was defined as the extent to which the developers of the intervention felt that the intervention should be used to achieve the desired effect ([12] 5ix). When this information was not reported, it was inferred from the description of the intervention. For example, interventions requiring patients to monitor their behavior and receive feedback once a week to achieve the desired effect, were coded as intended to be used once a week.

Actual usage

All reported information regarding the usage of the intervention, related to its intended usage, was collected, including the number of times the user/patient logged on and the number of modules completed ([12] 6aii).

Adherence

A percentage of adherence was calculated to enable a comparison to be made between the different interventions. This was done by calculating the percentage of participants that adhered to the intervention. For example, when the intended use of an intervention was 'complete 8 modules' and 60 out of 100 participants completed 8 modules, the adherence was 60%. For each intervention that was included, one overall adherence percentage was calculated. When more studies about the same intervention yielded different adherence percentages, the overall adherence percentage was calculated using a weighted average, based on the number of participants in each study. Furthermore, when the study included a waiting list, the respondents in this waiting list received access to the intervention at a later stage and when usage data was available, the adherence was calculated based on all participants, including the waiting list group.

Updates

The frequency of updates of content in the web-based intervention for a participant was recorded. This could be based on new information being uploaded for all participants, or a new lesson becoming available for a specific participant.

Duration

The duration of the intervention in weeks was recorded.

Set-up

For each intervention a record was made indicating whether the set-up was modular (i.e. content is delivered in a sequential order, whereby new content is made available when the user reaches a certain point) or free (i.e. all the content of the intervention is available to the user from the start).

Interaction

All information about the interaction with participants was recorded ([12] 5viii, 5x and 5xi). This interaction could be with the system (e.g. automatic e-mail reminders or a web-based automated response to filling out an exercise), with a counselor (e.g. through e-mail, telephone or face-to-face) or with peers (e.g. through a discussion board, chat group or face-to-face group sessions).

Modality

When interaction with the system, counselor or peers took place through a different modality than web-based (face-to-face, telephone or SMS), this was recorded. An exception was made when the study protocol included a face-to-face or telephone intake. This was not coded as interaction through a different modality because it was not an actual part of the intervention.

Persuasive technology in the intervention

The applied principles of persuasive technology within the interventions were coded according to the PSD-framework of Oinas-Kukkonen and Harjumaa [31]. We omitted system credibility support because of an observed lack of reporting of these principles in the studies that were included. The elements from the PSD-framework on primary task, dialogue and social support with the definitions and the coding scheme we used, are presented in Table 1. The coding scheme is somewhat modified for the purpose of this study and to account for the computer-mediated communication that is included. However, when coding the persuasive technology elements, the technology was central, not the content of the interaction. Therefore, when computer-mediated communication was present, the content of this communication was not coded as persuasive technology. For example, when a feedback message from a care provider contained praise, this was not coded as dialogue support, but when the technology provided a praising message after the user had successfully filled out a diary entry, then it was coded. For each intervention, the elements that were present were coded, irrespective of whether the designers of the intervention deliberately included these elements as persuasive technology elements. To check for differences in interpretation when coding the persuasive technology elements, 10 interventions were coded by 2 researchers (SK and JvG). The interrater reliability, measured by Cohen's kappa, was 0.91.

Table 1. PSD-framework elements coding scheme

Principle and definition according to PSD-framework [31]	Coded as element included when the web-based intervention:	Example
Primary task support		
Reduction A system that reduces complex behavior into simple tasks helps users perform the target behavior, and it may increase the benefit/cost ratio of a behavior.	Specifically divides the target behavior into small and simple steps.	A web-based intervention for weight management includes a diary for recording daily calorie intake, thereby dividing the target behavior (reducing calorie intake) into small and simple steps of which one is recording calorie intake.
Tunneling Using the system to guide users through a process or experience provides opportunities to persuade along the way.	Delivers content in a step-by-step format with a predefined order.	A web-based intervention for the prevention of depression which delivers the content in sequential lessons that can only be accessed when the previous lesson is completed.
Tailoring Information provided by the system will be more persuasive if it is tailored to the potential needs, interests, personality, usage context, or other factors relevant to a user group.	Provides content that is adapted to factors relevant to a user group, or when a counselor provides feedback based on information filled out by a participant.	A web-based intervention for supporting self-management among patients with diabetes provides information adapted to patients based on whether they have diabetes mellitus type I or II.
Personalization A system that offers personalized content or services has a greater capability for persuasion.	Provides content that is adapted to one user, i.e. the name of the user is mentioned and/or the user can adapt a part of the intervention.	A web-based intervention for increasing physical activity allows the user to choose whether he wants to see his or her weekly activity score on the home page or not.
Self-monitoring A system that keeps track of one's own performance or status supports the user in achieving goals.	Provides the ability to track and view the user's behavior, performance or status.	A web-based intervention for the treatment of alcohol dependence provides a diary to track and view daily alcohol use.
Simulation Systems that provide simulations can persuade by enabling users to observe immediately the link between cause and effect.	Provides the ability to observe the cause and effect relationship of relevant behavior.	A web-based intervention for smoking cessation includes a calculator that shows how much you will save when you quit smoking.

Rehearsal A system providing means with which to rehearse a behavior can enable people to change their attitudes or behavior in the real world.	Provides the ability and stimulation to rehearse a behavior or to rehearse the content of the intervention.	A web-based intervention for supporting self-management in patients with epilepsy starts each lesson with the same important exercise on stress-management.
Dialogue support		
Praise By offering praise, a system can make users more open to persuasion.	Offers praise to the participant on any occasion.	A web-based intervention that aims to promote healthy nutritional habits compliments the participant when he/she has eaten 2 pieces of fruit for 5 days.
Rewards Systems that reward target behaviors may have great persuasive powers.	Offers some kind of reward when the participant performs a target behavior relating to the use or goal of the intervention.	A web-based intervention for the treatment of social phobia gives points to the participant when he or she engages in exposure exercises.
Reminders If a system reminds users of their target behavior, the users will more likely achieve their goals.	Provides reminders about the use of the intervention or the performance of target behavior.	A web-based intervention to support self-management among patients with rheumatic arthritis sends an automatic email message to remind the participant that the new lesson may begin.
Suggestion Systems offering fitting suggestions will have greater persuasive powers.	Provides a suggestion to help the participants reach the target behavior.	A web-based intervention for weight management provides low calorie recipes.
Similarity People are more readily persuaded through systems that remind them of themselves in some meaningful way.	Is designed to look familiar and designed especially for the participant.	A web-based intervention for the treatment of panic disorder in teenage girls explains the exercises through a teenage girl with panic problems.
Liking A system that is visually attractive for its users is likely to be more persuasive.	Is visually designed to be attractive to the participants.	During the design of a web-based intervention to increase physical activity in middle-aged women, a representative group is asked for feedback on the design and their feedback is subsequently incorporated in the new design.

Social role If a system adopts a social role, users will more likely use it for persuasive purposes.	Itself acts as if it has a social role, e.g. a coach, instructor or buddy.	A web-based intervention to support self-management among patients with migraine incorporated an avatar to guide the participant through the intervention.
Social Support		
Social learning A person will be more motivated to perform a target behavior if (s)he can use a system to observe others performing the behavior.	Provides the opportunity and stimulates participants to see others using the intervention or performing the target behavior	A web-based intervention for weight management provides the option, and stresses the importance, of posting physical activity self-monitoring data on the discussion board and commenting on the performance of others.
Social comparison System users will have a greater motivation to perform the target behavior if they can compare their performance with the performance of others.	Provides the opportunity for participants to compare their behavior to the target behavior of other participants and stimulates them to do this.	A web-based intervention for drug abuse prevention for teenagers automatically compares the response of the participant to other users of the intervention.
Normative influence A system can leverage normative influence or peer pressure to increase the likelihood that a person will adopt a target behavior.	Provides normative information on the target behavior or the usage of the intervention.	A web-based intervention to promote self-management among patients with COPD provides feedback on the level of physical activity of the participant by comparing it to the physical activity of well-managed COPD patients.
Social facilitation System users are more likely to perform target behavior if they discern via the system that others are performing the behavior along with them.	Provides the opportunity to see whether there are other participants using the intervention.	A web-based intervention for smoking cessation includes a discussion board for users of the intervention.
Cooperation A system can motivate users to adopt a target attitude or behavior by leveraging human beings' natural drive to co-operate.	Stimulates participants to cooperate in order to achieve a target behavior.	A web-based intervention for the promotion of physical activity stimulates participants to form groups and to achieve the group goal of a certain number of steps each week.

Competition A system can motivate users to adopt a target attitude or behavior by leveraging human beings' natural drive to compete.	Stimulates participants to compete with each other in order to achieve a target behavior.	A web-based intervention for diabetes management among children includes a leaderboard in which the children who enter blood glucose levels at the right times receive the highest place.
Recognition By offering public recognition for an individual or group, a system can increase the likelihood that a person/group will adopt a target behavior.	Prominently shows (former) participants who adopted the target behavior.	A web-based intervention treatment of anxiety includes a testimonial page where successful users of the intervention tell their story.

Analyses

All data on each intervention was entered in SPSS version 19.0 (IBM Corporation, Somers, NY, USA), where each intervention was seen as a separate case. Descriptive data of the combined data of all included interventions on all variables were calculated using SPSS. Differences in variables between health care areas were calculated using Fisher's exact tests (because of the small expectation values) and one-way analyses of variance. To investigate whether the characteristics of the included interventions could predict the observed adherence, a hierarchical multiple linear regression analysis was performed, using a blockwise 'ENTER' method. The first block was related to the context of the web-based intervention and included the health care area (coded as dummy variables) and the study design (RCT vs observational) which have been proposed to influence adherence or the effect of web-based interventions in literature [7, 29, 34]. The second block relates to our concept of interaction as one of the aspects of a web-based intervention and consists of the frequency of interaction with a counselor, the system and peers, and the modality employed. The third and fourth blocks relate to our concept of technology in a web-based intervention, where the third block contains the intervention characteristics intended usage, set-up, updates and duration, and the last block contains the categories of persuasive system design. Important to note is that we have chosen to include the categories and not the separate elements in the multiple regression, because (1) when some elements are hardly used and these elements are entered as predictors, this could bias the results; (2) entering all 21 elements increases the chance of a type I error; (3) the PSD-model has grouped the elements on their key benefits; when the benefits of the specific elements in a category are similar, then looking at the specific elements could cause the overall influence of the category to be missed.

Results

Study selection

The search yielded 7345 unique titles. After title, abstract and full text screening, 101 articles on 83 interventions were included (Figure 1). In total, 315 articles were excluded based on the full text. The most common reason for exclusion was related to usage data: the lack thereof (n = 84) or the presentation of inadequate (i.e. subjective or not usable for calculating adherence) usage data (n = 78). Other studies were excluded based on the studied intervention: not aimed at health promotion by changing behavior (n = 40), not primarily meant to be used from a computer or laptop at the user's home (n = 41), not intended to be visited and used on more than one occasion (n = 34) or not targeted at the 'patient' (n = 3). Twenty-seven publications were excluded because the study design did not include an assessment of the effect of the intervention, for example when they only presented qualitative data on the design of an intervention, or when the study design did not provide unique usage data, for example a study about the long-term effects of an intervention. Seven publications were excluded because of the description of the intervention or study: in 4 publications no information could be gathered on the applied persuasive features of the technology from the description of the intervention and in 3 publications the data on the number of participants and their usage of the intervention was unclear. Finally, in the case of one citation no full-text could be retrieved; this citation was therefore excluded.

Characteristics of the studies that were included

The 83 interventions that were included are presented in Multimedia appendix 2. Overall, 19 interventions targeted a specific chronic condition, in which diabetes was targeted most often (6 interventions). Sixteen interventions were targeted at lifestyle behavior, in which weight management was targeted most often (7 interventions), but smoking cessation was also often seen (5 interventions were targeted solely on smoking cessation and 1 intervention included smoking cessation as one of multiple targeted behaviors). Finally, mental health was targeted most often in the studies that were included. Of these 48 interventions, 12 focused on social phobia, although it should be noted that these interventions are only from two research groups which extensively studied their interventions. Depression, panic disorder and anxiety were also targeted frequently in the interventions which we included (10, 8 and 7 interventions, respectively).

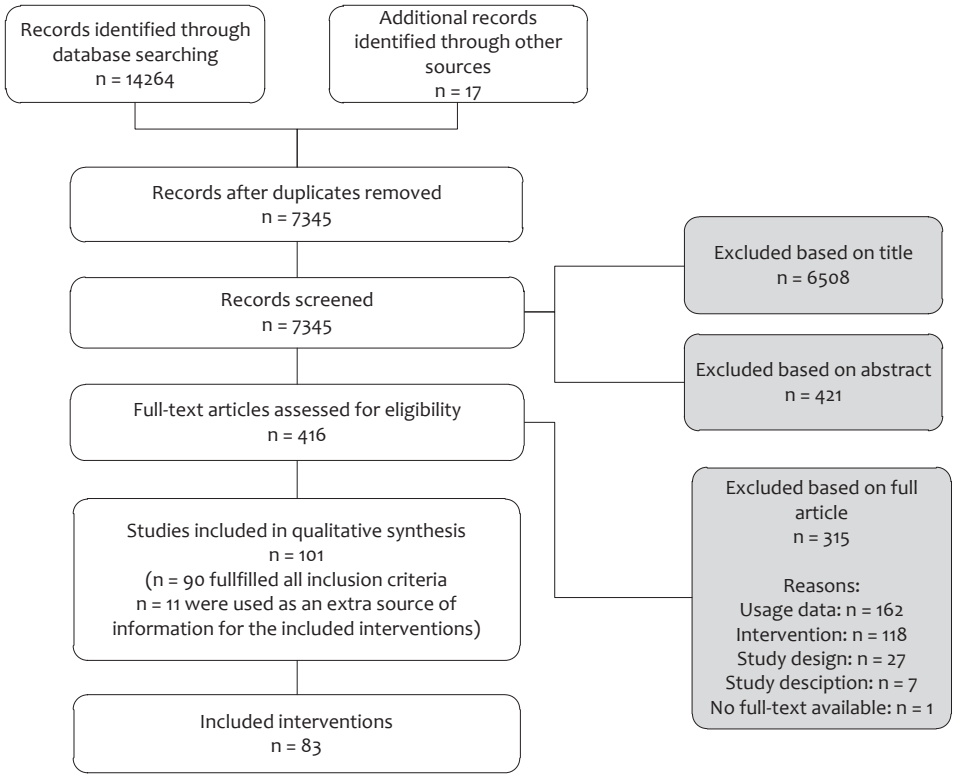


Figure 1. Flow diagram of study selection

Table 2 presents on overview of the variables of the interventions that were coded and their distribution over the different areas (chronic condition, lifestyle and mental health). Overall, we can see that most interventions were meant to be used once a week, were set up in a modular way, updated once a week and lasted for approximately 16 weeks (median duration 10 weeks). Face-to-face, telephone and SMS support were infrequently used and a combination of these modes even less, with 4 interventions combining face-to-face and telephone (interventions 3, 10, 33 and 72) and 2 interventions combining telephone and SMS (interventions 24 and 81). Seventy-six per cent of the interventions included interaction of the participant with a counselor and a similar percentage (73%) included some form of interaction with the system. A little over half of the interventions (53%) included interaction with peers, with and without counselor interaction. Regarding adherence, the average percentage of participants who adhere to an intervention is 50.3% (min 1%, max 93%). The values of each of the variables for each included intervention can be found in Multimedia Appendix 3.

Table 2. Descriptive variables of the included interventions per health care area

Variable		chronic (N = 19), n (%)	lifestyle (N = 16), n (%)	mental (N = 48), n (%)	total (N = 83), n (%)
Intended usage	<= 1/month	1 (5)	3 (19)	1 (2)	5 (6)
	1/month – 1/week	4 (21)	4 (25)	2 (4)	10 (12)
	1/week	13 (68)	6 (38)	40 (83)	59 (71)
	>1/week	1 (5)	3 (3)	5 (10)	9 (11)
Set-up	free	5 (26)	10 (63)	1 (2)	16 (19)
	modular	14 (74)	6 (38)	47 (93)	67 (81)
Updates	none	1 (5)	5 (31)	1 (1)	7 (8)
	yes, FNS[a]	0 (0)	2 (13)	0 (0)	2 (2)
	<= 1/month	2 (11)	1 (6)	1 (2)	4 (5)
	1/month – 1/week	3 (16)	1 (6)	3 (6)	7 (8)
	1/week	12 (63)	6 (38)	42 (88)	60 (72)
	>1/week	1 (5)	1 (6)	1 (2)	3 (4)
Duration	mean (sd)	18.2 (15.8)	29.8 (33.9)[b]	11.1 (18.5)	15.8 (18.5)
(weeks)	median	11	17	9	10
Interaction with	none	2 (11)	8 (50)	10 (21)	20 (24)
counselor	yes, FNS	3 (16)	3 (19)	2 (4)	8 (10)
	<1/week	5 (26)	3 (19)	2 (4)	10 (12)
	1/week	7 (37)	2 (13)	23 (48)	32 (39)
	>1/week	2 (011	0 (0)	11 (23)	13 (16)
Interaction with	none	7 (37)	1 (6)	14 (29)	22 (27)
system	yes, FNS	6 (32)	1 (6)	3 (6)	10 (12)
	<1/week	1 (5)	5 (31)	2 (4)	8 (10)
	1/week	2 (11)	6 (38)	14 (29)	22 (27)
	>1/week	3 (16)	3 (19)	15 (31)	21 (25)
Interaction with	none	5 (26)	10 (63)	24 (50)	39 (47)
peers	yes, FNS	10 (53)	4 (25)	10 (21)	24 (29)
	<1/week	2 (11)	0 (0)	1 (2)	3 (4)
	1/week	1 (5)	2 (13)	13 (27)	16 (19)
	>1/week	1 (5)	0 (0)	0 (0)	1 (1)
Face-to-face	included	3 (16)	1 (6)	1 (2)	5(6)
Phone	included	7 (37)	5 (31)	17 (35)	29 (35)
SMS	included	0 (0)	2 (13)	5 (10)	7 (8)
Adherence	mean (sd)	55.3 (19.8)	32.8 (23.0)	54.2 (27.4)	50.3 (26.2)

[a] FNS = Frequency not specified; [b] Based on 13 interventions; three (23, 26 and 27) did not specify a duration.

Differences in intervention characteristics between health care areas

When comparing the interventions of the different health care areas using Fisher's exact tests, we find significant differences on intended usage (p=.004), set-up (p<.001), updates (p<.001), frequency of interaction with a counselor (p<.001), the system (p=.003) and peers

(p=.017). When looking at the standardized residuals (data not shown) we can see where these differences are manifested. We see that lifestyle interventions are more often intended to be used less than once a month than interventions in the other areas. We see that mental health interventions are less often free in terms of their set-up than the other two areas. Lifestyle interventions are more often not updated or updated without a known frequency. Regarding interaction with a counselor, we see that lifestyle interventions more often do not employ this feature. Furthermore, we see that lifestyle interventions more frequently include interaction with the system less than once a week. Finally, on interaction with peers, chronic interventions more often have interaction for which the frequency is not specified. One-way analyses of variance show that there are differences in duration (F=6.068, p=.004) and adherence (F=4.833, p=.010), where Bonferroni post hoc analyses show that the difference in duration is between lifestyle and mental health interventions (lifestyle interventions are longer), whereas on adherence the difference is between lifestyle and chronic condition interventions and between lifestyle and mental health interventions (lifestyle interventions have a lower adherence rate). In sum, lifestyle interventions are longer, the intended usage is less frequent, have fewer updates, less interaction with the system and a counselor, and lower adherence than interventions aimed at chronic conditions and mental health. Mental health interventions are less often free in their set-up and interventions aimed at a chronic condition include interaction with peers more often, for which the frequency is not specified.

Persuasive technology

When examining the persuasive technology elements that are presented in Table 3, we see that a mean of 5.6 (median 5) out of a possible 21 elements were used within a web-based intervention. Primary task support shows the highest mean (2.9 out of a possible 7; median 3), while social support shows the lowest mean (1.2 out of a possible 7; median 1). One-way analyses of variance show that there is a significant difference between the use of persuasive technology elements for primary task support (F=5.631, p=.005). A Bonferroni post hoc analysis shows that this difference is between lifestyle and mental health interventions, where lifestyle interventions employ a higher mean of elements than mental health interventions. Furthermore, we can see that in primary task support, tunneling is used most often (n = 75; 90%), closely followed by tailoring (n = 73; 88%). Tunneling is used in all included mental health interventions, but only in 10 (63%) of lifestyle interventions (significant difference; p<.001). Reduction and self-monitoring are less often used in mental health interventions than in the other areas (significant difference reduction; p=.033 and self-monitoring; p<.001) which is most strikingly seen in self-monitoring which is used in 94% of lifestyle interventions, as opposed to 12% in the mental health interventions. Overall, rehearsal and simulation are used least of all out of the primary task support elements. From the dialogue support elements, reminders are most often used (n = 61; 74%) across all areas. Suggestion is the second most frequently used element (n = 24; 29%), although this is

used more often in web-based interventions targeted at chronic conditions than in mental health (p=.008). Praise was not used in any of the interventions and rewards only in 3 interventions. In social support, we see that social facilitation is most often used (n = 43; 52%), with a significant difference between interventions aimed at a chronic condition (n = 14; 74% including social facilitation) and at lifestyle (n = 5; 31%; p=.046). Furthermore, social learning and social comparison are used reasonably frequently (respectively n = 31; 39% and n = 14; 17%), with mental health interventions predominantly contributing to these numbers (with a significant difference only for social learning: p=.044). Cooperation on the other hand is used in 2 lifestyle interventions and 1 chronic intervention, but in none of the mental health interventions (significant difference; p=.041). The other elements (normative influence, competition and recognition) are hardly used. In sum, primary task support is most extensively employed while dialogue support and social support are sparsely employed. Tunneling, tailoring (primary task support), reminders (dialogue support) and social facilitation (social support support) are the most frequently used elements. On average, lifestyle interventions employ more primary task support elements than mental health interventions.

Predictors of adherence

A hierarchical multiple linear regression, using a blockwise 'ENTER' method, was performed to explore the predictors of adherence. Variables expected to predict adherence were entered in the analysis in blocks of related constructs as specified in the methods-section. The final model explained 55% of the variance in adherence. In this model, interventions studied with a RCT-design (instead of an observational study), increased interaction with a counselor, more frequent intended usage, more frequent updates and more extensive employment of dialogue support significantly predicted better adherence.

Table 3. Persuasive technology in web-based interventions included in this study per health care area

Variable		chronic (N = 19), n (%)	lifestyle (N = 16), n (%)	mental (N = 48), n (%)	total (N = 83), n (%)	P[a]
Primary task support	*mean (sd)*	*3.3 (1.0)*	*3.4 (1.3)*	*2.6 (1.0)*	*2.9 (1.1)*	
	median	*4*	*3.5*	*2*	*3*	
Reduction		10 (53)	10 (63)	14 (29)	34 (41)	.033
Tunneling		17 (90)	10 (63)	48 (100)	75 (90)	<.001
Tailoring		16 (84)	14 (88)	43 (90)	73 (88)	.814
Personalization		4 (21)	2 (13)	3 (6)	9 (11)	.209
Self-monitoring		12 (63)	15 (94)	12 (12)	39 (47)	<.001
Simulation		2 (11)	3 (19)	2 (4)	7 (8)	.118
Rehearsal		1 (5)	1 (6)	0 (0)	2 (2)	.175
Dialogue support	*mean (sd)*	*1.6 (1.0)*	*1.4 (1.3)*	*1.6 (0.9)*	*1.5 (1.0)*	
	median	*2*	*1*	*1*	*1*	
Praise		0 (0)	0 (0)	0 (0)	0 (0)	
Rewards		0 (0)	2 (13)	1 (2)	3 (4)	.134
Reminders		13 (68)	11 (69)	37 (77)	61 (74)	.656
Suggestion		11 (58)	4 (25)	9 (19)	24 (29)	.008
Similarity		4 (21)	1 (6)	16 (33)	21 (25)	.088
Liking		2 (11)	4 (25)	8 (17)	14 (17)	.561
Social role		1 (5)	0 (0)	4 (8)	5 (6)	.819
Social support	*mean (sd)*	*1.1 (0.7)*	*0.8 (0.9)*	*1.3 (1.2)*	*1.2 (1.0)*	
	median	*1*	*0.5*	*1*	*1*	
Social learning		5 (26)	3 (19)	24 (50)	31 (39)	.044
Social comparison		1 (5)	1 (6)	12 (25)	14 (17)	.088
Normative influence		0 (0)	0 (0)	1 (2)	1 (1)	1.000
Social facilitation		14 (74)	5 (31)	24 (50)	43 (52)	.046
Cooperation		1 (5)	2 (13)	0 (0)	3 (4)	.041
Competition		0 (0)	1 (6)	0 (0)	1 (1)	.193
Recognition		0 (0)	1 (6)	2 (4)	3 (4)	.767
Total	*mean (sd)*	*6.0 (2.2)*	*5.6 (2.5)*	*5.4 (2.0)*	*5.6 (2.1)*	

[a] Based on Fisher's exact test. Note: results in *italics* present the mean (sd) and median number of elements used per intervention. Other results are presented as the number (%) of interventions that include a certain element.

Table 4. Predictors of adherence in a hierarchical multiple linear regression

Step	Variable	*B*	*SE B*	*Beta*	*P*
1	Constant	0.40	.06		<.001
	Chronic	0.04	.07	.07	.55
	Lifestyle	-0.17	.08	-.25	.025
	Study design	0.18	.06	.30	.007
2	Constant	0.25	.09		.006
	Chronic	0.07	.07	-.11	.34
	Lifestyle	-0.11	.08	-.16	.17
	Study design	0.16	.07	.28	.014
	Freq. interaction with counselor	0.04	.02	.28	.055
	Freq. interaction with system	0.01	.02	.03	.79
	Freq. interaction with peers	0.01	.02	.05	.63
	Phone	0.09	.06	.16	.17
	Face-to-face	-0.08	.12	-.08	.48
	SMS	0.04	.10	.04	.69
3	Constant	-0.04	.21		.85
	Chronic	0.08	.07	.13	.26
	Lifestyle	-0.07	.09	-.09	.47
	Study design	0.18	.06	.30	.005
	Freq. interaction with counselor	0.02	.02	.12	.31
	Freq. interaction with system	-0.02	.02	-.09	.42
	Freq. interaction with peers	0.01	.02	.05	.60
	Phone	0.13	.06	.26	.027
	Face-to-face	-0.08	.11	-.08	.47
	SMS	0.02	.09	.03	.81
	Intended usage	0.09	.05	.23	.057
	Setup	-0.15	.11	-.22	.18
	Updates	0.10	.03	.43	.004
	Duration	-0.00	.00	-.06	.63
4	Constant	-0.12	.19		.51
	Chronic	0.08	.06	.14	.20
	Lifestyle	-0.04	.08	-.01	.96
	Study design	0.15	.06	.26	.008
	Freq. interaction with counselor	0.04	.02	.22	.039
	Freq. interaction with system	-0.04	.02	-.22	.058
	Freq. interaction with peers	-0.03	.03	-.15	.34
	Phone	0.05	.06	.10	.37
	Face-to-face	-0.10	.10	-.10	.31
	SMS	0.02	.08	.02	.85
	Intended usage	0.11	.04	.27	.014
	Setup	-0.16	.10	-.23	.11
	Updates	0.09	.03	.40	.002

Duration	-0.00	.00	-.02	.88
Primary task support	-0.02	.03	-.11	.41
Dialogue support	0.09	.03	.36	.006
Social support	0.07	.04	.27	.095

Note R^2=.14 for step 1 (p=.08); ΔR^2=.10 for step 2 (p=.16); ΔR^2=.15 for step 3 (p=.006); ΔR^2=.15 for step 4 (p<.001); cumulative variance explained in the final (step 4) model: R^2= .55 (p<.001)

Discussion

In this systematic review we have attempted to synthesize the combined knowledge of eHealth researchers to gain insights into the factors that affect adherence to web-based interventions in the areas of chronic conditions, lifestyle and mental health. In this study, technology is viewed from a theoretical perspective and we have conceived adherence as an objective measurement that allows for comparison between different interventions.

Principal results

We included 101 publications describing research into 83 interventions. Mental health interventions (n = 48) constituted the largest part of these interventions. With regard to our first research question regarding the characteristics of web-based interventions, it appears that the typical web-based intervention is meant to be used once a week, is modular in set-up, is updated once a week, lasts for ten weeks, includes interaction with the system, a counselor and peers on the web, includes some persuasive technology elements, and circa 50% of the participants adhere to the intervention. However, to answer our second research question, there do appear to be differences between health care areas. Overall, lifestyle interventions are longer and less strict (more employ a free set-up, less frequent intended usage, fewer updates, less interaction) than interventions aimed at chronic conditions and mental health, which seems to result in lower adherence. Mental health interventions follow the weekly, modular format the most, with only one intervention using a free set-up. This may be explained by the difference in scope of lifestyle and mental health interventions; lifestyle interventions may be more oriented towards long-term changes, while mental health interventions are often aimed at treatment which is delivered in a short, strict format. However, interventions for a chronic condition are also aimed at a long-term change or goal, but these interventions are on average more strict than lifestyle interventions. More counselor involvement is likely to be an explanation, because these interventions are often offered in a health care setting and we saw a significant difference between these areas.

Regarding persuasive technology, we see that primary task support elements are most commonly employed, especially in interventions aimed at chronic conditions and lifestyle. Tunneling, which is a technological result of a modular set-up, is employed most often in mental health interventions and less frequently in lifestyle interventions, which is a logical

result of the differences in set-up between interventions in these areas. This finding is not surprising, taking into account that most mental health interventions are based on regular face-to-face therapy where psycho-education and behavior modification is usually delivered step-wise (see e.g. [3]). Tailoring, which is widely recognized as an important feature of effective health communication [35, 36], is used in one form or another in 88% of the interventions. Strikingly, rehearsal, which is also seen as very important in learning and behavior change [37, 38], is seldom employed. It may be that rehearsal is seen by the authors of the articles that are described as such an obvious part of an intervention that a description of this process is omitted from the description of the interventions, but if not, this should be a point of particular interest when (re)designing web-based interventions.

Only a mean of 1.5 out of a possible seven dialogue support elements are employed per web-based intervention. It should be noted that we have not coded the elements that may be present in email-like messages sent by a counselor because we feel that this is part of the counselor interaction and not so much a part of the dialogue support that Oinas-Kukkonen and Harjumaa [31] and Fogg [24] describe. Reminders are the most frequently employed element. Studies have shown the importance of reminders in increasing adherence and in increasing the effectiveness of web-based interventions [7, 39], therefore we found it striking that 26% of the interventions did not include reminders in some way. Suggestion was the second most frequently used element and was employed more in interventions aimed at chronic conditions than mental health. This seems likely to be due to the focus of the first area at coping with a condition and giving suggestions or strategies to achieve this, whereas in mental health interventions, the focus is often more curative to 'solve' a certain problem. Praise and rewards are seldom used, which may be a shortcoming when looking at the recent literature into serious gaming and gamification, where employing game-like strategies, as praise and rewards, are expected to have positive effects on the outcomes of health interventions [40, 41].

Social support is widely recognized as an important strategy in behavior change [42, 43] and it might be disappointing to see that, on average, only 1.2 out of a possible seven elements are used per web-based intervention. Social facilitation was used in more than half of the interventions, but here it must be noted that social facilitation means providing the opportunity to contact others using the same intervention; it does not say anything about whether the opportunity is actually used. In practical terms, this means that when an intervention includes a discussion board, social facilitation is employed, even when there are no posts on the discussion board. Social learning and social comparison were employed, for example through obligatory posts of exercise answers on a discussion board or by providing a story by a user (real or fictive) including how he or she dealt with the situation. Cooperation, competition, normative influence and recognition are seldom used and therefore provide areas in which web-based interventions might be improved. However, in

this study, social support did not affect adherence, so more research is needed to investigate whether or not this area provides added value.

Our third research question was about the percentage of participants that adheres to web-based interventions. We found an average adherence of 50%, which confirms that non-adherence rightly is an issue in web-based interventions. There was a wide range in the level of adherence, with six interventions scoring below 10% adherence and five interventions scoring 90% adherence or higher. Our last research question was aimed at determining which characteristics of web-based interventions relating to technology and interaction are related to better adherence. Using a hierarchical multiple linear regression, our final model explains 55% of the variance in adherence, which, in our view, is a substantial amount that provides valuable insights into the issue of adherence.

Interestingly, the first two models (including the context of the intervention and the interaction within the intervention) were not significant. It was only when aspects relating to the format of the intervention and the technology employed were entered that the model reached significance. In the final model, an RCT study, opposed to an observational study, significantly predicted better adherence. A likely explanation is found in the fact that the observational studies in our review were mainly small pilot studies and large real-life studies. Pilot studies are likely to show lower adherence rates because the interventions are not fully tested and are improved after the outcomes of the pilot are known. Real-life observational studies have been shown to have lower adherence rates, which suggests that the formal structure of a trial is important for participants to adhere to an intervention [34]. Furthermore, due to the selection processes of many RCTs it is likely that there is a difference in the participants in both settings which contributes to the difference in adherence. The frequency of interaction with a counselor was a significant predictor of adherence. This finding concurs with reviews of Brouwer [29], Schubart [30] and other studies (for an overview see [44]) that conclude that counselor or clinician support is related to greater exposure and engagement. Of the significant predictors in our study, this variable contributes the least. In our review, we have found no evidence that the frequency of interaction with peers is related to adherence. This is somewhat contrary to the results of Brouwer [29], who concluded that peer support was related to greater exposure, but in that study exposure was seen as the time visitors spend on the website, which is very different from our definition of adherence. Furthermore, in this study we coded the frequency of interaction, not merely whether there was any interaction or not. This resulted in 29% of interventions which were coded as 'yes, there is interaction with peers, but the frequency is unknown'. This frequency may vary to a large degree between these interventions, but without clear information, we cannot make a distinction, which may have influenced our results. In the final model, the frequency of interaction with the system seems to negatively influence adherence, although not significantly. This surprising finding may be explained by the fact that more interaction with the system meant, in many cases,

that there was no interaction with a counselor. More frequent intended usage also predicts better adherence. This might seem counterintuitive, but might also mean that when people are expected to be more active they become more engaged with the system. Moreover, more frequent intended usage will, in many cases, lead to more frequent reminders and we know that reminders can positively influence adherence [39]. That the provision of frequent updates is important was also seen in the review of Brouwer [29] and is confirmed in this study. Finally, more extensive employment of dialogue support is related to better adherence. This outcome was predicted by the persuasive system design model [31], but this study is, to our knowledge, the first to confirm this outcome related to adherence in a health setting. When looking at the other persuasive technology categories, we see that social support shows a trend towards a significant contribution to better adherence. We feel that this trend warrants further investigation. It might be that because of the limited use of social support elements in the included interventions, it has no significant predictive value in this study. Interestingly, primary task support does not show any predictive value for adherence. This may well be explained by the purpose of the employment of primary task support. As indicated in the name, these elements make the primary task (i.e. the goal of the intervention) easier, and are not so much focused on the process (i.e. using the intervention or adhering to the intervention). It seems likely that these elements play a more important role in the effect of the intervention than in the adherence.

A final comment on the model for the prediction of adherence is on the different health care areas. We see that in the first model, lifestyle interventions, as opposed to mental health interventions, predict a lower adherence, but when adding the characteristics of the interventions in the model, this predictive value is negated. It seems that the health care area *per se* does not predict adherence, but the differences in the characteristics of the interventions in these areas do predict adherence.

Implications and recommendations

Taking into account the results of this study, it seems reasonable to not only hope for adherence, but to plan for adherence when designing web-based interventions. Although 33 studies that are included in this review state that they have planned for adherence, it is remarkable that 18 state that encouraging adherence is a task for the counselor [45-62] and one study included monetary incentives to promote adherence [63]. Of the 15 studies that mention adapting the design of the intervention to increase adherence, eight do so without any theoretical basis or reference [64-71], four studies make the adaptation the focus of their study [72-75] and two studies have adapted the design based on a prior study on the same intervention [76, 77]. Overall, it seems that adapting web-based interventions to promote adherence is done in an ad-hoc manner and that a framework to guide researchers and developers in this area is needed. The PSD-model [31] may provide such a framework for the design of web-based interventions.

Moreover, it seems valuable to look much further than simply the health care area that the intervention is being designed for. Although each health care area has its own demands and limitations, the different areas might learn from each other's strong points. Lifestyle interventions, although aimed a long-term goals, might benefit from incorporating segments with a more strict format and shorter duration, while mental health interventions might think of extending an intervention to aim at more long-term goals like relapse prevention and therefore employ a less strict format, while being aware that adherence might become a larger problem. Moreover, mental health interventions might look at the primary task support elements used in chronic condition and lifestyle interventions to see whether there are elements here that might improve the effect of their own interventions.

Furthermore, we now have evidence that certain intervention characteristics and persuasive technology can improve adherence. It seems that expecting a certain amount of engagement from the target group can actually be helpful in promoting adherence and is something that seems to be easy to implement in new and existing web-based interventions. With regard to this, we must keep in mind that the effect of intended usage might also be due to a bias among the participants when only those participants who agree in advance with a high level of engagement participate in such interventions. Duration seems harder to change, but cutting an intervention into shorter segments may be enough to improve adherence, although this should be further investigated. Including and possibly increasing the frequency of interaction with a counselor seems a more costly way to improve adherence and might therefore, when specifically used as a strategy to increase adherence, be a less than optimal starting point. Increasing dialogue support using persuasive technology seems to be a more cost-effective vantage point in this respect and may even be enhanced by the increasing use of mobile technology which seems likely to, in turn, offer a valuable platform for introducing on-the-spot reminders and feedback.

Additionally, our results can be of value for blended care (i.e. a combination of online and face-to-face care) by clarifying the crucial aspects for promoting adherence in web-based interventions. When it is not possible to adapt a web-based intervention to promote adherence, it may be feasible to include a face-to-face segment in the overall intervention at a crucial stage to make up for the predicted loss of adherence.

The results of this study can be used to make an informed decision on how to design a web-based intervention that has a greater likelihood of being adhered to. It must be noted, however, that we do not advocate a so-called 'technology push' where technology is introduced only for the sake of the technology and the ability to create the technology. It should always be created in close collaboration with the target audience and with a clear goal to create a viable eHealth technology [12]. This study provides insights into the choices one can make with the target audience.

In this study we defined adherence as being the proportion of participants who use the intervention as it is intended to be used. By doing this, we have created an adherence

measurement from objective data which is comparable between interventions. We feel that the study shows that this is a promising approach and this adherence measurement can be used for a wide variety of studies. However, to date, few studies report adherence as the measurement we have chosen to use. For review studies, this means that researchers have to define the intended use, search for the usage data that corresponded to this intended use, and then calculate the adherence. This might lead to a different interpretation of the usage data than the original authors intended. However, from our experience, we can say that as long as there is enough information on the intervention and the usage, it is feasible to calculate an objective and comparable adherence measurement. For intervention studies, we would advise researchers to at least provide the information needed (i.e. intended usage and usage data related to this intended usage) to calculate this adherence measurement and preferably, to state the calculated adherence percentage for easy comparison between interventions.

Limitations

In this study, we have excluded many interventions because data about usage was absent or the usage data that was presented had no direct relationship to the intended use. For example, studies that only presented mean login data per week for all respondents and had an intended usage of once a week, were excluded, because these data do not show us which percentage of respondents logged in each week. This strict selection based on usage data might have introduced a bias in our included studies.

We have coded the web-based interventions included in this study based on the descriptions in the published literature. Although we have made an effort to find all the information in the published literature about each intervention, our coding was limited by the description of the interventions on paper. As is noted by other authors, the description of these interventions is very varied [12, 29, 30] which makes it difficult to capture all the characteristics of each intervention and this might have influenced our results. Initiatives to standardize and improve the description of web-based interventions like the Consort statement for eHealth [12], a protocol for systematic reviews in eHealth [33] and guidelines for executing and reporting internet intervention research [78] are therefore very necessary and will hopefully improve the possibility to compare eHealth technologies and learn from each other.

Lastly, a limitation of this review might be that we have only focused on the published literature. We have not included grey literature and have therefore included little real-life adherence data. As noted by Christensen [34] there is a difference between the usage of web-based interventions in a research setting and in a more real-life setting. We have tried to cope with this by using a strict definition of adherence, separating it from following the research protocol and filling out questionnaires and by coding all interaction which might be the result of being part of a study as part of the intervention. Nonetheless, the limited amount of real-life data in our review might have influenced the results.

Overall, our results confirm the conclusions of prior studies [29, 30] that interaction with a counselor and regular updates promote adherence. Furthermore, the results of this review elaborate on the role of intervention characteristics (duration, set-up, intended usage) and persuasive technology, especially elements to support the dialogue. Finally, this study has provided practical recommendations to increase adherence when (re)designing a web-based intervention.

Future research

The data and results from this study provide numerous points of departure for future research. To increase our understanding of the characteristics of web-based interventions and their effect on adherence, it would be interesting to compare interventions that show high adherence with interventions that show low adherence using in-depth, qualitative analyses. The positive deviance approach used by Schubart [30] seems appropriate for this goal. Furthermore, it is interesting to test our statistical adherence model in experimental studies. Additionally, expanding the model by including the characteristics of participants seems to be relevant. Finally, exploring the relationship between persuasive technology, especially primary task support, and (clinical) outcomes of an intervention is likely to be a worthwhile line of research.

Multimedia appendixes

Multimedia appendix 1. Keywords literature search
Multimedia appendix 2. Included interventions, targeted behavior or conditions, and studies
Multimedia appendix 3. Characteristics of, and adherence to, web-based interventions included in this study

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Multimedia appendix 1. Keywords literature search

Web-based	Intervention	Adherence	Health
web page	treatment	motiv*	health*
web application	intervention	attrition	behavio*
website	program	dropout	manage*
internet delivered	programme	drop out	self help
web based	therapy	adherence	self control
internet based	coach	nonadherence	selfmanagement
internet mediated		compliance	self care
internet supported		noncompliance	
online*		persist*	
medical informatics		response*	
Information technology		nonresponse	
e health		loyalty	
ehealth		engagement	
e therap*		disengagement	
telemedic*		involvement	
telecare		noninvolvement	
telehealth		reach	
e mental health		intention*	
emental health		satisfy*	

Multimedia appendix 2. Included interventions, targeted behavior or conditions, and studies

Intervention name	Behavior/Condition	Studies
Chronic Condition		
1. Van den Berg	arthritis	Van den Berg 2007 [45]; Van den Berg 2006 [79]
2. Teens Taking Charge	arthritis	Stinson 2010 [80]
3. Rheumates@work	arthritis	Lelieveld 2010 [81]
4. Oneself	chronic pain	Schulz 2010 [82]
5. WebMAP	chronic pain	Long 2009 [83]; Palermo 2009 [84]
6. SPAIN	CVD	Goessens 2008 [59]; Goessens 2006 [85]
7. DPP	diabetes	McTigue 2009 [60]
8. NetPLAY	diabetes	Liebreich 2009 [71]
9. My Path1	diabetes	Glasgow 2011 [70]
10. My Path2	diabetes	Glasgow 2011 [70]
11. YourWay	diabetes	Mulvaney 2010 [86]
12. 'Diabetergestemd'	diabetes	Van Bastelaar 2011a [77]; Van Bastelaar 2011b [87]
13. WebEase	epilepsy	DiIorio 2009 [88]
14. Rekindle	erectile dysfunction	McCabe 2008 [61]; McCabe 2009 [89]
15. Heartnet	heart transplant	Dew 2004 [90]
16. Ljottson	IBS	Ljottson 2010 [58]
17. MyMigraine	migraine	Sorbi 2010 [91]
18. EPP online	self-management	Lorig 2008 [92]; Lorig 2006 [62]
19. Andersson-T	tinnitus	Andersson 2002 [93]
Lifestyle		
20. 5 a Day, the Rio Grande Way	nutrition	Woodall 2007 [74]; Buller 2008 [68]
21. Active U	PA	Buis 2009 [94]
22. Fun, Food and Fitness Club	PA, nutrition	Thompson 2008 [75]; Thompson 2007 [95]; Baranowski 2003 [96]
23. Healthy Life Check	PA, nutrition, smoking cessation	Brouwer 2010 [97]
24. Happy Ending	smoking cessation	Brendryen 2008a [98]; Brendryen 2008b [99]
25. Lenert	smoking cessation	Lenert 2003 [100]
26. QuitCoach	smoking cessation	Balmford 2008 [101]
27. QuitNet	smoking cessation	Graham 2007 [102]; Saul 2007 [103]; Cobb 2005 [104]
28. Real U	smoking cessation	An 2008 [63]; An 2006 [105]
29. Health Partners	weight management	Van Wier 2009 [57]
30. Healthy Weight for Life	weight management	Cussler 2008 [69]

31. LEARN	weight management	Hunter 2008 [106]
32. Weight Loss Management	weight management	Meenan 2009 [107]; Svetkey 2009 [108]; Stevens 2008 [76]; Funk 2010 [109]
33. Step up, Trim down	weight management	Bennet 2010 [67]
34. Healthy Weight Assistant	weight management	Kelders 2011 [11]
35. SHED-IT	weight management	Morgan 2011 [110]
Mental Health		
36. BRAVE1	anxiety	March 2009 [66]
37. BRAVE2	anxiety	Spence 2011a [64]
38. Worry Program	anxiety	Titov 2009a [111]
39. Anxiety program	anxiety	Titov 2010a [112]
40. Andersson-A	anxiety	Andersson 2011 [113]
41. Hedman	severe health anxiety	Hedman 2011a [50]
42. Down Your Drink	alcohol	Linke 2007 [114]; Linke 2004 [115]
43. 'Alcohol de Baas'1	alcohol	Postel 2010a [116]
44. 'Alcohol de Baas'2	alcohol	Postel 2010b [117]
45. M-PASS	alcohol	Bingham 2010 [118]
46. MORE	alcohol and drugs	Klein 2012 [119]
47. RealTeen	drug abuse prevention	Schwinn 2010 [120]
48. BEP1	bipolar disorder	Nicholas 2010 [121]
49. BEP2	bipolar disorder	Nicholas 2010 [121]
50. Everything under Control	depression	Van Straten 2008 [122]; Warmerdam 2008 [123]
51. Colour your Life1	depression	De Graaf 2009a [124]; De Graaf 2009b [125]
52. Colour your Life2	depression	Warmerdam 2008 [123]
53. Deprexis	depression	Meyer 2009 [126]
54. Master your Mood	depression	Gerrits 2007 [51]
55. MoodGym	depression	Christensen 2006 [127]
56. Sadness	depression	Perini 2009 [52]
57. MoodManager	depression	Mohr 2010 [46]
58. Vernmark	depression	Vernmark 2010 [47]
59. Wellbeing program	depression and anxiety	Titov 2011 [128]
60. Carrard1	eating disorder	Carrard 2011a [129]
61. Carrard2	eating disorder	Carrard 2011b [48]
62. Carlbring1	panic disorder	Carlbring 2005 [130]
63. Carlbring2	panic disorder	Carlbring 2006 [131]
64. Panic Center	panic disorder	Farvolden 2005 [132]
65. Panic Online1	panic disorder	Klein 2006 [133]; Richards 2006 [134]
66. Panic Online2	panic disorder	Richards 2006 [134]; Kiropoulos 2008 [135]; Klein 2009 [136]
67. Panic Online3	panic disorder	Klein 2009 [136]
68. Interapy	panic disorder	Ruwaard 2010 [137]

69. Panic program	panic disorder	Wims 2010 [138]
70. PTSD program	PTSD	Spence 2011b [49]
71. PTSD online	PTSD	Klein 2010 [139]
72. Andersson-S1	social phobia	Andersson 2006 [140]; Tilfors 2008 [141]
73. Andersson-S2	social phobia	Tilfors 2008 [141]; Furmark 2009 [142]; Tilfors 2011 [143]
74. Andersson-S3	social phobia	Carlbring 2007 [144]
75. Andersson-S4	social phobia	Hedman 2011b [145]
76. IAR	social phobia	Furmark 2009 [142]
77. Shyness1	social phobia	Titov 2008a [55]; Titov 2008b [56]; Titov 2008c [54]
78. Shyness2	social phobia	Aydos 2009 [53]
79. Shyness3	social phobia	Titov 2008c [54]
80. Shyness4	social phobia	Titov 2009b [72]
81. Shyness5	social phobia	Titov 2009b [72]; Titov 2009c [73]
82. Shyness6	social phobia	Titov 2009c [73]
83. Shyness 7	social phobia	Titov 2010b [65]

Multimedia appendix 3. Characteristics of, and adherence to, web-based interventions included in this study

Intervention name *study level*	Intended usage	Actual usage	Setup	Up-dates	Duration (weeks)	Interaction[a]			Moda-lity[b]			Persuasive technology[c]			Adher-ence (in %)
						System	Care provider	Peers	1	2	3	PTS	DS	SS	
Chronic Condition															
1.Van den Berg *RCT*	return PA schedule at least 26/52 weeks	n = 44 high or sufficient PA schedule return rate	modu-les	weekly	52	none	1/week	FNS	+	-	-	b,c	k	r	52
2.Teens Taking Charge *RCT*	complete 12 modules and weekly phone calls with a coach within a maximum of 21 weeks	91% completed 12 modules	modules	weekly	12-21	none	more	FNS	-	-	+	b,c,e	j	r	91
3.Rheumates @work *RCT*	complete 17 lessons in 17 weeks	n = 14 completed the internet program	modules	weekly	17	FNS	1/week	less	+	-	+	b,c,d,f	j,k,m,n	r	82
4.Oneself *Observational*	login 11 times in 12 months	n = 516 used 0-10 times; n = 169 used 11-100 times; n = 63 used 101+ times	free	weekly	52	none	less	FNS	-	-	-	a,c	-	r	31
5.WebMAP *RCT*	complete 8 modules	20/26 completed all 8 modules	modules	weekly	8	more	1/week	none	-	-	-	b,c,d,e,g	j,l,m	p	77

6. SPAIN *Observational*	login frequently	n = 5 used <6 times; n = 13 used >=6 - <26 times; n=18 used >=26 - <41 times; n=14 used >=41 times	free	weekly	26	FNS	less	none	-	-	-	a,c,e	j	-	64
7. DPP *Observational*	complete 24 lessons	n = 8 completed 21-24 lessons	modules	biweekly	52	less	less	1/week	-	-	+	a,b,c,e	j,k	r	16
8. NetPLAY *RCT*	once a week for at least 8 weeks	n = 15 used at least once per week for a minimum of 8 weeks	modules	weekly	12	FNS	1/week	FNS	-	-	-	a,b,c,e	j,k	r	60
9. My Path1 *RCT*	login weekly	66% logged in weekly from 0 to 6 weeks; 44% logged in weekly from 6 weeks to 4 months	free	once in 4 months	16	more	FNS	FNS	-	-	+	a,b,c,e	j,k	r	44
10. My Path2 *RCT*	login weekly	74% logged in weekly from 0 to 6 weeks; 41% logged in weekly from 6 weeks to 4 months	free	once in 4 months	16	more	less	less	+	-	+	a,b,c,e	j,k	o,r	51
11. YourWay *RCT*	view 6 stories in 11 weeks	63% viewed all 6 stories	modules	biweekly	11	1/week	FNS	FNS	-	-	-	b,c,d,f	j,k,l	p,r	63
12. Diabetergestemd *RCT*	complete 8 lessons	n = 53 completed all 8 lessons	modules	weekly	8	1/week	1/week	FNS	-	-	-	a,b,c,e	j,l	o,r	42

13. WebEase *Observational*	complete 3 biweekly modules	n = 15 completed all 3 modules	modules	daily	6	FNS	none	FNS	-	-	-	a,b,c,e	-	r	43
14. Rekindle *RCT*	complete 5 modules in 10 weeks	n = 12 completed all 5 modules	modules	biweekly	10	none	less	none	-	-	-	b,e	j	-	30
15. Heartnet *Observational*	at least weekly	n = 10 used weekly or more often	free	none	17	none	FNS	FNS	-	-	+	a,b	k	r	42
16. Ljottson *RCT*	complete 5 steps in 10 weeks	n = 29 reached fifth step and engaged in exposure exercises	modules	weekly for first 5 weeks	10	none	weekly	FNS	-	-	+	b,c	j	r	74
17. MyMigraine *Observational*	complete 8 lessons in 10 weeks	n = 6 completed 8 lessons	modules	weekly	10	FNS	none	none	-	-	-	b,e	k,l	o	60
18. EPP online *Observational*	login several times a week	79% reached last session	modules	weekly	6	FNS	more	more	-	-	-	a,b,c,e	j,k	o,r,s	79
19. Andersson-T *RCT*	complete 6 modules	n = 26 finished treatment	modules	weekly	6	none	1/week	none	-	-	-	b,c,e	k	-	49

[a] FNS = Frequency Not Specified; less = less than once a week; more = more than once a week; [b] 1 = face to face; 2 = SMS; 3 = phone; [c] PTS = Primary Task Support; DS = Dialogue Support; SS = Social Support; a = Reduction; b = Tunneling ; c = Tailoring; d = Personalization; e = Self-monitoring; f = Simulation; g = Rehearsal; h = Praise; i = Rewards; j = Reminders; k = Suggestion; l = Similarity; m = Liking; n = Social role; o = Social learning; p = Social comparison; q = Normative influence; r = Social facilitation; s = Cooperation; t = Competition; u = Recognition

Intervention name *study level*	Intended usage	Actual usage	Setup	Up-dates	Duration (weeks)	Interaction[a]			Moda-lity[b]			Persuasive technology[c]			Adher-ence (in %)
						System	Care provider	Peers	1	2	3	PTS	DS	SS	
Lifestyle															
20. 5 a Day, the Rio Grande Way *RCT*	Login once a month	192 used at least once; of these mean login = 3.3; 75th percentile = 4; n = 48 used at least 4 times	free	monthly	17	less	none	none	-	-	-	a	k	-	13
21. Active U *Observational*	Login and enter monitoring data once a week	n = 2304 entered data for all 8 weeks of the program	free	weekly	8	1/week	none	FNS	-	-	-	c,e	j,k	s,t	31
22. Fun, Food and Fitness Club *RCT*	Login once a week and complete activities	Study 1 (I = 19): lowest logon % per week = 37%; Study 2 (I = 78) lowest logon % per week = 68%	modules	weekly	8	1/week	weekly	none	-	-	+	b,c,e,f	i,j,l,m	o,s	63
23. Healthy Life Check *Observational*	login multiple times	n = 4857 visited more than once	free	none	NS	FNS	none	none	-	-	-	b,c,e	-	-	6
24. Happy Ending *RCT*	400 contact moments	Study 1: n = 45 quit the intervention; Study 2: n = 57 quit the intervention	modules	daily	54	more	none	none	-	+	+	a,b,c,e	j,k	-	70
25. Lenert *Observational*	complete 8 modules	n = 10 completed all modules	modules	weekly	8	1/week	none	none	-	-	-	a,b c,e	j	-	20

26. QuitCoach *Observational*	Login at least 5 times	3% used at least 5 times	free	none	NS	less	none	none	-	-	-	a,b,c,e	j	-	3
27. QuitNet *Observational*	Login at least 4 times	Study 1: n = 425 used at least 4 times; Study 2: n = 115 used at least 4 times	free	none	NS	less	FNS	FNS	-	-	-	a,c,e,f	j	r	23
28. Real U *RCT*	20 weekly visits	n = 172 visited weekly	modules	weekly	30	1/week	none	1/week	-	-	-	b,c,e	j	o,u	67
29. Health Partners *RCT*	complete 10 biweekly modules	18% was counseled for 10 modules	modules	biweekly	20	less	less	none	-	+	-	a,b,c,e	j	-	18
30. Healthy Weight for Life *RCT*	Login and enter data once a week	39% used diet log at least weekly	free	FNS	52	none	FNS	1/week	-	-	-	a,e	-	o,r	39
31. LEARN *RCT*	5 logins a week	Mean login 2 per week; 4th quartile 133.6±83.7 logins; n = 57 used at least 120 times	modules	weekly	24	1/week	1/week	none	-	-	+	b,c,e	-	-	25
32. Weight Loss Management *RCT*	login once a month	n = 212 logging in and having at least one weight entry for 26/28 months	free	weekly	130	1/week	FNS	FNS	-	-	+	a,b,c,d,e,f,g	i,j,k,m	r	61
33. Step up, Trim down *RCT*	using the website at least 3 times weekly	at least n = 22 with login goal each week	free	none	12	more	less	none	+	-	+	a,c,e	j,m	p,r	43

34. Healthy Weight Assistant *RCT*	biweekly visits	n = 4 logged in 6 times or more	free	FNS	12	less	none	none	-	-	-	b,c ,d, e	j	-	3
35. SHED-IT *RCT*	at least 7 weeks of submission of daily eating and exercise diaries and weekly check-ins	n = 14 complied	free	none	12	more	less	FNS	-	-	-	a,c ,e	m	r	41

[a] FNS = Frequency Not Specified; less = less than once a week; more = more than once a week; [b] 1 = face to face; 2 = SMS; 3 = phone; [c] PTS = Primary Task Support; DS = Dialogue Support; SS = Social Support; a = Reduction; b = Tunneling ; c = Tailoring; d = Personalization; e = Self-monitoring; f = Simulation; g = Rehearsal; h = Praise; i = Rewards; j = Reminders; k = Suggestion; l = Similarity; m = Liking; n = Social role; o = Social learning; p = Social comparison; q = Normative influence; r = Social facilitation; s = Cooperation; t = Competition; u = Recognition

Intervention name *study level*	Intended usage	Actual usage	Setup	Up-dates	Duration (weeks)	Interaction[a]			Moda-lity[b]			Persuasive technology[c]			Adher-ence (in %)
						Syste m	Care provider	Peer s	1	2	3	PT S	DS	SS	
Mental Health															
36. BRAVE1 *RCT*	complete 10 weekly sessions	n = 13 completed all sessions	modul es	weekly	10	more	1/week	none	-	-	+	b,c	j,k, m	-	32
37. BRAVE2 *RCT*	finish 10 sessions	39% finished 10 modules	modul es	weekly	12	more	1/week	none	-	-	+	b,c ,d, e,f	j,l, m	o	39
38. Worry Program *RCT*	complete 6 lessons in 9 weeks	n = 18 finished all lessons	modul es	weekly	9	more	1/week	FNS	-	-	+	b,c	j,n	o,r	72
39. Anxiety program *RCT*	complete 6 lessons in 8 weeks	n = 30 completed all 6 lessons	modul es	weekly	8	1/we ek	1/week	FNS	-	-	-	b,c	j,l	o,r	75
40. Andersson-A *Observational*	complete 10 self-chosen modules	n = 9 completed 10 modules	modul es	weekly	10	none	1/week	none	-	-	-	b,c ,d	j	-	33
41. Hedman *RCT*	complete all 12 modules	n = 14 completed 12 modules	modul es	weekly	12	none	1/week	FNS	-	-	-	b,c	j	r	35
42. Down Your Drink *Observational*	complete 6 lessons	Study 1: n= 79 completed all lessons; Study 2: n = 1654 completed all lessons	modul es	weekly	6	more	none	FNS	-	+	-	a,b ,c, e,f	j,k	r	15
43. Alcohol de Baas1 *Observational*	complete 12 week program	n = 173 completed treatment	modul es	weekly	12	more	more	FNS	-	-	-	a,b ,c, e	j	r	21

44. Alcohol de Baas2 *RCT*	complete 12 week program	n= 36 completed treatment	modules	weekly	12	more	more	FNS	-	-	-	a,b,c,e	j	r	46
45. M-PASS *RCT*	complete 4 online sessions	80% completed all 4 sessions	modules	weekly for 4 weeks	9	more	none	none	-	-	-	a,b,c,e	j,l,m,n	q	80
46. MORE *Observational*	finish 7 modules in 18 months	n = 58 accessed all 7 modules	modules	7 times in 18 months	78	less	less	FNS	-	-	+	a,b,c,e	j,k,m	r,u	5
47. RealTeen *RCT*	finish 12 modules in 6 weeks	n = 108 completed all 12 sessions	modules	twice weekly	6	more	none	FNS	-	-	-	a,b,c,d	i,l,m,n	o,p,r	92
48. BEP1 *RCT*	complete 8 modules	n = 80 completed 8 modules	modules	weekly	8	1/week	none	none	-	-	-	b	j,m	-	67
49. BEP2 *RCT*	complete 8 modules	n = 80 completed 8 modules	modules	weekly	8	1/week	FNS	none	-	-	-	b,c	j,m	o	81
50. All under Control *RCT*	complete 4 lessons	Study 1: n= 59 completed whole course; Study 2: n = 33 completed whole course	modules	weekly	5	1/week	1/week	none	-	-	-	a,b,c	j	o	47
51. Colour your Life1 *RCT*	complete 8 sessions and a booster sessions 12 weeks later	n = 14 completed 8 sessions	modules	weekly	9	1/week	none	none	-	-	-	b,e	-	-	14
52. Colour your Life2 *RCT*	complete 8 sessions and booster 12 weeks later	n = 34 completed whole course	modules	weekly	9	1/week	1/week	none	-	-	-	a,b,c	j	-	39

53. Deprexis *RCT*	complete 9/12 modules	n = 46 completed 9 modules	free	none	9	FNS	none	none	-	-	-	b,c	k,n	-	14
54. Master your Mood *Observational*	complete 8 lessons	n = 50 completed all sessions	modules	weekly	8	none	more	1/week	-	+	-	b,c	j	p,r	26
55. MoodGym *RCT*	complete 5 modules	n = 9 completed 5 modules	modules	weekly	6	none	none	none	-	-	-	b	l	-	2
56. Sadness *RCT*	complete 6 lessons in 8 weeks	n = 20 completed all lessons	modules	weekly	8	none	1/week	1/week	-	-	+	b,c	j,l	o,p,r	74
57. MoodManager *Observational*	complete 6 modules and fill out self-management tools daily	n = 19 completed 6 modules	modules	weekly	6	more	more	none	-	-	+	a,b,c,e	j,k,m	-	91
58. Vernmark *RCT*	finish all 7 modules in time	n = 17 finished in time	modules	weekly	8	1/week	1/week	none	-	-	-	b,c	j	-	59
59. Wellbeing program *RCT*	complete 8 lessons in 10 weeks	n = 30 completed all 8 lessons	modules	weekly	10	more	1/week	1/week	-	-	+	b,c	j,k,l	o,p,r,u	81
60. Carrard1 *Observational*	complete 7 modules	n = 40 completed all 7 modules	modules	biweekly	16	FNS	1/week	none	-	-	-	a,b,c,e	l	o	31
61. Carrard2 *RCT*	complete 11 modules in 6 months	n = 25/74 completed 11 modules	modules	biweekly	26	FNS	1/week	none	-	-	+	a,b,c,e	j	-	34
62. Carlbring1 *RCT*	complete 10 lessons and post in the bulletin board	28% finished all modules within the timeframe	modules	weekly	10	1/week	1/week	1/week	-	-	-	b,c	-	o,r	28

63. Carlbring2 *RCT*	complete 10 lessons and post in the bulletin board	80% finished all modules within the timeframe	modules	weekly	10	1/week	more	1/week	-	-	+	b,c	j	o,r	80
64. Panic Center *Observational*	complete 12 lessons	n = 12 completed the 2 week program	modules	weekly	12	1/week	FNS	FNS	-	-	-	b,e	-	r	1
65. Panic Online1 *RCT*	complete 6 modules	Study 1: n= 18 completed all modules; Study 2: n = 10 completed all modules	modules	weekly	8	none	more	none	-	-	-	a,b,c	-	-	90
66. Panic Online2 *RCT*	complete 8 modules	Study 1: n= 10 completed all modules; Study 2: n = 41 completed all modules; Study 3: n = 22 completed all modules	modules	weekly	12	none	more	none	-	-	-	a,b,c	j	-	86
67. Panic Online3 *RCT*	complete 8 modules	n= 21 completed all modules	modules	weekly	12	none	1/week	none	-	-	-	a,b,c	j	-	72
68. Interapy *RCT*	complete 7 modules in 11 weeks	n = 47/58 completed treatment Note: waiting list had access to intervention after intervention period	modules	at least biweekly	11	none	more	none	-	-	-	b,c,e	k	-	81

69. Panic program *RCT*	complete all 6 lessons	n = 23 completed all 6 lessons	modules	biweekly	8	none	less	less	-	-	+	b,c	j,l	o,p,r	79
70. PTSD program *RCT*	complete all 7 lessons in 8 weeks	n = 18 completed all 7 lessons	modules	weekly	8	more	1/week	FNS	-	-	+	b,c	j,k	o,r	78
71. PTSD online *Observational*	complete 10 modules in 10 weeks	n = 16 completed the program	modules	weekly	10	none	1/week	none	-	-	-	b,c	k	-	73
72. Andersson-S1 *RCT*	complete 9 modules + post on bulletin board once a week	Study 1: n= 8 completed all modules; Study 2: n = 18 completed all modules	modules	weekly	9	1/week	1/week	1/week	+	-	+	b,c	j	o,r	51
73. Andersson-S2 *RCT*	complete 9 modules + post on bulletin board once a week	Study 1: n= 10 completed all modules; Study 2: n= 37 completed all modules; Study 3: n= 0 completed all modules	modules	weekly	9	1/week	1/week	1/week	-	-	+	b,c	j	o,r	48
74. Andersson-S3 *RCT*	complete 9 modules + post on bulletin board once a week	n= 27 completed all modules	modules	weekly	9	1/week	more	1/week	-	-	+	b,c	j	o,r	93
75. Andersson-S4 *RCT*	complete 15 modules	n = 19 completed all modules	modules	weekly	15	1/week	1/week	none	-	-	-	b,c	j	-	30

76. IAR *RCT*	complete 9 modules + post on bulletin board once a week	n = 10 completed all modules	modules	weekly	9	1/week	1/week	1/week	-	-	-	b,c	j	o,r	34
77. Shyness1 *RCT*	complete 6 lessons and post on bulletin board	Study 1: n= 39 completed all lessons; Study 2: n = 33 completed all lessons; Study 3: n = 24 completed all lessons	modules	weekly	10	none	more	1/week	-	-	+	b,c	j,l	o,p,r	79
78. Shyness2 *Observational*	complete 6 lessons and post on bulletin board	n = 14 completed all lessons	modules	weekly	8	none	more	1/week	-	-	+	b,c	j,l	o,p,r	74
79. Shyness3 *RCT*	complete 6 lessons and post on bulletin board	n= 10 completed all lessons	modules	weekly	10	none	none	1/week	-	-	-	b	l	o,p,r	33
80. Shyness4 *RCT*	complete 6 lessons	n= 56 completed all lessons	modules	weekly	8	more	none	none	-	+	-	b,c	j,l	o,p	67
81. Shyness5 *RCT*	complete 6 lessons	Study 1: n= 66 completed all modules; Study 2: n = 34 completed all modules	modules	weekly	8	more	1/week	none	-	+	+	b,c	j,l	o,p	78
82. Shyness6 *RCT*	complete 6 lessons and post on bulletin board	n= 31 completed all lessons	modules	weekly	8	more	1/week	1/week	-	+	-	b,c	j,l	o,p,r	76

83. Shyness 7 *RCT*	complete all 8 lessons in 11 weeks	n = 71 completed all 8 lessons	modules	weekly	11	more	none	none	-	-	-	b,c	j,l	o,p	64

[a] FNS = Frequency Not Specified; less = less than once a week; more = more than once a week; [b] 1 = face to face; 2 = SMS; 3 = phone; [c] PTS = Primary Task Support; DS = Dialogue Support; SS = Social Support; a = Reduction; b = Tunneling ; c = Tailoring; d = Personalization; e = Self-monitoring; f = Simulation; g = Rehearsal; h = Praise; i = Rewards; j = Reminders; k = Suggestion; l = Similarity; m = Liking; n = Social role; o = Social learning; p = Social comparison; q = Normative influence; r = Social facilitation; s = Cooperation; t = Competition; u = Recognition

Chapter 4

Development of a web-based intervention for the prevention of depression

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Development of a web-based intervention for the prevention of depression.
Submitted

Abstract

Background: To reduce the large public health burden of the high prevalence of depression, early interventions targeted at people at risk are essential and can be cost-effective. Web-based interventions are able to provide this care, but there is no agreement on how to best develop these applications and often the technology is seen as a given. This seems to be one of the main reasons that web-based interventions do not reach their full potential. The current study describes the development of a web-based intervention for the prevention of depression, employing the CeHRes (Center for eHealth Research and Disease Management) roadmap. The goals are to create a user-friendly application which fits the values of the stakeholders and to evaluate the process of development.

Methods: The employed methods are a literature search and discussion in the contextual inquiry; interviews, rapid prototyping and a requirement session in the value specification stage; and user-based usability evaluation, expert-based usability inspection and a requirement session in the design stage.

Results: The contextual inquiry showed that there is a need for easily accessible interventions for the prevention of depression and web-based interventions are seen as potentially meeting this need. The value specification stage yielded expected needs of potential participants, comments on the usefulness of the proposed features and comments on two proposed designs of the web-based intervention. The design stage yielded valuable comments on the system, content and service of the web-based intervention.

Conclusions: Overall, we found that by developing the technology, we successfully (re)designed the system, content and service of the web-based intervention to match the values of stakeholders. Key lessons we have learned from the process evaluation were: involving users, experts, researchers, designers and programmers in the development process seemed to create commitment and a sense of ownership from all stakeholders; to prevent confusion and time delays, it is important to specify the roles of the multidisciplinary team in advance; research is a part of the development process, but additionally provides the overview of the project as a whole; each project has its own preconditions, but only when explicating these preconditions, they can be managed.

Keywords

Development; Web-based intervention; depression; prevention; process evaluation; Acceptance and Commitment Therapy

Background

To reduce the large public health burden of the high prevalence of depression, early interventions targeted at people at risk are essential and can be cost-effective [1, 2]. However, recruiting participants for interventions to prevent the onset of depressive disorders is quite a challenge [3]. According to Cuijpers et al. (2010), there are three groups of reasons for this challenge: reasons within the participants (e.g. unwilling to participate due to the stigma associated with depression); reasons within the health care system (e.g. limited capacity for preventive services in mental health care); and reasons associated with the communication about these services (e.g. lacking awareness of preventive services in potential participants and health professionals). Developing and implementing web-based preventive interventions provides an opportunity to overcome this challenge by tackling the reasons for the low participation rates [3-5]. For example, web-based interventions can decrease the stigma associated with a (mental) health condition by providing a certain degree of anonymity [6, 7]. Advantages of web-based interventions can be seen not only in the broader reach, but also in increasing convenience for the users, the opportunity to provide information in an interactive and timely manner and cost-effectiveness [7-9]. Meta-analyses have showed that these interventions, on average, are effective in reducing the severity of mental health complaints [10, 11].

However, not all web-based interventions show these positive effects. In many cases the effects are less than expected and the implementation of these interventions in regular care is lacking [5, 12-14]. It seems that the problem of non-adherence, i.e. participants not following the intervention protocol, is one of the issues behind the lacking effect [15, 16]. Studies have showed that better adherence is associated with better (clinical) outcomes of an intervention (see for a systematic review [17]). The reasons behind non-adherence are still unclear, although there are many proposed reasons. Important proposed reasons are: issues with the usability of the application [16]; issues regarding the attunement of the goals of the technology with the aims of the participants [13, 18]; and implementation issues as the lack of clarity in the costs-benefit structure and integrating the technology in usual care and daily life [19, 20].

Web-based applications are developed at a startling rate, but there is no scientifically underpinned agreement on how to best develop these applications [21]. Many web-based interventions seem to be designed ad hoc; there is a presumed problem for which technology is supposed to be the solution, or the technology is used as a starting point and is developed because of the technological possibility, not because of the needs of the target group. In many cases, the content of these web-based interventions has been the subject of research and consists of evidence-based therapies, but when creating a web-based intervention based on this content, the technology is seen as a given. This ad hoc design and a lack of a holistic overview, in which the human and technological context is given a

prominent place, seems to be one of the main reasons that web-based interventions do not reach their full potential in terms of adherence and outcomes [13, 21, 22].

In a recent viewpoint paper [13] a holistic framework to improve the uptake and impact of eHealth technologies was proposed. This framework is aimed at overcoming the problems described in the earlier paragraphs. The framework is based on persuasive technology theories, human centered design approaches and business modeling. Persuasive technology refers to the capacity of technology to influence behavior and is used in eHealth research to understand the role of technology in changing behavior [23, 24]. Human centered design advocates the systematic, continuous consultation of potential users during the whole design process [25] and has been shown to have a positive effect especially on user satisfaction and on fitting to user needs [26]. Business modeling stems from commercial strategic management [27] and focusses on value creation with stakeholders. In eHealth this approach can be used to make the development of eHealth technology value-driven, i.e. creating technology that matches the values of and makes sense to the different stakeholders [20].

In this paper, we describe a study into the development of a web-based intervention for the prevention of depression, employing the CeHRes (Center for eHealth Research and Disease Management) roadmap for the development of eHealth technologies, which is included in the holistic framework introduced in the previous paragraph [13]. This roadmap is presented in Figure 1 and consists of six research and development activities. Our study is focused on the first steps of development: contextual inquiry, value specification and design. According to the roadmap, each development process should have multidisciplinary project management that facilitates between the creators and the users of the technology. In this study, the project management team consisted of researchers, a clinical psychologist working at the University and at a mental health institute, a developer of the course 'Living to the full' (which is the basis for the content of the web-based intervention) who is working at the University, a web-designer and technical programmers.

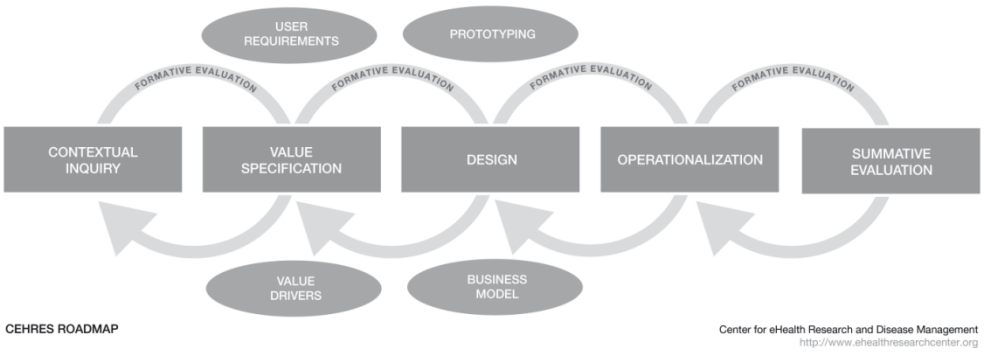

Figure 1. CeHRes Roadmap for eHealth development

In the contextual inquiry, information is gathered from the intended users and their environment to see whether there is a need for technology and how this technology might fit into the daily routines of the intended users. In this study, this is done by conducting a literature scan, combined with discussions with the project management team. In the design step, (a prototypical version of) the technology is developed, based on the requirements. The framework states that the quality of the design can be assessed at the levels system quality (user friendly application that matches the end-users' role and task), content quality (providing meaningful and persuasive information) and service quality (providing an adequate and feasible service that fits the context) [29]. In our study, this was done by conducting an expert-based usability inspection, a user-based usability evaluation and a requirement session with the project development team.

The goal of this study is twofold. The first goal is to create a user-friendly application which fits the values of the stakeholders and which can be implemented in daily routine. Our second goal is to evaluate the process of development. The significance of this study is obvious for the application being developed, but additionally, the results regarding the actual application and the process of development can be used as a vantage point when developing similar web-based applications.

In the following sections, of each step of the CeHRes roadmap that we undertook, the method, results and conclusion will be described. We have chosen to present these sections per step, to increase clarity and to retain the iterative process of the development.

Contextual inquiry

Methods

To gain a better insight in the context of web-based interventions for the prevention of depression, we performed a literature search. Specific goals of the literature search were: gaining insight in the need for a web-based intervention for the prevention of depression, in features that might enhance the effect of a web-based intervention, and in the effectiveness of the course that provides the content for the web-based intervention. Additionally, we discussed the goals of the project and the needs of project team with the project management team.

Results

The literature search showed that there is a supposed need for easily accessible interventions for the prevention of depression [2, 3, 5, 30-33]. Web-based guided self-help interventions are frequently mentioned as potentially meeting this need [3, 5, 30, 33]. However, this need is mostly stated by care professionals and researchers, for the intended clients. Nonetheless, a recent study on the effectiveness of a self-help intervention for the prevention of depression with email support conducted at our University showed

overwhelming numbers of interested participants [34]. This supports the need for these interventions found in our literature search.

Our literature search for features that might enhance the effect of a web-based intervention found strong indications that providing support is essential for an intervention to be effective [35, 36]. Furthermore, there is indicative evidence for the effectiveness of using additional text messages to communicate with participants [37]. This is strengthened by the results of a systematic review that shows that periodic prompts can enhance the effectiveness of web-based interventions [38]. Lastly, diaries for self-monitoring have been shown to be successful in a variety of mental health conditions [39] and have been advocated as a useful persuasive technology feature [23, 24].

The content of the web-based intervention that will be developed, is based on the self-help book 'Living to the full' [40]. This intervention is based on acceptance and commitment therapy (ACT; [41]) and mindfulness [42, 43], and targets experiential avoidance that can be considered as a generic risk factor for mental illnesses [44]. The intervention has been shown to be effective in reducing depressive symptoms using a group format and using a guided self-help format with email support by a counselor [34, 45, 46].

From the discussion of the goals of our development study and the needs of the project team, we concluded that the web-based intervention that will be developed, is, at this stage, primarily a research tool. This means that for the implementation, there is no concrete planned setting apart from the research setting at our University. It was deemed important that the intervention can be easily adapted at a later stage to incorporate the needs and values of future implementation settings, which might be mental health organizations and an ambulant care center at the University.

Conclusion

A web-based intervention for the prevention of depression based on 'Living to the full' seems to be answering a need for an effective low threshold intervention, but this need has to be confirmed by the intended users. Text message coaching, an online diary and providing support are likely to be useful features of such an intervention, but this has to be verified in the target audience. Furthermore, because of the choice for a research implementation setting, researchers are deemed an important stakeholder group and, in this stage, care providers are less prominent in the development process. The intervention needs to be developed to be easily adaptable to future implementation settings, but the main goal at this stage is to create a client-centered intervention. Therefore, in the next development steps, care providers will not be included as a stakeholder group, the target users will be the most important stakeholder and the researchers will take the lead in the project management team.

Value Specification

Methods

In this stage it was determined which values (in this respect, values are anything that a stakeholder deems important related to the goals of the web-based intervention and can be socio-economical as well as behavioral) the prospective users deem important and how they could be implemented in the design of the intervention. This was done by investigating the expected needs of prospective end-users , i.e. people with mild depressive symptoms who were willing to participate in a preventive intervention, using interviews combined with rapid prototyping. Needs are seen as an amplification of the often more abstract values and are expected to be easier voiced by the participants. To translate the expected needs into requirements, a requirement session with the project management team was held.

Interviews combined with rapid prototyping

Semi-structured interviews were performed to identify general expected needs of the target group and specific expected needs regarding the usefulness of the features that came forward in the contextual inquiry. The interviews were combined with rapid prototyping [28]. In total, 18 interviews were conducted, which was a similar number of participants used in the study described by Kinzie et al. [28]. The interview participants were people that were interested in participating in a previous study into the effectiveness of 'Living to the full' as a guided self-help format with e-mail support [34], but could not enroll in that study because the maximum number of participants was reached. All participants received a gift voucher for their participation. Prior to the interview, the interviewer explained the goal and process of the interview, obtained permission to audio record the interview and each interviewee signed an informed consent. A typical interview lasted about 45 minutes.

The interview scheme was based upon eHealth and Human Centered Design literature [13, 28, 47, 48] and consisted of three parts. Part one focused on previous experience with the content of the intervention and with web-based interventions in general to assess the background and experience of the participants. Additionally, the expected needs were discussed by asking three cruxes that the web-based intervention had to satisfy and one aspect that would be a reason to quit (or not to start) the intervention. Rapid prototyping was part two of the interview and focused on the usefulness of three features that were available as a paper prototype, i.e. text message coaching, online diary and support in the form of a feedback message. Furthermore, satisfaction with the design and usefulness of the general application was assessed by asking the participants to comment on two different designs of a general home page, a personal homepage and a page with an assignment within the course. The general homepage of the first design and the personal

homepage of the second design are presented in Figure 2. All paper prototypes can be found in Additional file 1. Part three assessed demographics, such as age, education and internet experience. The interviews were analyzed within 48 hours after the interview had taken place [49]. We used an inductive thematic analysis to identify patterns in the responses [50]. All analyses were done by two independent coders (SK and MO).

Figure 2. Paper Prototypes: General Homepage, First Design (Left); Personal Homepage, Second Design (right)

Requirement session

The results of the interviews and rapid prototyping were communicated to the designers and programmers by means of a report written by the researchers. The report consisted of the thematic analyses of the responses of the participants. The responses were summarized and quantified where possible, but no interpretation was made by the researchers. During the discussion of the results with the project development team, the responses were translated into requirements. The researchers addressed the expected needs and categorized comments of the participants, and clarified them when they were unclear to the designers and programmers. The designers and programmers used their expertise to fit the expected need or comment in a requirement. The researchers verified whether the requirement did truly meet the expected need or comment by checking the actual comments as they were expressed by the participants.

Results

Participants

The mean age of the 18 participants was 45 years (range 26-62, sd = 10), 78% (n = 14) was female and 78% (n = 14) completed at least higher vocational education. Of the participants 50% (n = 9) had no experience with mindfulness or meditation, 33% (n = 6) had experience with meditation, 6% (n = 1) had experience with mindfulness and 11% (n = 2) had experience

with the course 'Living to the full'. Self-reported experience with using the Internet was high for 39% (n = 7), medium for 56% (n = 10) and low for 6% (n = 1) of the participants. After the interview 78% (n = 14) indicated that they would use the course when available as a web-based intervention, 6% (n = 1) would not use the application and 17% (n = 3) were not sure whether they would use the application or not.

Expected needs

The expected needs that were mentioned by the participants were inductively categorized (Table 1; see Additional file 2 for an overview of the specific expected needs). Almost all participants (n = 17) expected a need for professional support and feedback. These needs were formulated as for example 'The system needs to provide contact with a counselor' (n = 8) or 'The application needs to provide feedback on your progress' (n = 8). A need specifically targeted at the system itself was expected by 78% (n = 14) . 'The application needs to be user friendly' was the most often mentioned need (n = 12). Content needs were expected by 13 participants (72%), where they most often needed the content to have added value (n = 8) and be effective (n = 6). A service need was expected by 56% (n = 10) . Service needs related to the process of receiving care through technology, for example 'The course needs to have a flexible time planning'(n = 5) or 'The course needs to have a fixed endpoint' (n = 3). Finally, 8 respondents (44%) expected a need for contact with others using the application (peer support).

Table 1. Categories of Expected Needs of Prospective Users

Category	**n**	**%**
Professional support and feedback	17	94
System	14	78
Content	13	72
Service	10	56
Peer support	8	44

Usefulness of features

Of the participants, 67% (n = 12) indicated that they would use text message coaching. 11% (n = 2) would not use this feature and for the remaining 22% (n = 4) using this feature would depend on the content of the text messages. Reminders (n = 11) are seen as the most useful content for the text messages, although assignments (n = 6) and motivation (n = 4) were also seen as useful content. The possibility of an online diary was received with mixed reactions. Of the respondents, 44% (n = 8) would definitely use it and saw it as a pleasant addition. However, 56% (n = 10) would only use the diary when it is a part of an assignment in the course. All respondents indicated that support in the form of feedback messages would be useful and essential. Feedback is expected on assignments, but furthermore, it

could be useful for gaining new insights, support and motivation. Several respondents (n = 5) stress the importance of the feedback being personal.

Feedback on design

For both the homepage and the exercise, the first paper prototype was preferred (56% and 77% respectively). Positive associations with the first prototype were 'professional' (n = 5), 'calm' (n = 5) and 'clear' (n = 3). Negative associations were less common, but 'bleak' was mentioned by 2 respondents. For the second prototype the most mentioned association was 'busy' (n = 5), followed by 'cheerful' (n = 4). Furthermore, comments of the participants on both paper prototypes regarded the appropriateness and attractiveness of the used images, shapes, header, color, font, text, buttons, menu structure and process indicator. An example of the written comments of two participants on two paper prototypes is presented in Additional file 3.

Requirement session

The results of the interviews were discussed with the project development team as described in the method. The expected needs of the participants that were not yet met in the design of the web-based intervention, were discussed regarding urgency, feasibility and desirability according to the stakeholders (participants, researchers, designers and programmers). This resulted in requirements regarding the system, the service and peer support, where for example for peer support, it was chosen not to fully incorporate the need of the participants for 'contact with others using the application' but to include prewritten experiences of people who used the self-help book 'Living to the full'. The comments of participants regarding the appropriateness and attractiveness of the used images, shapes, header, color, font, text, buttons, menu structure and process indicator were discussed and translated into requirements that were implemented in the prototype. Finally, a time planning for building the prototype was agreed upon, including another requirement session where the progress was discussed.

Conclusion

The most expected needs of the participants were related to professional support and feedback, which shows that it is important for a web-based intervention to provide some form of counseling and not to expect that all participants will be able to follow a web-based intervention on their own. This concurs with literature that shows that web-based interventions that include support are more effective than web-based interventions without support [35]. Furthermore, needs related to the system and the content were expected by 78% and 72% respectively, which underscores the importance of a user-friendly application and content that has added value. The expected service needs relate to the proposed advantages of online interventions regarding flexible time planning and independence of time and place. Griffiths et al. (2006) emphasize the need and expectation of participants

that a web-based intervention will fulfill these advantages. The need for peer support was mentioned by less than half of the participants, which concurs with a study that found that a minority of patients actually engages in online peer support [51].

Regarding the usefulness of features, we can conclude that text message coaching was regarded a useful feature of the web-based intervention, as long as the content of the text messages serves as a reminder, an assignment or is motivational. An online diary can be useful, under the condition that the diary is embedded in assignments. Moreover, support in the form of feedback messages is deemed essential by the participants for a web-based intervention for the prevention of depression, which concurs with the need for professional support and feedback that was mentioned by almost all participants. It seems that the desired features closely mirror traditional face-to-face interventions, supplemented with features technology can offer, which might be explained by the image participants have of (face-to-face) mental health care.

Regarding design, we can conclude that both versions of the paper prototypes yielded valuable comments and recommendations, and that the participants preferred the first prototype, but would like to see the strong points of the second prototype added to the first prototype.

The requirement session proved to be a constructive way to discuss the results of the interviews and rapid prototyping and to efficiently transform the qualitative results into requirements while keeping the perspectives of the different stakeholders in mind.

Design

Methods

A working prototype of the web-based intervention was developed according to the requirements specified in the value specification stage. The prototype consisted of the registration procedure, the first lesson of the course and the personal home page with the features: testimonials, diary, text message coach, overview of completed assignments and overview of feedback. The prototype was evaluated on system quality, content quality and service quality by conducting an expert-based usability inspection and a user-based usability evaluation. In line with the recommendation by Jaspers (2009), we have chosen to employ both a user-based and an expert-based evaluation method. We have investigated issues identified by these methods and the overlap of identified issues by both methods. This knowledge will help us make founded choices on which methods to use in similar development processes. Issues that came forward using these evaluation methods were combined to points for improvement, which were discussed with the development team to translate these points into requirements and prioritize these requirements.

User-based usability evaluation

We employed a scenario-based think aloud protocol [52], i.e. prospective users were guided through the application by means of scenarios that pose a problem or task that may be solved or completed by using the program, and respondents were instructed to verbalize their thoughts during the whole test. We conducted usability tests with ten prospective users, which is deemed sufficient to identify the main usability problems [53]. Participants were recruited using online advertisements and were part of the target group of the web-based intervention. All participants received a gift voucher for their participation. Prior to the usability test each participant signed an informed consent. All usability tests were recorded and coded retrospectively. The material (audio and video) was reviewed and comments were identified by the researcher. Comments were defined as relevant verbalizations of a thought, problems encountered by the participants, tasks that were completed smoothly and relevant feedback the participant provided during the interview. These comments were analyzed using a coding scheme following the work of DeLone and McLean (2003) and Van Gemert-Pijnen (2011) which distinguishes between system quality, content quality and service quality. System quality refers to the user friendliness of the application, including the placement of buttons and the lay-out of the application. Content quality refers to the usefulness and persuasiveness of the information presented in the application, including spelling and understandability of all texts in the application. Service quality refers to the process of care given by the application, including the registration procedure and features that have (not) been included.

Expert-based usability inspection

The cognitive walkthrough method [52] was used to assess the usability of the application by experts. In a cognitive walkthrough, experts analyze and evaluate the steps a typical user would take when trying to reach a certain goal. Important in a cognitive walkthrough is that it is specifically guided by user tasks or goals. The experts that carried out the cognitive walkthrough were all eHealth researchers and were working at the University of Twente. One of the experts is a clinical psychologist and has expert knowledge about the target group. Issues were coded using the same coding scheme as used for user-based usability evaluation. To check for differences in coding, 20% of the results from the user-based usability evaluation and 20% of the results of the expert-based usability inspection were coded by two researchers (SK and JvG). The interrater reliability, measured by Cohen's kappa, was 0.84 for the categories 'content', 'system' and 'service', and 0.90 for the categories 'positive', 'neutral' and 'negative'.

Requirement session

The report written by the researchers contained the points for improvement which were the summarized comments from both evaluation methods. The points for improvement

were clustered along different parts of the prototype. For each point, the non-interpreted issue was present, but in some cases, a recommendation was added by the researcher, based on the results of the evaluation methods. During the discussion of the results with the project development team, the points for improvement were translated into requirements. The researchers addressed the points for improvement and clarified them when they were unclear to the designers and programmers. The designers and programmers used their expertise to fit the point for improvement in a requirement. The researchers checked whether the requirement did truly meet the point for improvement as it was expressed by the participants. Finally, a prioritization was made considering on the one hand the frequency and urgency of an issue and on the other hand the prediction of time and effort to implement the new requirement.

Results

Participants

The mean age of the 10 participants of the usability test was 38 years (range 24-53, sd = 11), 90% (n = 9) was female and 70% (n = 7) completed at least higher vocational education. The cognitive walkthrough was carried out by 8 participants, who can be categorized as usability experts (n = 7) and a target group expert (n = 1) [52].

Evaluation of system, content and service quality

In total, both methods yielded 476 comments, virtually equally distributed between the user-based and expert-based evaluation method (respectively 52% (n = 246) and 48% (n = 230)). Table 2 shows the distribution of the comments over system, content and service quality and the amount of positive (+), neutral (+/-) and negative (-) comments.

Table 2. Number of Comments Yielded From User-Based and Expert-Based Methods

	Users				**Experts**				**Total**
	+	**+/-**	**-**	**total**	**+**	**+/-**	**-**	**total**	
System	50	7	98	155	26	2	99	127	282
Content	18	7	35	60	7	2	57	66	126
Service	9	2	20	31	2	3	34	39	70
Total	77	16	153	246	35	7	190	232	478

Chi square analyses show that there were no significant differences in the distribution of comments on system, content and service between both evaluation methods ($\chi 2 = 3.57$; $p = .168$). There was a significant difference in the distribution of positive, neutral and negative comments between both evaluation methods ($\chi 2 = 22.9$; $p < .001$), where the user-based method yielded relatively more positive comments and the expert-based method yielded relatively more negative comments. Positive comments that arose from the user-based method were, for example, the ease of finding the story about the experiences of a

previous participant of the course (participant 3,4,6,7; system quality), the recognizability of the content of the first lesson (participant 3,7,10,11; content quality) and a positive comment on the possibility to keep a diary within the web-based intervention (participant 6; service quality). Positive comments from the expert-based method were for example the well-organized personal homepage (expert 1,7,8; system quality) and the readability of the text (expert 8; content quality). Neutral comments were aspects that were remarkable, but no positive or negative value was given. For example, participant 5 commented that you cannot go to the next page without filling in all the exercises, but this was neither perceived as positive or negative. All negative comments were clustered on subject and transformed into points for improvement, where multiple comments on the same subject were combined in one point for improvement. An overview of points for improvements that arose from the user-based method, the expert-based method and both methods can be found in Table 3.

The points for improvement ranged from very specific elements of system quality (for example: spaces and hyphens should be allowed when entering your phone number, user-based method; reduce the needed amount of scrolling on the registration page, both methods; increase the line spacing on page 4 of the registration, expert-based method) and content quality (for example: be consistent in using full stops in the table of contents of the lesson, user-based method; correct spelling errors in the text of the lesson, both methods; make the table of contents reflect the contents completely, expert-based method) to broader elements of service quality (for example: the options that the participant can choose from as reasons to enroll in the course are limited, both methods; improve the clarity of when a participant will be called as a part of the registration and screening procedure, expert-based method). Of the points for improvement, 49% came forward in both methods, 16% came forward only in the user-based method and 35% came forward only in the expert-based method.

Table 3. Points for Improvement From User-Based Evaluation Method, Expert-Based Evaluation Method and Both Evaluation Methods

	Users	Experts	Both	Total
System	16	25	22	63
Content	2	23	10	35
Service	0	6	6	12
Total	18	38	54	110

Requirement session

The points for improvement were discussed with the project development team, consisting of researchers, designers and programmers. Requirements and suggestions to meet the points for improvement were formulated. It was decided to build the full web-based intervention based on these requirements and suggestions. Furthermore, a detailed

planning was made of when which parts of the intervention would be ready and would be available for error-checking. Additionally, different points for improvement of service quality were discussed with the project management team (including a care provider and a developer of the course 'Living to the full') to reach a decision on how to implement these points for improvement. This was done, for example, for 'be clearer to participants on when telephone screening is needed for the registration procedure' and 'is it always necessary that an exercise is completed before a participant can go to the next page?'.

Conclusion

Both the user-based and the expert-based evaluation method yielded many comments on the system, content and service quality of the prototype of the web-based intervention, of which most comments were negative. This is not surprising, because the aim of both methods is to reveal problems with the quality of the prototype [52]. We chose to include positive and neutral statements as comments, to gain a broader overview of the quality of the prototype. Of the comments, 59% related to the quality of the system, which is again not surprising as the system is the main focus of both methods. However, the comments on content and service allow us to do a broader evaluation of the prototype than only on user-friendliness, which resembles our view to see a web-based intervention not only as a stand-alone tool, but as an intervention which is part of the context. When looking at the points for improvement, approximately the same distribution over system, content and service quality is seen. Points for improvement on system and content quality seem to be more specific, whereas the points on service quality tend to be more general and relate to the choices that have been or ought to be made regarding, for example, the target audience, screening procedure and the way intervention should be used.

An important advantage of the user-based method is that the participants are part of the target audience and this way the added value of the prototype can be assessed by the people who it matters to the most. This might explain the finding that the user-based method yielded more positive comments. The expert-based method yielded more negative comments, mostly on content and service quality, which indicates that the experts used their eHealth experience to inspect the prototype from a comprehensive perspective. On points for improvement, the quantitative value of the expert-based evaluation method is largest, with only 16% of unique points for improvement that would not have been found by using only this expert-based method. This is contrary to the overview of usability methods of Jaspers (2009) that states that the think aloud method revealed more severe and recurring problems than the cognitive walkthrough. However, according to Jaspers (2009) this can be explained by the small number of respondents in the cognitive walkthrough in these studies (no more than two). In our study, eight experts conducted the cognitive walkthrough, which may well have led to more unique points for improvement. Nonetheless, as stated earlier, the most important advantage of the user-based method is that the target audience assesses the prototype from their view and context, which is an

advantage that should be seized, if only to check whether the experts were successful in assessing the prototype form the point of view of an actual participant. The large overlap in results from both methods (49% of points for improvement were found in both methods) strengthen the idea that the experts successfully assessed the prototype from the point of view of a participant, but also have a more comprehensive view based on their experience.

The points for improvement were somewhat similar to the needs that were expected by the participants in the value specification stage. The categories system, content and service mirror the needs, but the points for improvements were most often a specification of these needs. For example, the need for a user friendly application was specified in many of the system-related points for improvement. The same holds for the content-related points for improvement, where for example the need for added value of the content of the intervention was specified in points for improvement like 'be clearer about the goal of choosing a picture that represents your motto'. The service-related points for improvement did not directly relate to the expected needs, but were related to the overall flow through the intervention. The professional support and feedback, and peer support needs were not seen in the points for improvement, which might indicate that these needs were satisfied. However, no specific attention was given to these parts of the prototype and support is likely to be more important when actually using an intervention as opposed to testing an intervention which may be reasons for not finding points for improvement on these aspects.

The requirement session was similar to the session in the value specification stage, only this time, there were more specific issues regarding system and content quality, which were relatively easy to implement in the final design of the web-based intervention. Furthermore, the multidisciplinarity of the project management team proved to be of value when discussing the points for improvement on service quality.

Discussion

This study was aimed at creating a user-friendly application which fits the values of the involved stakeholders and which can be implemented in daily routine, and at evaluating the process of development. In the next sections we will reflect on the goals related to the application and the process.

Application

By employing the CeHRes roadmap we have been able to attune the web-based intervention to the values of the involved stakeholders. In the contextual inquiry the project management team decided to focus the design of the application on the first implementation setting, namely a research environment. By specifying this choice, the most important stakeholders could be determined (users, researchers, designers and programmers). By clarifying the expected needs of the users and specifying requirements, a

foundation for evaluation of the web-based intervention has been established in that the evaluation should focus on the realization of these needs and requirements.

The results of this study can be of value to others who are developing a web-based intervention by taking our results as a vantage point. Especially for an intervention targeted at the same audience it is reasonable to believe that the expected needs are similar. Additionally, it may well be that the values we identified are generalizable to the target audience of other web-based interventions as the users of these interventions are most often similar (overrepresentation of highly educated females (e.g. [34]). However, our results should only be taken as a starting point and should be verified in the target audience of the intervention. The same can be said for the results on the usefulness of text message coaching, an online diary and feedback; the results of this study can be used as a starting point, but need to be verified in the context of the intervention to be developed.

Process

In both the value specification and the design stage we have used a multidisciplinary requirement session to translate the results (expected needs or points for improvements) into requirements. This requirement engineering step [54] proved to be a complex matter with limited prior research on how to exactly perform this step. One of the problems we encountered was the difference in methods and vocabulary between researchers on the one hand and developers and designers on the other hand. This issue is seen in many eHealth development processes [21] and remains important in interdisciplinary projects. Because of the continuous evaluation cycles and the stakeholder approach of the CeHRes roadmap, these differences were discerned at an early stage and could be resolved. A second issue with requirement engineering was that the relationship between a need or a point for improvement and a requirement is not always clear. For example, for the need 'The application needs to provide feedback on your progress' there is no one perfect requirement. In this study, the requirement was specified by the project development team, but the designers and developers had a large degree of freedom on how to implement the requirement. We did not use a standard way of documenting the requirements, but rather worked with reports that depicted the overall requirements. Although our method was less time-consuming, without a standard way of documenting requirements, it is harder to verify whether all requirements were implemented in a satisfactory way. More research is needed on the best way of translating values into requirements and on how to implement these in the design.

Another point regarding the multidisciplinary approach was project management. In our study, there was no formal project leader, instead one of the researchers took this role. Although this informal project management worked well most of the time, there were instances where the informal project leader did not have the authority to make certain decisions or the resources to be involved in all aspects of the development process. These

issues have led to time delays and confusion that could have been avoided when the project management had been discussed at the start of the project.

Notwithstanding these issues, the overall process of development was satisfactory. The combination of iterative stages provided more insights in the goals and processes of the technology we were developing than the separate stages. Each step yielded insights that build on the knowledge from earlier steps and shaped the next step. The holistic view, incorporating system, content and service as well as the perspectives and values of the different stakeholders provided the opportunity to investigate and develop the technology not as merely a tool, but as an essential part of the care it is intended to provide. However, the development process of this web-based intervention is not finished. Besides the evaluation of the intervention in the research context which will be done in future studies, the intervention needs to be redesigned for a different (care) setting. Therefore, and to assess which lessons can be learned from this development process, we will reflect on the working principles of the CeHRes roadmap.

eHealth technology development is a participatory process

Involving users, experts, researchers, designers and programmers in the development process seemed to create commitment and a sense of ownership from all stakeholders. Although this seems to have a positive effect on the developed web-based intervention and has been shown to be effective in other studies (e.g. [55]), whether the intervention actually reaches its goals will be evaluated in future research.

eHealth technology development involves continuous evaluation cycles

In this study, we have used three evaluation cycles of which two involved feedback from the end-users which have provided valuable information to adapt and improve the concept, prototype and actual intervention. It must be noted that the methods and steps we have described are not truly separate, but can be viewed as continuous. This entails that the results of a certain method can be used as input for a different step. For example, the interviews held in the value specification step, have also provided information on the context, which would, ideally be gathered in the contextual inquiry step. Moreover, in this study, we saw that the process itself advances the knowledge of project group. The ideas about the goals and mechanisms of the web-based intervention changed as the process of development progressed and the views of different stakeholders were integrated. The role of research in the process is twofold; on the one hand research is a part of the process, with its own methods and goals, on the other hand, research provides an overview of the project as a whole.

eHealth technology development is intertwined with implementation

In the contextual inquiry, it was decided that the primary implementation setting was research. This has led to choices in the used methods and involved stakeholders in the development process. In this respect, the development was intertwined with implementation in this study. However, the choice for research as an implementation setting was not ideal, because research is only an intermediate implementation setting, not a final, viable, long term setting. Nonetheless, in each project there are preconditions and only when explicating these preconditions, they can be managed.

eHealth technology development changes the organization of health care

In this case, the development of the web-based intervention did not in itself change health care, but it has explicated the process of health care for the prevention of depression. By making research the implementation setting, we have made the University the health care organization, while the University is not created as a health care organization. This has implications for the way the service of the intervention will be delivered.

eHealth technology development should involve persuasive design techniques

Interestingly, this principle came forward in the needs that were expected by the users. Users described to have a need to be supported by or through the web-based intervention (need for professional support and feedback). This is one of the goals of a persuasive design [24]. The need was also mentioned directly by the need for an attractive and encouraging design of the application. Persuasive features that were embedded in the developed application are for example text message coaching and feedback.

eHealth technology development needs advanced methods to assess impact

The methods used in this study seem to provide valuable feedback that reaches further than only comments on color or the lay-out of buttons and encompasses the context of the intervention. However, a large part of the content of the intervention was predefined and not subject to redesign. It might be valuable, in future studies, to focus more on the content to create a fit between the technology and the therapy of an intervention. This might need different methods or a different application of methods. A recent initiative to provide an overview of eHealth research and development methods on a Wiki-platform might help researchers to select the appropriate methods to attain their goals (http://www.ehealthwiki.org).

Furthermore, the results have provided a foundation for the evaluation of the impact by clarifying the needs the application needs to fulfill and the requirements that need to be met. However, we have not yet assessed the impact of the intervention. Future research will need to assess whether the target users will actually use the intervention and whether it has the intended effects. Therefore, it is important to employ methods to objectively

measure usage, provide qualitative feedback on the satisfaction of users and assess the (clinical) effectiveness. Furthermore, to assess the effects of different features of the intervention, experimental studies are needed.

Limitations

A limitation of this study is that it did not involve all stakeholders in all stages. The users were not involved in the contextual inquiry, while the CeHRes roadmap advocates this. We did conduct a literature search, but we have not assessed the actual need for a web-based intervention of the target audience. Furthermore, care providers have not been included as stakeholder in this study. This decision was the result of the contextual inquiry where we decided to take research as the implementation setting. We have coped with this limitation by including a care provider in the project management team and by making the application easily adaptable to a different care setting, but nonetheless, when developing this application further for a different implementation setting, care providers need to be involved.

We have not assessed whether developing a web-based intervention using the CeHRes roadmap is better than developing a web-based intervention in a different way. In our view, this will always remain an issue, because it seems difficult, if not impossible or undesirable, to develop two web-based interventions using different methods, but using the same ideas or content as a starting point. However, we can say that using the methods in this study, we have been able to clarify expected needs for this web-based intervention and we have been able to adapt the intervention to these needs. Additionally, future research will show whether the intervention reaches the intended effects and will provide information on how to redesign or refine the web-based intervention to better reach these effects.

Conclusion

This study has showed the importance of a structured development process of a web-based intervention for the prevention of depression because: (1) it allows the development team to clarify the needs that have to be met for the intervention to be of use to the target audience; and (2) it yields feedback on the design of the application that is broader than color and buttons, but encompasses comments on the quality of the service that the application offers. In this study, specific examples of what the structured development process has generated are: more attention to the process and the flow of participants in the application (what do the participants exactly have to do in each lesson, when can they proceed to the next lesson, when do they get reminders etc.); prevented us from creating a complex menu structure in which the users would have lost their way as they indicated in the rapid prototyping stage; the idea that text message coaching can not only be used for reminding participants, but also act as a short assignment and as motivation. Overall, by developing the technology, not only technical aspects are developed, but the whole

process, including system, content and service is (re)designed to match the values of stakeholders.

Additional files

Additional file 1. All Paper Prototypes: General Homepage, Exercise and Menu Overlay, First Design; General homepage, Personal Homepage and Exercise, Second Design
Additional file 2. Overview of Expected Needs of Prospective Users
Additional file 3. Example of Written Comments of Two Participants on Two Paper Prototypes

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Additional file 1. All Paper Prototypes: General Homepage, Exercise and Menu Overlay, First Design; General homepage, Personal Homepage and Exercise, Second Design

mijn gegevens contact disclaimer

inleiding dagboek oefening metafoor metafoor intermezzo mindfulness

Dagboek
Agenda
Oefeningen
Kladblok
Contact

Oefening: de rugzak met leed

In deze oefening willen we je vragen om een overzicht te maken van alles waar je last van hebt en waar je nu mee worstelt in het leven. Het gaat om emoties, gevoelens, gedachten, gewoonten en gedrag waar je vanaf wilt. Het is als het ware de pijnlijke bagage die je dagelijks met je meedraagt in een rugzak. Het is het leed waar je onder gebukt gaat. We geven een aantal voorbeelden:

- Verdriet over mijn overleden kat.
- Ik ben snel boos.
- Ik eet te veel.
- Ik zie elke ochtend op tegen de dag.
- Mijn schuldgevoelens dat ik te weinig tijd heb voor mijn kinderen.
- De gedachte dat ik niet veel waard ben.
- Het gevoel van uitputting.
- Mijn onzekerheid.
- Dat ik te veel drink.
- Etc. etc.

Ik heb last van:

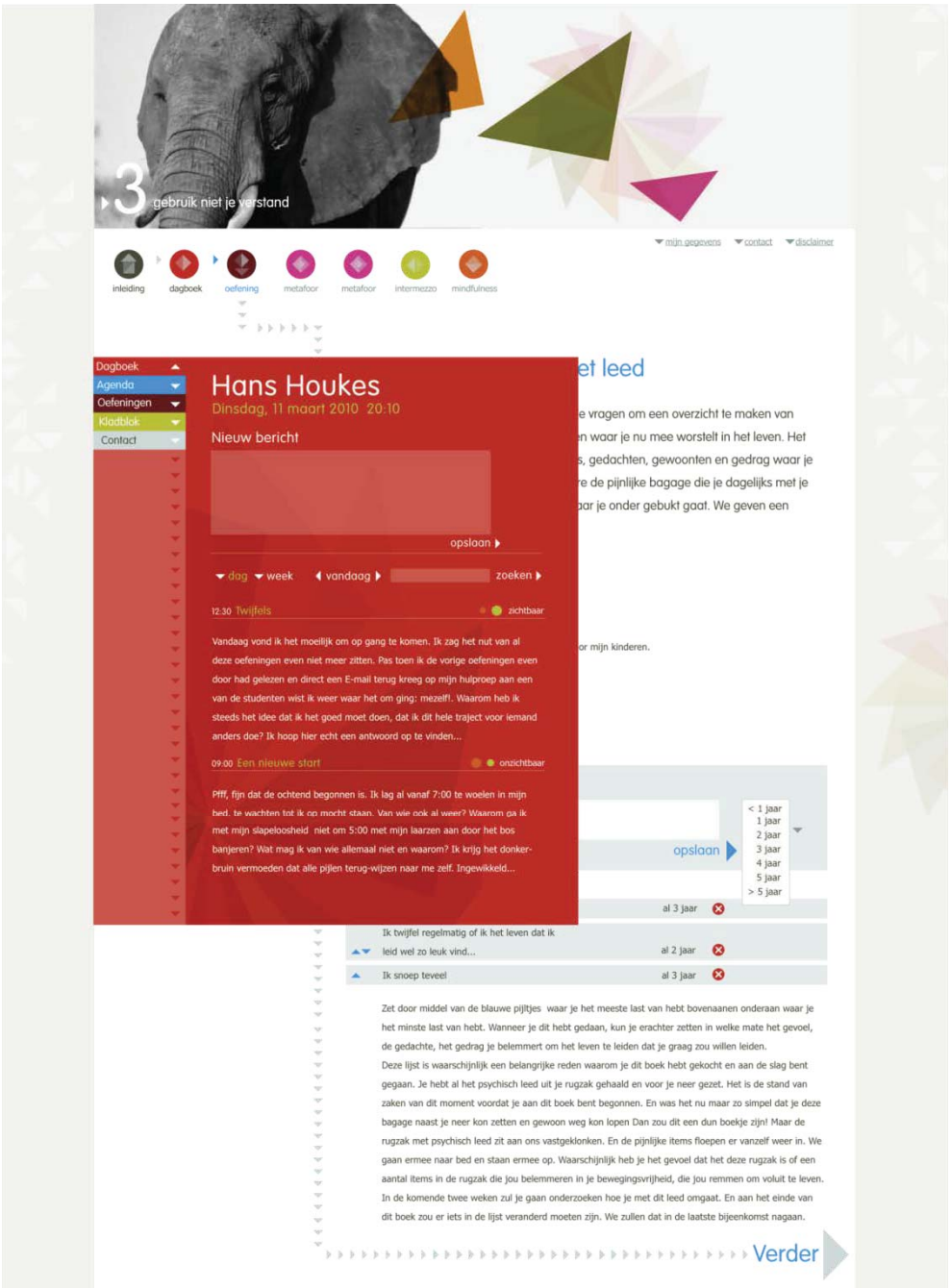
opslaan

< 1 jaar
1 jaar
2 jaar
3 jaar
4 jaar
5 jaar
> 5 jaar

Ik irriteer me aan mijn buren	al 3 jaar
Ik twijfel regelmatig of ik het leven dat ik leid wel zo leuk vind...	al 2 jaar
Ik snoep teveel	al 3 jaar

Zet door middel van de blauwe pijltjes waar je het meeste last van hebt bovenaanen onderaan waar je het minste last van hebt. Wanneer je dit hebt gedaan, kun je erachter zetten in welke mate het gevoel, de gedachte, het gedrag je belemmert om het leven te leiden dat je graag zou willen leiden.
Deze lijst is waarschijnlijk een belangrijke reden waarom je dit boek hebt gekocht en aan de slag bent gegaan. Je hebt al het psychisch leed uit je rugzak gehaald en voor je neer gezet. Het is de stand van zaken van dit moment voordat je aan dit boek bent begonnen. En was het nu maar zo simpel dat je deze bagage naast je neer kon zetten en gewoon weg kon lopen Dan zou dit een dun boekje zijn! Maar de rugzak met psychisch leed zit aan ons vastgeklonken. En de pijnlijke items floepen er vanzelf weer in. We gaan ermee naar bed en staan ermee op. Waarschijnlijk heb je het gevoel dat het deze rugzak is of een aantal items in de rugzak die jou belemmeren in je bewegingsvrijheid, die jou remmen om voluit te leven. In de komende twee weken zul je gaan onderzoeken hoe je met dit leed omgaat. En aan het einde van dit boek zou er iets in de lijst veranderd moeten zijn. We zullen dat in de laatste bijeenkomst nagaan.

Verder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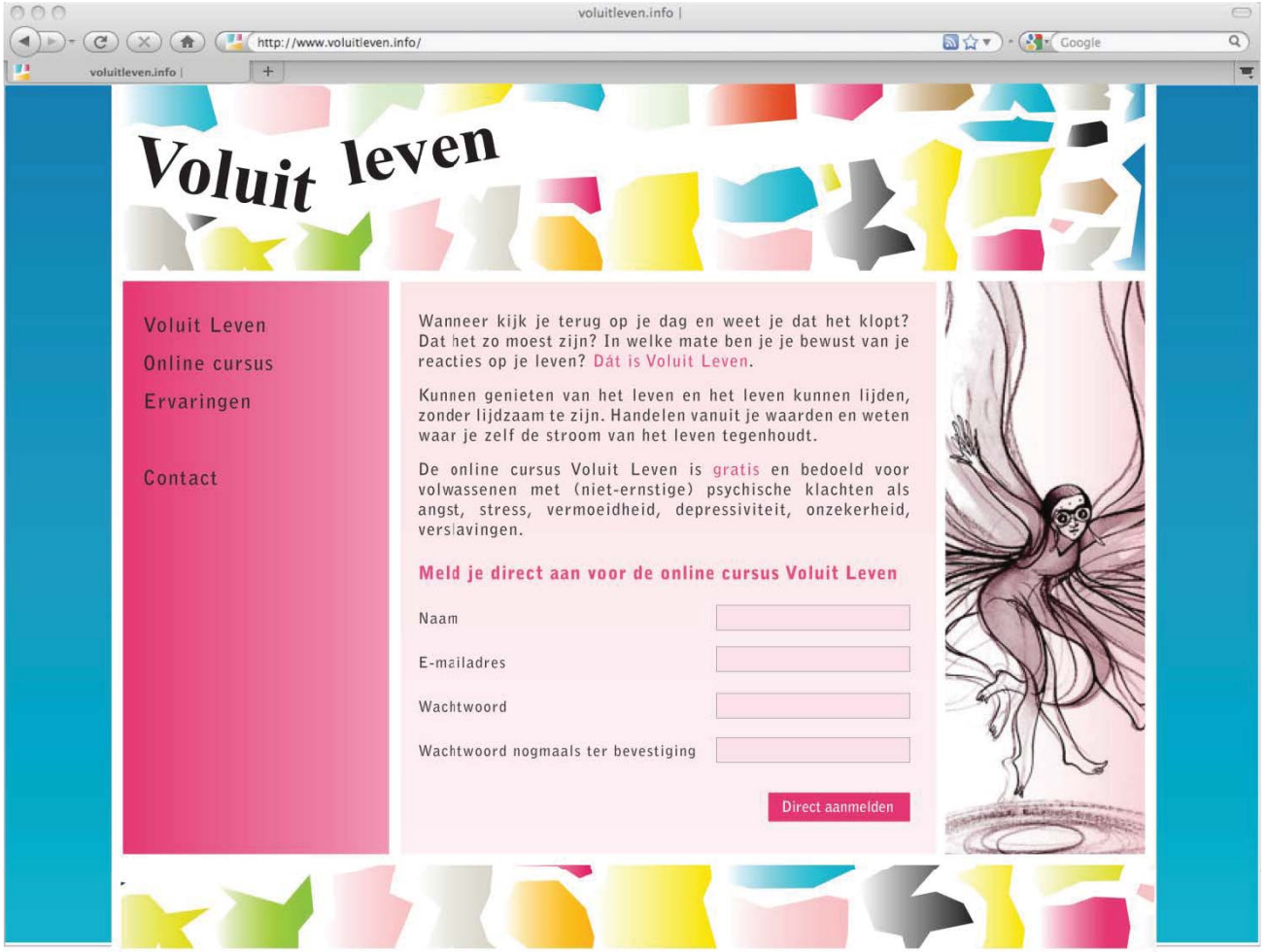
mindfulness
Dagboek
Agenda
Oefeningen
Kladblok
Contact
Hans Houkes
Dinsdag, 11 maart 2010 20:10
Nieuw bericht
opslaan
dag
week
vandaag
zoeken
12:30 Twijfels
zichtbaar
Vandaag vond ik het moeilijk om op gang te komen. Ik zag het nut van al deze oefeningen even niet meer zitten. Pas toen ik de vorige oefeningen even door had gelezen en direct een E-mail terug kreeg op mijn hulproep aan een van de studenten wist ik weer waar het om ging: mezelf!. Waarom heb ik steeds het idee dat ik het goed moet doen, dat ik dit hele traject voor iemand anders doe? Ik hoop hier echt een antwoord op te vinden...
09:00 Een nieuwe start
onzichtbaar
Pfff, fijn dat de ochtend begonnen is. Ik lag al vanaf 7:00 te woelen in mijn bed, te wachten tot ik op mocht staan. Van wie ook al weer? Waarom ga ik met mijn slapeloosheid niet om 5:00 met mijn laarzen aan door het bos banjeren? Wat mag ik van wie allemaal niet en waarom? Ik krijg het donker-bruin vermoeden dat alle pijlen terug-wijzen naar me zelf. Ingewikkeld...
et leed
e vragen om een overzicht te maken van
n waar je nu mee worstelt in het leven. Het
s, gedachten, gewoonten en gedrag waar je
re de pijnlijke bagage die je dagelijks met je
aar je onder gebukt gaat. We geven een
or mijn kinderen.
opslaan
< 1 jaar
1 jaar
2 jaar
3 jaar
4 jaar
5 jaar
> 5 jaar
al 3 jaar
Ik twijfel regelmatig of ik het leven dat ik
leid wel zo leuk vind...
al 2 jaar
Ik snoep teveel
al 3 jaar
Zet door middel van de blauwe pijltjes waar je het meeste last van hebt bovenaanen onderaan waar je het minste last van hebt. Wanneer je dit hebt gedaan, kun je erachter zetten in welke mate het gevoel, de gedachte, het gedrag je belemmert om het leven te leiden dat je graag zou willen leiden.
Deze lijst is waarschijnlijk een belangrijke reden waarom je dit boek hebt gekocht en aan de slag bent gegaan. Je hebt al het psychisch leed uit je rugzak gehaald en voor je neer gezet. Het is de stand van zaken van dit moment voordat je aan dit boek bent begonnen. En was het nu maar zo simpel dat je deze bagage naast je neer kon zetten en gewoon weg kon lopen Dan zou dit een dun boekje zijn! Maar de rugzak met psychisch leed zit aan ons vastgeklonken. En de pijnlijke items floepen er vanzelf weer in. We gaan ermee naar bed en staan ermee op. Waarschijnlijk heb je het gevoel dat het deze rugzak is of een aantal items in de rugzak die jou belemmeren in je bewegingsvrijheid, die jou remmen om voluit te leven. In de komende twee weken zul je gaan onderzoeken hoe je met dit leed omgaat. En aan het einde van dit boek zou er iets in de lijst veranderd moeten zijn. We zullen dat in de laatste bijeenkomst nagaan.
Verder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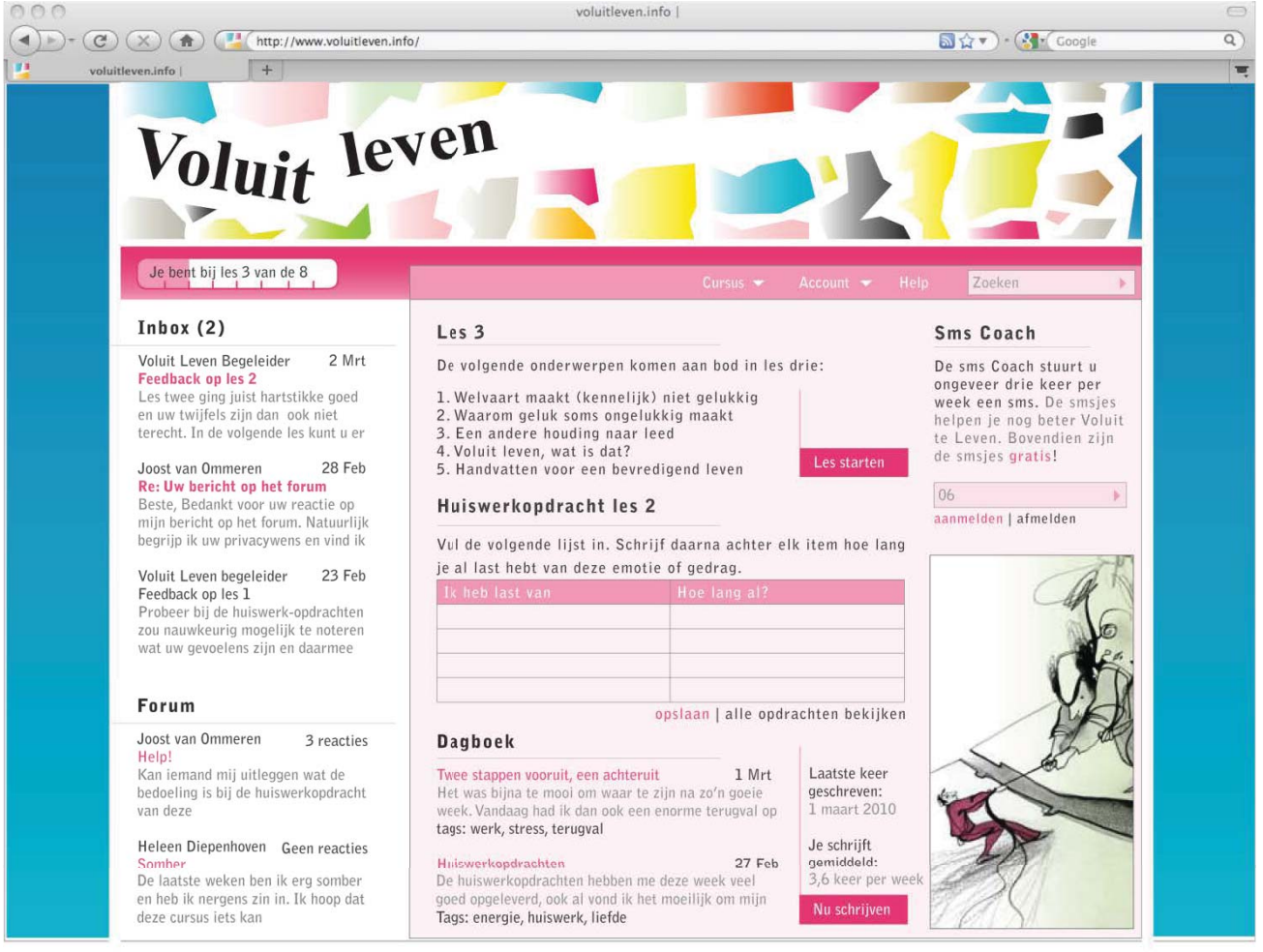
Voluit Leven
Online cursus
Ervaringen
Contact
Wanneer kijk je terug op je dag en weet je dat het klopt? Dat het zo moest zijn? In welke mate ben je je bewust van je reacties op je leven? Dát is Voluit Leven.
Kunnen genieten van het leven en het leven kunnen lijden, zonder lijdzaam te zijn. Handelen vanuit je waarden en weten waar je zelf de stroom van het leven tegenhoudt.
De online cursus Voluit Leven is gratis en bedoeld voor volwassenen met (niet-ernstige) psychische klachten als angst, stress, vermoeidheid, depressiviteit, onzekerheid, verslavingen.
Meld je direct aan voor de online cursus Voluit Leven
Naam
E-mailadres
Wachtwoord
Wachtwoord nogmaals ter bevestiging
Direct aanmelden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Je bent bij les 3 van de 8
Cursus
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Help
Zoeken
Inbox (2)
Voluit Leven Begeleider 2 Mrt
Feedback op les 2
Les twee ging juist hartstikke goed en uw twijfels zijn dan ook niet terecht. In de volgende les kunt u er
Joost van Ommeren 28 Feb
Re: Uw bericht op het forum
Beste, Bedankt voor uw reactie op mijn bericht op het forum. Natuurlijk begrijp ik uw privacywens en vind ik
Voluit Leven begeleider 23 Feb
Feedback op les 1
Probeer bij de huiswerk-opdrachten zou nauwkeurig mogelijk te noteren wat uw gevoelens zijn en daarmee
Forum
Joost van Ommeren 3 reacties
Help!
Kan iemand mij uitleggen wat de bedoeling is bij de huiswerkopdracht van deze
Heleen Diepenhoven Geen reacties
Somber
De laatste weken ben ik erg somber en heb ik nergens zin in. Ik hoop dat deze cursus iets kan
Les 3
De volgende onderwerpen komen aan bod in les drie:
1. Welvaart maakt (kennelijk) niet gelukkig
2. Waarom geluk soms ongelukkig maakt
3. Een andere houding naar leed
4. Voluit leven, wat is dat?
5. Handvatten voor een bevredigend leven
Les starten
Huiswerkopdracht les 2
Vul de volgende lijst in. Schrijf daarna achter elk item hoe lang je al last hebt van deze emotie of gedrag.
Ik heb last van
Hoe lang al?
opslaan | alle opdrachten bekijken
Dagboek
Twee stappen vooruit, een achteruit 1 Mrt
Het was bijna te mooi om waar te zijn na zo'n goeie week. Vandaag had ik dan ook een enorme terugval op
tags: werk, stress, terugval
Huiswerkopdrachten 27 Feb
De huiswerkopdrachten hebben me deze week veel goed opgeleverd, ook al vond ik het moeilijk om mijn
Tags: energie, huiswerk, liefde
Laatste keer geschreven:
1 maart 2010
Je schrijft gemiddeld:
3,6 keer per week
Nu schrijven
Sms Coach
De sms Coach stuurt u ongeveer drie keer per week een sms. De smsjes helpen je nog beter Voluit te Leven. Bovendien zijn de smsjes gratis!
06
aanmelden | afmelden


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Oefening
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Intermezzo
Mindfulness
Huiswerkopdracht
Persoonlijke homepagina
Dagboek
Inbox (2)
Oefening: de rugzak met leed
In deze oefening willen we je vragen om een overzicht te maken van alles waar je last van hebt en waar je nu mee worstelt in het leven. Het gaat om emoties, gevoelens, gedachten, gewoonten en gedrag waar je vanaf wilt. Het is als het ware de pijnlijke bagage die je dagelijks met je meedraagt in een rugzak. Het is het leed waar je onder gebukt gaat. We geven een aantal voorbeelden:
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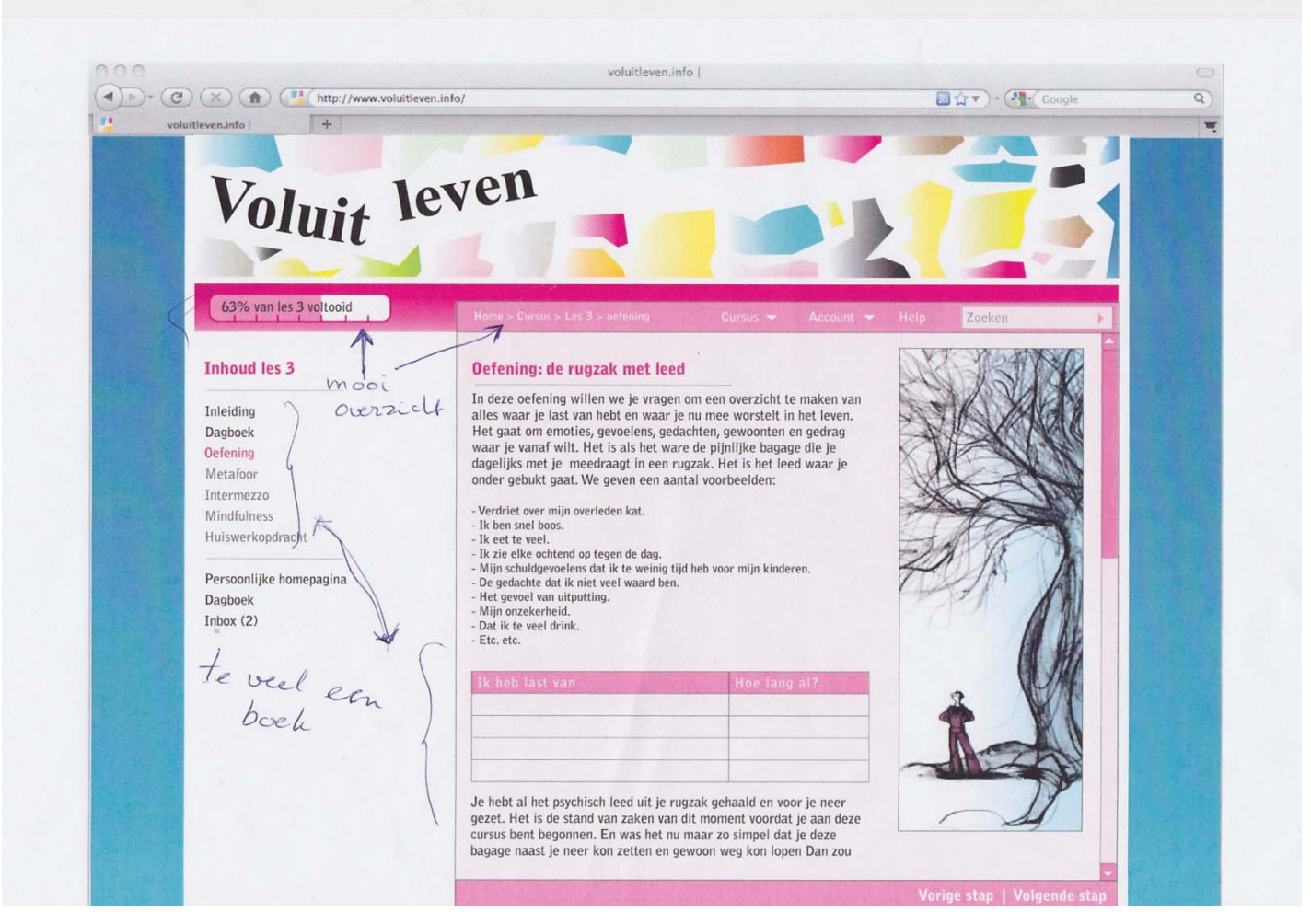
- Ik ben snel boos.
- Ik eet te veel.
- Ik zie elke ochtend op tegen de dag.
- Mijn schuldgevoelens dat ik te weinig tijd heb voor mijn kinderen.
- De gedachte dat ik niet veel waard ben.
- Het gevoel van uitputting.
- Mijn onzekerheid.
- Dat ik te veel drink.
- Etc. etc.
Ik heb last van
Hoe lang al?
Je hebt al het psychisch leed uit je rugzak gehaald en voor je neer gezet. Het is de stand van zaken van dit moment voordat je aan deze cursus bent begonnen. En was het nu maar zo simpel dat je deze bagage naast je neer kon zetten en gewoon weg kon lopen Dan zou
Vorige stap | Volgende stap

Additional file 2. Overview of Expected Needs of Prospective Users

Expected Needs	n	%
Support and feedback	*17*	*94*
Contact with counselor	8	44
Feedback	8	44
Personal attention	3	17
Specific instructions	3	17
Chat function	1	6
Being taken seriously	1	6
Application	*14*	*78*
User friendly	12	67
Attractive	5	28
Encouragement to complete the course	3	17
Content	*13*	*72*
Added value	8	44
Effective	6	33
To-the-point	3	17
Focus on real world	1	6
Varied assignments	1	6
Service	*10*	*56*
Flexible time planning	5	28
Fixed endpoint	3	17
Limited time behind pc	1	6
No need to go outdoors	1	6
Flexible pace	1	6
Anonymity	1	6
Combines well with other activities	1	6
Aftercare	1	6
Social support	*8*	*44*
Contact with others using the application	8	44

Additional file 3. Example of Written Comments of Two Participants on Two Paper Prototypes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Inbox (2)
te veel een boek
Oefening: de rugzak met leed
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- De gedachte dat ik niet veel waard ben.
- Het gevoel van uitputting.
- Mijn onzekerheid.
- Dat ik te veel drink.
- Etc. etc.
Ik heb last van
Hoe lang al?
Je hebt al het psychisch leed uit je rugzak gehaald en voor je neer gezet. Het is de stand van zaken van dit moment voordat je aan deze cursus bent begonnen. En was het nu maar zo simpel dat je deze bagage naast je neer kon zetten en gewoon weg kon lopen Dan zou
Vorige stap | Volgende stap

Chapter 5

Persuasive technology, adherence and effect of a web-based intervention for the prevention of depression

Kelders SM, Pots WTM, Bohlmeijer ET, Van Gemert-Pijnen JEWC.
Persuasive technology, adherence and effect of a web-based intervention for the prevention of depression.
Submitted

Abstract

Background: Web-based interventions for the prevention of depression are needed and show promising effects. However, active components of web-based interventions remain unclear.

Purpose: Investigate the effect of support, text message coaching, experience, tailoring and personalization on clinical outcomes and on adherence of the web-based intervention 'Living to the full', and assess how participants evaluate the intervention.

Design: Fractional factorial RCT-design.

Participants: 239 participants with mild to moderate depressive symptoms.

Intervention: The web-based intervention consists of lessons, exercises, feedback, diary and success stories, and is based on Acceptance and Commitment Therapy and mindfulness. The 9 chronological lessons are to be completed in 12 weeks. Five components were randomized: human versus automated support; text message coaching versus no text message coaching; high versus low experience through technology; high- versus low-tailored success stories; high versus low personalization.

Measurements: Adherence was measured through log files. Depressive and anxiety symptoms were measured on baseline, post intervention and follow-up. Process measures (task enjoyment, involvement, trust and satisfaction) were measured on post intervention.

Findings: There was a significant interaction effect between support condition and time on clinical outcomes. This difference was on the course of change, not on the extent of improvement. No effects were found on adherence and on the other components. A trend in the data showed that human support, text message coaching and high experience were evaluated marginally more positively with significant differences only on involvement.

Conclusions: Automated support can be as effective as human support, without a loss in adherence. This may make web-based interventions for the prevention of depression more cost-effective and easier to implement in regular care. We did not find an effect of the other components, which implies that the isolation of active ingredients of web-based interventions might be more complex and that assumptions about adding components for increased effectiveness or adherence should not be made lightly.

Introduction

The high prevalence of depression poses a large public health burden for which early and easily accessible interventions are essential and can be (cost)effective[1-3]. Web-based interventions have been posed to fulfill this need and have been shown to be effective in reducing depressive symptoms [4-9].

However, not all web-based interventions are effective and implementation in regular care is lacking [10-13]. An issue is non-adherence, i.e. participants not following the intervention protocol [14, 15]. Studies have shown the relation between adherence and increased effect of an intervention (i.e. 'dose-effect relationship') [16, 17]. Furthermore, active components of web-based interventions remain unclear. It is important to distill the 'active ingredients' of an intervention, to be able to understand why some interventions achieve positive effects, while others do not [18-20].

In eHealth research, the major focus has been on the content of interventions, whereas the technology - or design - of interventions has only recently gained attention. Evidence suggests that the technology of web-based interventions influences the effectiveness and adherence of these interventions [17, 21-23]. Authors have suggested a holistic approach to eHealth and to view web-based interventions as the entirety of content, technology and the service they provide [11].

Standard RCT-studies are not able to untangle the active ingredients of an intervention, because they investigate whether a specific combination of content, technology and service has an effect compared to a control condition [18]. RCT-studies that compare two or more interventions that differ only on the studied variation are a viable, but slow way to investigate possible active ingredients. Possible active components that may influence effect or adherence are almost infinite. Furthermore, a comprehensive theory or basis that founds these components, is lacking. Therefore, it is important not only to focus on outcome measures like adherence and (clinical) effectiveness, but also on process measures that reflect how participants evaluate the intervention. Measures like enjoyment, involvement, trust and satisfaction might provide a linking pin between an intervention and adherence. Task enjoyment is an important component of social cognitive theories of achievement and intrinsic motivation and is seen as a mediator between achievement motivation and performance [24, 25]. As such, it might play a role between the intervention and adherence and effect. Involvement is defined as 'a person's perceived relevance of the object based on inherent needs, values and interests' and stems from consumer behavior research [26]. Involvement is suggested as an important predictor for voluntary system use [27]. Applied to web-based interventions, this indicates a possible relationship between involvement and adherence. Trust is widely considered to be important in how people decide to accept information and advice on their health [28, 29]. In the context of websites, trust can be divided in trust in the organization and trust in the technology, where both are

seen as important factors that determine whether a person will use a website, or in this case, a web-based intervention [30, 31]. Satisfaction with a web-based intervention is often included as a process measure and might predict adherence [15, 32].

Innovative ways to screen for the potential effects of components are needed. One such approach is the screening phase of MOST (Multiphase Optimization Strategy) [18, 20, 33]. In this phase, a relatively large number of potentially effective components can be examined in a single study, using randomized experimentation (fractional factorial design) to isolate the effects of each individual component.

This study focusses on a web-based intervention for the prevention of depression, called 'Living to the full'. This intervention was developed employing methods from the CeHRes Roadmap for eHealth development [11] and this process is described in a different paper [34]. The content of the intervention is based on ACT (Acceptance and Commitment Therapy) [35] and mindfulness [36, 37] and has been published as self-help book [38]. The intervention has been shown to be effective in reducing depressive and anxiety symptoms as a group course and as a self-help course with email support [39-41].

During the development of the web-based intervention, different variations of the intervention were created to investigate the effect of five components. The first component is support, i.e. feedback a participant receives on process and progress. Studies have shown the importance of support in web-based interventions [9]. However, there is no consensus on the amount and way of giving support. A few studies have shown that automated support can be effective, although less than human support or with lower adherence rates [42, 43]. However, a study on 'Living to the full' as self-help intervention with email support, showed that short, process support did not yield a significantly different effect than more elaborate support [40]. From a (cost-)effectiveness and implementation perspective, it is interesting to know whether human support is essential for a web-based intervention, or is something that can be omitted. Therefore, in this study we examine the effect of human versus automated support. The other components stem from persuasive technology literature and have been proposed to influence the effect and adherence of eHealth interventions [44, 45, 46]. Review studies have shown that interventions which include text messages (component 2) are more effective than interventions which do not include text messages [22] and that reminders increase the effect and adherence of web-based interventions [47]. Technology can be persuasive in its role as a medium because it creates an experience that motivates or persuades [45]. This is done, for example, by interactivity and by multimedia content (component 3) and there are experimental studies that suggest that interactivity increases adherence and effectiveness of web-based interventions [48, 49]. Tailoring (component 4) can be used in success stories to convey outcome and efficacy expectation messages and it has been shown that tailored success stories are more effective than general success stories in a smoking cessation intervention [20]. Increasing personalization is proposed to increase the persuasiveness of technology

[45, 46]. Personalization (component 5) can be seen as 'communication that is geared towards an individual's characteristics, preferences and context' [31]. Ways to achieve this are adaptation and adaptability of the content, presentation, navigation and user input. Adaptation means automatic, implicit personalization and adaptability means the system provides the opportunity to the user for personalizing the system [31, 50] .

The goal of this study is to investigate the effect of the five components support, text message coaching, experience, tailoring and personalization, on clinical outcomes (depressive and anxiety symptoms) and on adherence of the web-based intervention 'Living to the full', and to assess how participants evaluate the intervention with these components on enjoyment, involvement, trust and satisfaction.

Method

Participants

Participants were recruited through advertisements in Dutch newspapers between February and March 2011. Inclusion criteria were an age of 18 year or older and mild to moderate depressive symptoms (>9 and <39 on the Center of Epidemiological Studies – depression scale; CES-D [51]). People with severe depressive symptomatology and/or severe anxiety symptoms [more than 1 standard deviation above the population mean on the CES-D (cut-off score 39 [52]) and/or on the Hospital Anxiety and Depression Scale – anxiety subscale (HADS-A [53]; cut-off score 15 [54]) were excluded, because of the preventive nature of the intervention. Other exclusion criteria were: receiving psychological or psycho-pharmacological treatment within the last 3 months; having less than 3 hours per week time to spend on the web-based intervention; poor Dutch language skills. The study was approved by an independent medical ethics committee (METIGG; no. NL33619.097.10) and recorded in the Dutch primary trial register for clinical trials (NTR3007).

Procedure

Interested people visited the study website. After viewing on screen information on the study and having the opportunity to download this information, informed consent was obtained from the participant through a checkbox and a pop-up screen to check whether they were sure to give informed consent. Participants then filled out an online screening questionnaire and were instantly informed whether they fulfilled the inclusion criteria. People who fulfilled the inclusion criteria were emailed a link to the online baseline questionnaire. A total of 239 respondents fulfilled the inclusion criteria, completed the online baseline questionnaire and were automatically randomized to one of eight intervention arms. All participants received an emailed link to the website of the web-based intervention on the same day (25 March). Respondents were not blinded to their randomized arm, but had no in-depth knowledge of the other arms. Participants received an

emailed link to the online post intervention questionnaire three months after they could start the intervention. Six months after the start of the intervention period, participants received an emailed link to the online follow-up questionnaire. Participants received up to two automated email reminders when not filling out a questionnaire. Participants had no contact with the research staff, apart from the ability to ask questions via email or telephone.

Intervention

Participants could access the web-based intervention at any time, from any place, free of charge. When logging on to the web-based intervention, participants started in their 'cockpit' (Figure 1). From here, they could access all elements of the intervention. The elements that were included for all participants were: lessons (1), overview of completed exercises (2), feedback (3), diary (4), success stories (5), my account (6), help (7) and a 'react' button where respondents could comment on the application(8).

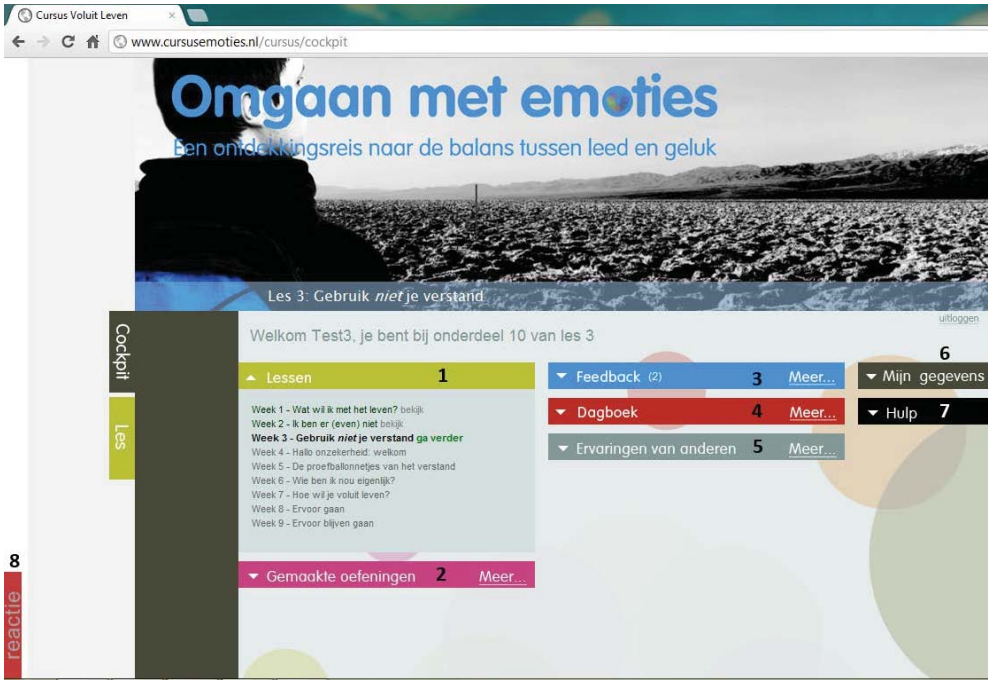

Figure 1. Personal home screen of the web-based intervention, the 'cockpit'

The web-based intervention included 9 chronological lessons. Participants were instructed to complete 1 lesson per week, but had 12 weeks in total to complete the 9 lessons. Lessons included online and offline exercises. It was estimated that participants would spend an average of 3 hours per week on the intervention. There were no content changes during the

intervention period and all interaction with and about the intervention was web-based. A detailed description of the intervention and each component can be found in Appendix 1.

Intervention components

Support

The source of support was either human or automated. To isolate the effect of the source of support, both conditions were designed as comparable as possible regarding length of feedback messages, tailored content and presentation (including a picture of the counselor). To maintain the unique differences between human and automated support (increased possibility for interaction in human support and the increased possibility for timely feedback in automated support), participants in the human support condition had the opportunity to ask questions to their counselor, and participants in the automated support condition received one additional instant feedback message per lesson.

Text message coaching

The text messages in the condition that included text message coaching were written before the study started by the researchers and the content was based on the results of the development study of the intervention [34]. Each week, three text messages were sent containing motivational, mindfulness and content-related information.

Experience through technology

The high experience condition contained additional multimedia and interactive material in the form of short movies, interactive exercises and multimedia presentations of metaphors.

Tailoring of success stories

The intervention contained a success story for each of the lessons of the intervention. For the high tailored condition, each success story was tailored on 4 of the aspects: gender, age, marital status, daily activity, most prominent symptom, reason for participating in the web-based intervention. The stories were tailored to a different combination of aspects each week and not on all aspects to maintain the credibility of the stories. In the low tailored condition, a standard success story was presented each week.

Personalization

In this study, the high personalization condition included personalized content that is adapted (the system shows the motto and picture selected by the participant; the system shows the most important values selected by the participant) and adaptable (possibility to create a personal 'top 5' of aspects from the course that the participant found most important).

Experimental design

Based on the MOST method, a balanced fractional factorial design with 8 arms was chosen to screen for the effects of the five components. Each level of each component is present in half of the intervention arms. This design is called a Resolution III design and allowed for the estimation of all main effects (of the components), confounded by certain 2-way

interactions. Because we have no theory or hypotheses to support an effect of 2-way interactions, this design was deemed sufficient [55]. The specific combinations of components in the 8 arms are presented in Table 1 and the 2-way interactions and confounders can be found in Appendix 2. The design was intended to be balanced by having the same number of participants in each experimental arm. Due to a programming error, this was not achieved. The actual number of participants in each group is shown in Table 1. As a result, we analyzed the data using all conditions as covariates (for ANOVA) or predictors (for regression analyses).

Table 1. Experimental groups of the fractional factorial design and the number of participants

Group	Support	Text messages	Experience	Tailoring	Personalization	Participants (n)
1	Automated	Yes	High	High	High	11
2	Automated	Yes	Low	Low	Low	43
3	Automated	No	High	Low	Low	36
4	Automated	No	Low	High	High	23
5	Human	Yes	High	Low	High	52
6	Human	Yes	Low	High	Low	19
7	Human	No	High	High	Low	35
8	Human	No	Low	Low	High	20

Measures

Usage of the web-based intervention was measured objectively by log files. Adherence was defined as a participant reaching or completing lesson 9. Depressive symptoms were measured with the CES-D (20 items, score 0-60; higher scores mean more depressive symptoms) [51, 56] at baseline, post intervention and follow-up. Anxiety symptoms were measured with the HADS-A (7 items, score 0-21; higher scores mean more anxiety symptoms) [53, 57] at baseline, post intervention and follow-up. Task enjoyment, involvement, trust and satisfaction with the web-based intervention were measured at post intervention. Task enjoyment was measured by 5 items [25]. Involvement was measured with the short version of the Personal Involvement Inventory (10 items) [58]. Trust was measured with two constructs: trust in the organization (4 items) and trust in the technology (4 items) [31]. Satisfaction was measured with 4 items on user friendliness, usefulness, recommending to others, and willingness to continue using the web-based intervention [32, 59]. For these measure a mean score was calculated (range 1-7; for satisfaction range 1-5), where a higher score is more positive.

Data analysis

Statistical analyses were done using PASW 18 (Predictive Analytics Software; IBM, USA). Differences between randomized conditions and between responders and non-responders

were investigated using one-way analyses of variance (ANOVA) and χ^2 tests. Missing data on clinical measures (CES-D and HADS-A) were imputed with the expectation-maximization method in PASW 18. This method estimates the unmeasured data based on maximum likelihood estimates using observed data in an iterative process [60]. Observed data on CES-D, HADS-A, gender, age, education, lesson reached and support condition were used for estimation. To examine differences on the clinical outcome measures on the components, Repeated Measures ANOVA with intention-to-treat data were used. All components were used as covariates. To examine differences on adherence, regression analyses were used with all components added to the model. These analyses were done per-protocol (i.e. only participants that have used the intervention at least once have been included in the analyses). To examine differences on process outcomes, ANOVA and regression analyses were used with per-protocol data of completers.

Results

Response rates

Of the 239 participants, 137 participants completed the post-intervention questionnaire and 135 participants completed the follow-up questionnaire. There were no differences in response rates between the intervention components. Chi square analyses and ANOVAs showed that males, lower educated participants and younger participants were more often drop-outs on post-intervention ($\chi^2 = 5.452$, $p = .02$; $\chi^2 = 13.703$, $p = .001$; $F = 3.905$, $p = .049$). Moreover, participants that did not adhere to the intervention were more often drop-outs on post-intervention and follow-up ($\chi^2 = 90.458$, $p < .001$; $\chi^2 = 94.990$, $p < .001$).

Participant characteristics

Baseline demographics of participants by support condition are presented in Table 2. Possible differences in baseline characteristics were examined by the five experimental conditions. Of the 5x10 comparisons, there were three significant differences at the $p < 0.05$, where females more often received text message coaching, more often received high experience and less often received high tailored success stories.

Adherence

The 239 participants completed on average 5.9 lessons within the intervention period (mode = 8). Of these participants, 33 (14%) did not start the intervention, and 118 (49%) completed all 9 lessons and therefore adhered to the intervention. A logistic regression showed that none of the intervention components significantly predicted adherence (all p-values > .10).

Table 2. Participant characteristics by support condition

Participant characteristic	Automated feedback (n = 113)	Personal feedback (n = 126)	Total (N = 239)
Age (M years)	44.1	45.5	44.9
Gender (women; %)	69.0	72.2	70.7
Ethnicity (%)			
Dutch	88.5	93.7	91.2
Other	11.5	6.3	8.8
Education			
High	69.0	63.5	66.1
Middle	22.1	30.2	26.4
Low	8.8	6.3	7.5
Marital status			
Married	39.8	32.5	36.0
Divorced	19.5	23.0	21.3
Widowed	1.8	1.6	1.7
Unmarried	38.9	42.9	41.0
Daily activities			
Paid job	62.8	63.5	63.2
Student	7.1	8.7	7.9
No job	30.1	27.8	28.9
CES-D (M)	24.3	25.6	25.0
HADS-A (M)	9.6	9.8	9.7

CES-D, Center of Epidemiological Studies – Depression scale; HADS-A, Hospital Anxiety and Depression Scale – Anxiety subscale

Clinical outcomes

A repeated measures ANOVA on the CES-D and HADS-A measures on baseline, post intervention and follow-up by intervention components, showed a significant effect of time and a significant interaction effect of time*support (Table 3). None of the other interactions were significant. Mauchly's test indicated that the assumption of sphericity had been violated; therefore the degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity. For both outcome measures there was a significant time effect, showing that both groups significantly improved. Furthermore, on both outcome measures, there was a significant time*support interaction effect, although within-subjects contrasts show that there is only a quadratic effect (CES-D: $F = 12.370$; $p = .001$; HADS-A: $F = 14.790$; $p < .001$; Figure 2 and 3). One-way ANOVAs showed that there is a significant difference between the support conditions on post intervention on HADS-A ($F = 4.716$, $p = .031$), but on follow-up there is no significant difference between support conditions. Repeated measures ANOVAs for both groups separately, showed that only the automated support condition significantly improves between post intervention and follow up (CES-D: $F = 19.841$;

p < .001; HADS-A: F = 7.590; p < .01). All reported analyses are intention to treat, but per protocol analyses showed the same results.

Table 3. Outcome measures and repeated-measures ANOVA by support condition; intention to treat analyses (n = 239)

Outcome	Group	Score			Anova: F		Effect size: d	
		Pre	Post	Follow-up	time	time x group	pre – foll.up	post – foll.up
CES-D	auto	24.33 (7.11)	20.38 (7.98)	17.58 (8.10)	13.667*	4.150**	0.52	0.89
	pers	25.62 (6.81)	18.99 (7.32)	18.54 (7.32)			0.94	1.00
	total	25.01 (6.97)	19.65 (7.65)	18.08 (8.22)			0.73	0.91
HADS-A	auto	9.56 (2.58)	8.30 (2.95)	7.30 (2.97)	15.642*	7.638***	0.45	0.81
	pers	9.81 (2.57)	7.46 (3.01)	7.61 (2.96)			0.84	0.79
	total	9.69 (2.57)	7.85 (3.00)	7.46 (2.96)			0.66	0.79

Scores are presented as mean (sd); *p < .001 **p = .022 ***p = .001; CES-D, Center of Epidemiological Studies – Depression scale; HADS-A, Hospital Anxiety and Depression Scale – Anxiety subscale

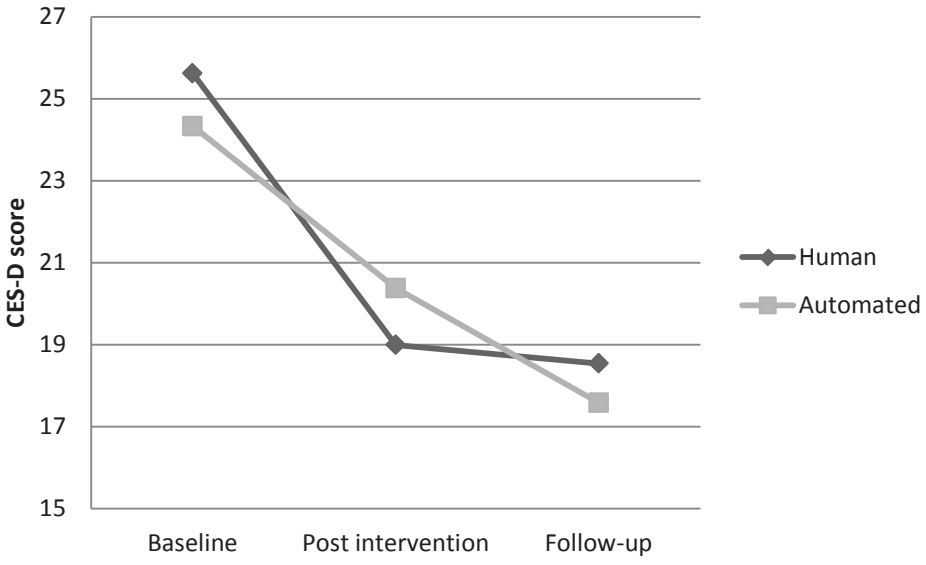

Figure 2. Time*support interaction effect on CES-D

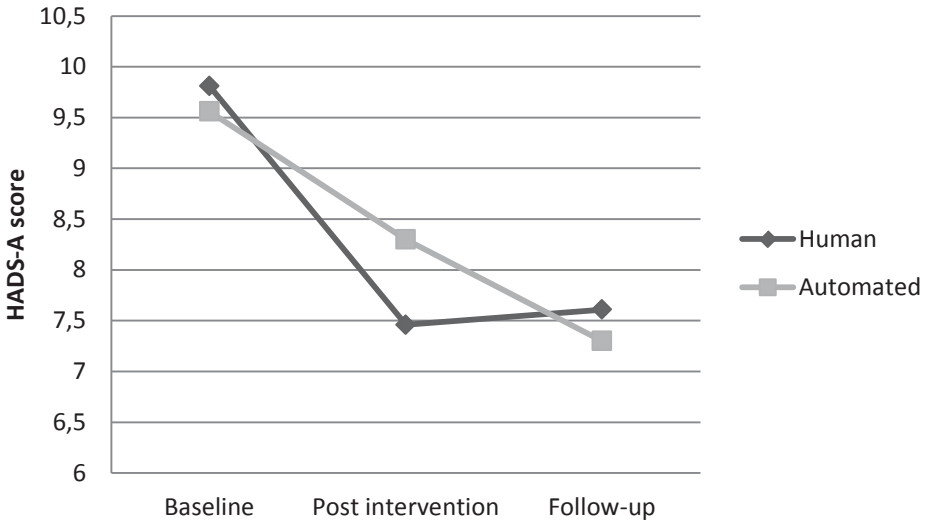

Figure 3. Time*support interaction effect on HADS-A

Dose – response relationship

The dose – response relationship was investigated using regression analyses with the clinical outcomes (CES-D and HADS-A on post intervention and follow-up) as dependent variables and adherence and lesson reached as predictor variables. All regression analyses were significant with $p < .001$ and β ranged from 0.242 - 0.422.

Secondary measures

Table 4 shows the scores of responders on the post-intervention questionnaire on task enjoyment, involvement, trust in the organization, trust in the technology and satisfaction by adherence and each level of the intervention components with a per protocol analysis. All mean values are relatively high, with significant differences between adherers and non-adherers on task enjoyment, involvement and satisfaction ($F = 17.644$; $p < .001$; $F = 12.734$; $p = .001$; $F = 7.694$; $p = .006$, respectively) and on involvement by support and by text message coaching ($F = 4.411$; $p = .038$; $F = 4.415$; $p = .038$, respectively). Furthermore, the data indicates that human support, the addition of text message coaching and high experience tend to be more positively evaluated on the secondary measures. For tailoring and personalization, there is no visible trend.

Table 4. Scores of responders on process measures by adherence and intervention components, per protocol analyses

	Task Enjoyment	Involvement	Trust in the organization	Trust in the technology	Satisfac-tion
All participants	5.83 (1.16)	5.69 (1.14)	5.94 (1.01)	5.38 (1.18)	4.21 (0.81)
Adherers	6.05 (0.94) ***	5.88 (0.96) **	6.02 (0.95)	5.42 (1.21)	4.31 (0.69) **
Non-adherers	5.12 (1.50)	5.10 (1.45)	5.65 (1.15)	5.24 (1.11)	3.86 (1.07)
Support					
Automated (n = 62)	5.70 (1.25)	5.50 (1.16)*	5.79 (1.03)	5.29 (1.08)	4.20 (0.83)
Human (n = 72; n = 71)[a]	5.99 (0.95)	5.90 (1.00)	6.08 (0.95)	5.46 (1.25)	4.24 (0.76)
Text messages					
No (n = 64; n = 63)[a]	5.69 (1.16)	5.51 (1.12)*	5.82 (1.02)	5.35 (1.23)	4.18 (0.81)
Yes (n = 70)	6.00 (1.03)	5.90 (1.04)	6.05 (0.96)	5.41 (1.13)	4.25 (0.78)
Experience					
Low (n = 54)	5.67 (1.36)	5.51 (1.27)	5.83 (1.10)	5.25 (1.28)	4.14 (0.92)
High (n = 80; n = 79)[a]	5.97 (0.88)	5.85 (0.94)	6.02 (0.94)	5.47 (1.09)	4.28 (0.69)
Tailoring					
Low (n = 82)	5.97 (1.03)	5.79 (1.04)	5.91 (0.93)	5.28 (1.21)	4.28 (0.77)
High (n = 52; n = 51)[a]	5.68 (1.20)	5.59 (1.17)	6.00 (1.10)	5.55 (1.10)	4.12 (0.83)
Personalisation					
Low (n = 72; n = 71)[a]	5.80 (1.07)	5.65 (1.09)	6.08 (0.96)	5.40 (1.05)	4.26 (0.79)
High (n = 62)	5.92 (1.14)	5.78 (1.10)	5.79 (1.01)	5.37 (1.31)	4.17 (0.80)

Scores are presented as mean (sd); a Due to missing data, on Trust in the organization, Trust in the technology and Satisfaction, the results are based on the responses of in total 133 responders instead of the responses of 134 responders on Task enjoyment and Involvement.; * p < .05; ** p < .01; *** p < .001

Discussion

Overall, participants who received the intervention showed a reduction in depressive and anxiety symptoms on post intervention and on follow-up. The effect size was medium to large from baseline to post intervention and large from baseline to follow-up. This is similar to the results of meta-analyses of the effectiveness of guided web-based interventions for depression [5, 9]. Approximately half of the participants adhered to the intervention, which is within the range of average adherence of web-based interventions [14, 44]. Our study confirmed the dose-response relationship; adherence was significantly related to better clinical outcomes.

There was a significant interaction effect between support condition and time on clinical outcomes, but this difference was on the course of change, not on the extent of improvement. Participants who received human support improved more during the intervention period, but this improvement stagnated between post intervention and follow-

up. Participants who received automated support showed less improvement during the intervention period, but the improvement carried on between post intervention and follow-up. The finding that at post intervention, human support is superior to automated support on anxiety symptoms, confirms the importance of a therapist in a web-based intervention. However, the finding that three months after the intervention period there is no significant difference between human and automated support, is interesting and promising from a cost-effectiveness perspective. Participants who received human support showed a maintenance of effect between post intervention and follow-up, whereas participants who received automated support showed an increasing improvement. There are two likely explanations for this difference. First, participants who received human support might not improve after the intervention period due to the sudden loss of support from the therapist. Participants who received automated support, have no therapeutic alliance that can be lost and might therefore continue to improve. Second, research shows that a sense of agency, or the attribution of the improvement to oneself instead of others (for example a therapist) is positively associated with the effectiveness of therapy [61, 62]. Participants who received automated support have no therapist to attribute the improvement to and may therefore attribute it more to themselves, which may enhance the effectiveness of this condition.

Support condition did not show differences on adherence to the intervention. This is contrary to earlier studies that found that the inclusion of human support increased adherence [14, 44]. A likely explanation is the implementation of support in the intervention. Automated support was implemented to closely resemble human support. Social presence was enhanced by using a photo of the automated counselor. This use of an avatar has been shown to have positive effects [63, 64]. Furthermore, the participants did not show a difference in trust between human and automated support, which indicates that the intervention was seen as trustworthy in both conditions. Additionally, automated support consisted of a weekly feedback message that was tailored to two answers given by the participant on the exercises of that week and which resembled a feedback message given by a human counselor on set-up, length and presentation. Moreover, during the week, participants received an additional tailored feedback message on a different exercise of that week. It may well be that the extensive and tailored nature of automated support and the similarity with a human support explains the lack of difference in adherence between human and automated support. It must be noted however, that we did not perform a non-inferiority or equivalence trial. Therefore, we cannot state that automated and human support are equivalent on effectiveness and adherence, only that we did not find a statistical difference.

Contrary to what we expected, the other components showed no differences on clinical outcomes or adherence. An explanation might be that the variations between the levels of the components were too small to show an effect. Especially for tailoring, the difference is on one small part of the intervention (the success stories) which were not an

obligatory part of the intervention. Moreover, analyses of the log-data showed that not all components were used frequently [65], which might have lessened the effect. Furthermore, the different components may have been too little distinctive; there may have been overlap between for example tailoring and personalization. This is strengthened by the fact that all components are mainly focused on the system or the technology, which is only a part of the intervention. The components may have been more distinctive when the components involved the content and service of the intervention, as well as the system. Additionally, we used the screening phase of MOST with a fractional factorial design, which entailed that we screened different components in one study. However, it might be that the addition of one enhanced version of a component to the basic intervention already increases the effectiveness or adherence in the way described by the literature on each component, and that the addition of another enhanced version of a different component does not further increase this effect. This would mean that we would only expect a difference between the basic intervention and the basic intervention with one or more enhanced components. This would explain the lack of difference between the variations, as each study arm includes one or more enhanced components.

Overall, the intervention was evaluated positively by the participants. Adherers evaluated the intervention more positively than non-adherers with significant differences on task enjoyment, involvement and satisfaction. A trend in the data showed that human support, the addition of text message coaching and high experience were evaluated marginally more positively with significant differences only on involvement. Although the differences on these process outcomes between the levels of the components are small and the relationship between adherence or clinical outcomes is not clear, we feel that these results warrant further investigation into especially involvement as this perceived relevance of the web-based intervention might discriminate between how different interventions are received and might provide a linking pin between the intervention and adherence or effect.

Concluding, the MOST method allowed us to screen for the effects of multiple components within a web-based intervention for the prevention of depression. We found a significant difference in the course of improvement on clinical outcomes, not on effectiveness, between human and automated support, which indicates that automated support can be as effective as human support, without a loss in adherence. This may make web-based interventions for the prevention of depression even more cost-effective and easier to implement in regular care. We did not find an effect of the other components, which implies that the isolation of active ingredients of web-based interventions might be more complex than we envisioned and that assumptions about adding components for increased effectiveness or adherence should not be made lightly and should be tested rigorously during the development process.

Appendixes

Appendix 1. Detailed description of intervention and intervention components
Appendix 2. The 2^{5-2}_{III} fractional factorial design with 2-way interactions and confounders

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Appendix 1. Detailed description of intervention and intervention components

Intervention, independent of randomized condition

The web-based intervention included 9 chronological lessons. Each lesson consisted of psycho-educational material and exercises. Participants could proceed to the next lesson after receiving feedback. Feedback was provided when a participant viewed all psycho-educational material, completed all exercises and had started the lesson at least 5 days earlier for the human support condition and 6 days earlier for the automated support condition. All interaction was web-based. Feedback messages were provided in the application, but participants received automated email messages when they could complete a lesson, when feedback was received and to remind them to finish a lesson or to start a new lesson. Participants were instructed to complete 1 lesson per week, but had 12 weeks in total to complete the 9 lessons. Participants were free to choose whether they worked through a lesson in one session or in multiple sessions. Exercises the participants were asked to complete were both online and offline. Online exercises consisted of, among others, free text questions, multiple choice questions and monitoring behavior in the web-based diary. Offline exercises consisted of, among others, practicing mindfulness, performing chosen actions and practicing cognitive defusion. It was estimated that participants would spend an average of 3 hours per week on the intervention (online and offline activities combined). There were no content changes during the intervention period.

Support

Participants randomized in the human support condition, received their weekly feedback from a human counselor. Participants randomized in the automated support condition, received weekly automatically generated feedback. The human counselors were four psychology Masters students of the University of Twente, who had received a 2-day workshop from an experienced clinical psychologist. The feedback messages were supervised by a clinical psychologist. The counselors were instructed to write a weekly feedback message containing the key learning points and goal of the completed lesson; the key exercises and feedback on at least the core exercise; feedback on the mindfulness exercise; and a preview of the following lesson. The automatically generated feedback contained the same elements, where the feedback on the core exercise and the mindfulness exercise was tailored based on the multiple choice responses of the participants to the question which was added to both exercises. An example question that was added after a core exercise was: 'Was writing down your 'bag of sorrow' confronting to you?". Feedback messages in both conditions were presented in the same manner (Figure A1): under 'feedback' in the personal home screen, accompanied by a picture of the counselor. In the automated support condition, a picture of a clinical psychologist was

placed who was not directly involved in the study. Participants were aware of whether their counselor was human or automated. Apart from the source of the feedback message, there were two differences in between the conditions. Participants in the human support condition had the opportunity to ask questions to their counselor. Questions were elicited when participants completed a lesson, but could also be asked at any time. Participants in the automated support condition, received one additional instant feedback message per lesson. This was a automatically generated message tailored to the multiple choice response of the participant on a different exercise than the core-exercise and was presented as a pop-up accompanied by the picture of the counselor.

Text message coaching

Participants in the condition that included text message coaching, had the opportunity to turn the text message coach on. This text message coach sent 3 pre-designed text messages each week to a mobile phone number provided by the participant. The timing of the text messages was different each week, but all messages were sent between 9AM and 9PM. Each week one message contained a motivational message (e.g. "Do you realize you have taken the first step to learn to 'live to the full'? Congratulations and keep going!"), one message contained a mindfulness trigger (e.g. "How mindful are you today?") and one message reflected on the content of that week (e.g. "Avoidance is like scratching an itch. It only works for a short time.") All text messages were presented in the 'text message' tab of the application, independent of whether the text message coach was turned on or off, but only for the participants in the condition that included text message coaching (Figure A2).

Experience through technology

The high experience condition was different to the low experience condition in two aspects. In 8 of the 9 lessons, a short movie was added in which the writer of the course or an experiences clinical psychologist explains the key points of the lesson. The movie does not contain other information than the text, but the information is presented in a different way (Figure A3). The second difference was that the high experience condition contained an interactive exercise or multimedia presentation of an exercise or metaphor in 7 of the 9 lessons (Figure A4).

Tailoring of success stories

The intervention contained a success story for each of the lessons of the intervention that came available at the same time as the lessons. The participants accessed these stories from to cockpit , under 'experiences of others' and the stories were fictional, but based on the experiences of participants in an earlier study on the self-help book version of the intervention (Figure A5). For the high tailored condition, each success story was tailored on 4 of the following aspects: gender, age, marital status, daily activity, most prominent symptom and the reason for participating in the web-based intervention. In the low tailored

condition, each week a standard success story was presented. Hereby attention was paid to vary these stories on the aspects that were used for tailoring in the high tailored condition.

Personalization

Independent of condition, all respondents were addressed with their (reported) first name when logging on to the intervention in a welcome message (e.g. Welcome Saskia, you are at part 1 of lesson 4). Additionally, the high personalization condition (figure A6) showed the self-chosen picture and motto of the participant in the cockpit as soon as this was chosen in lesson 1; and showed the self-chosen most important values in the cockpit (from lesson 7 onwards). Furthermore, in this condition, participants had the opportunity to create their own 'top 5' of things from the course that they found most important. This top 5 was also showed in the cockpit. The low personalization condition did not provide these options.

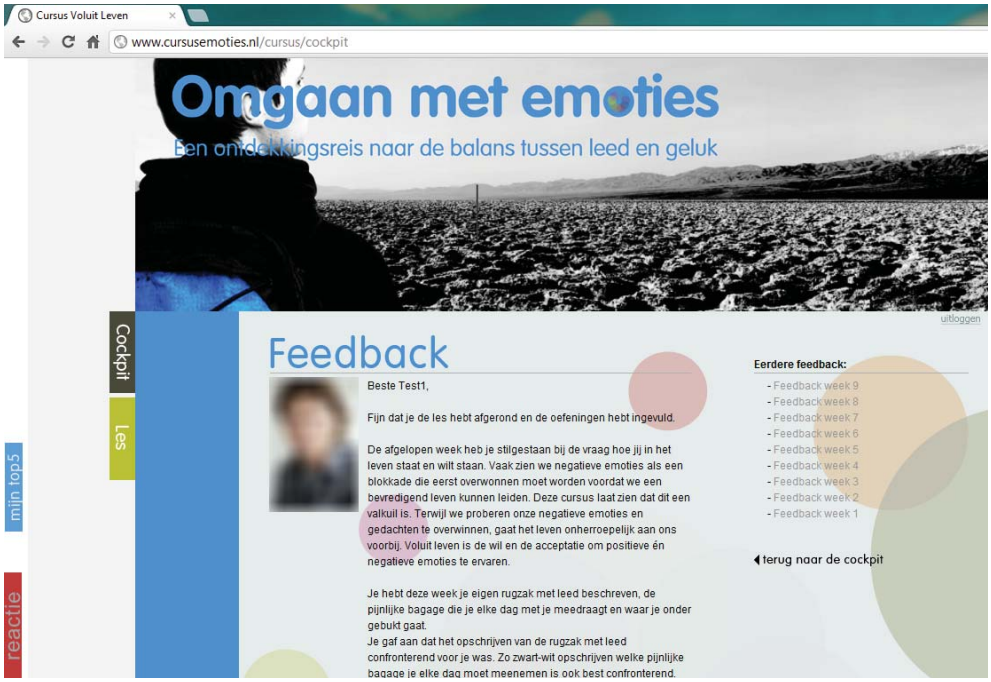


Figure A1. Feedback message in the automated support condition

Note: In this screenshot, the picture of the care-provider has been blurred for privacy.

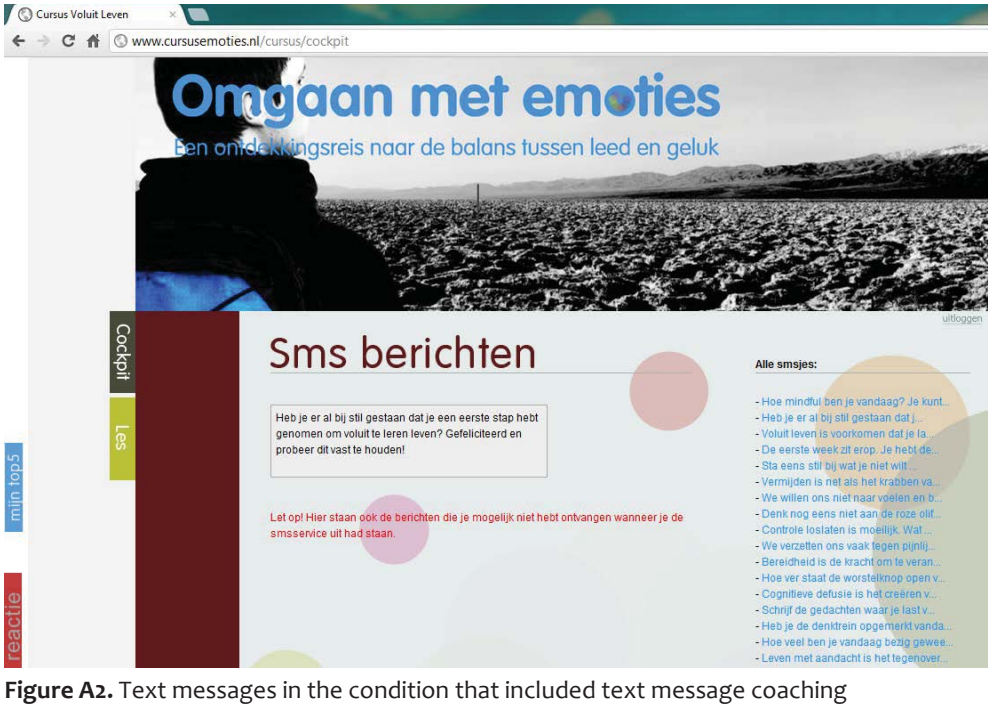


Figure A2. Text messages in the condition that included text message coaching

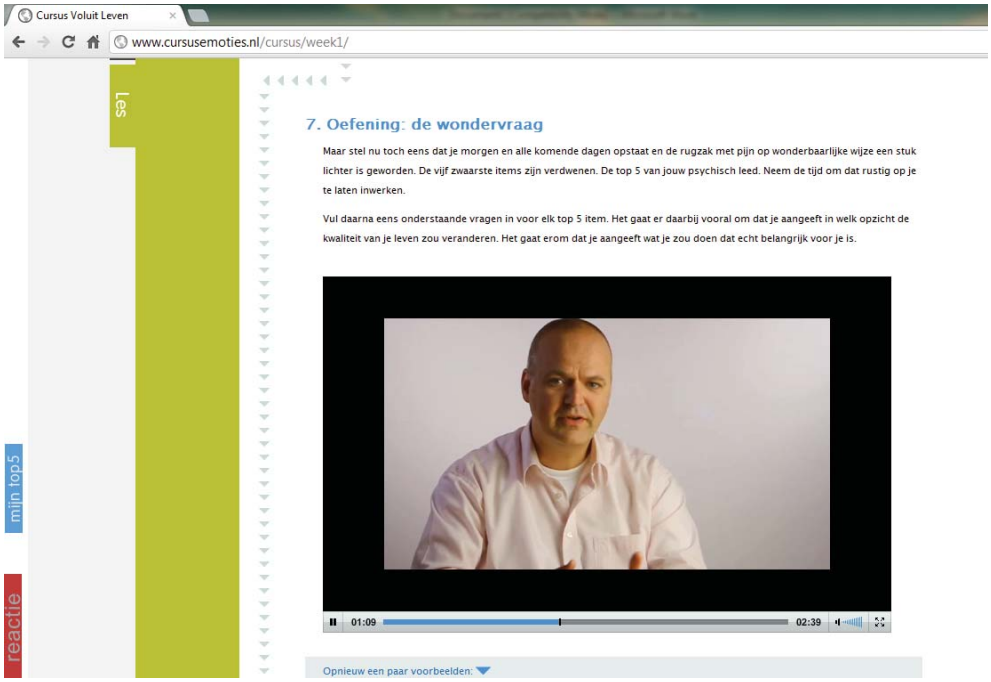


Figure A3. A movie in the high experience condition

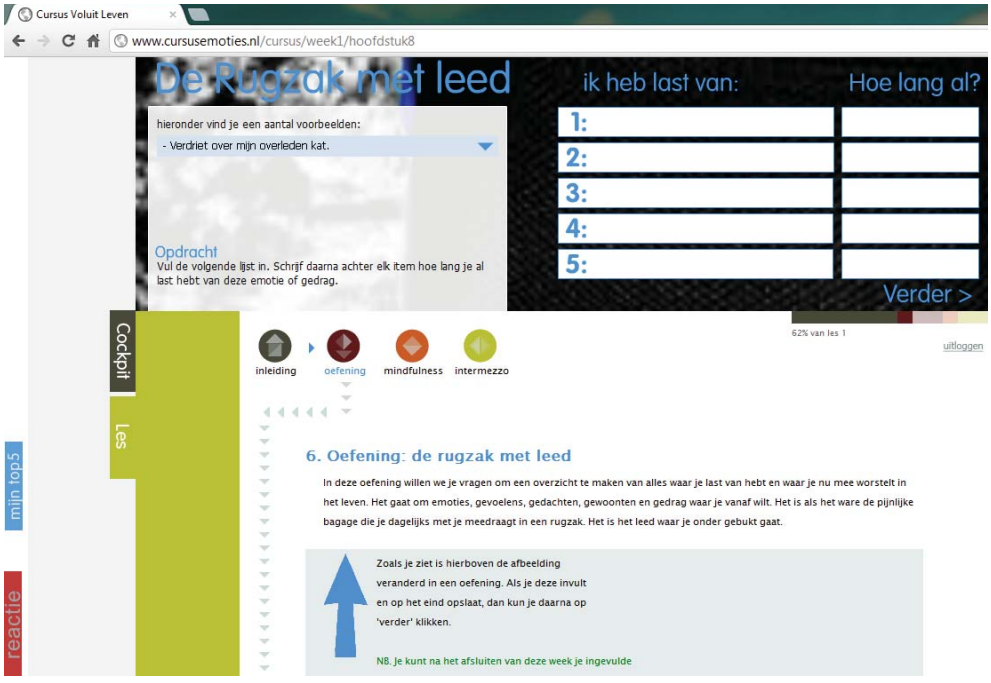


Figure A4. An interactive exercise in the high experience condition

Figure A5. Example of a success story

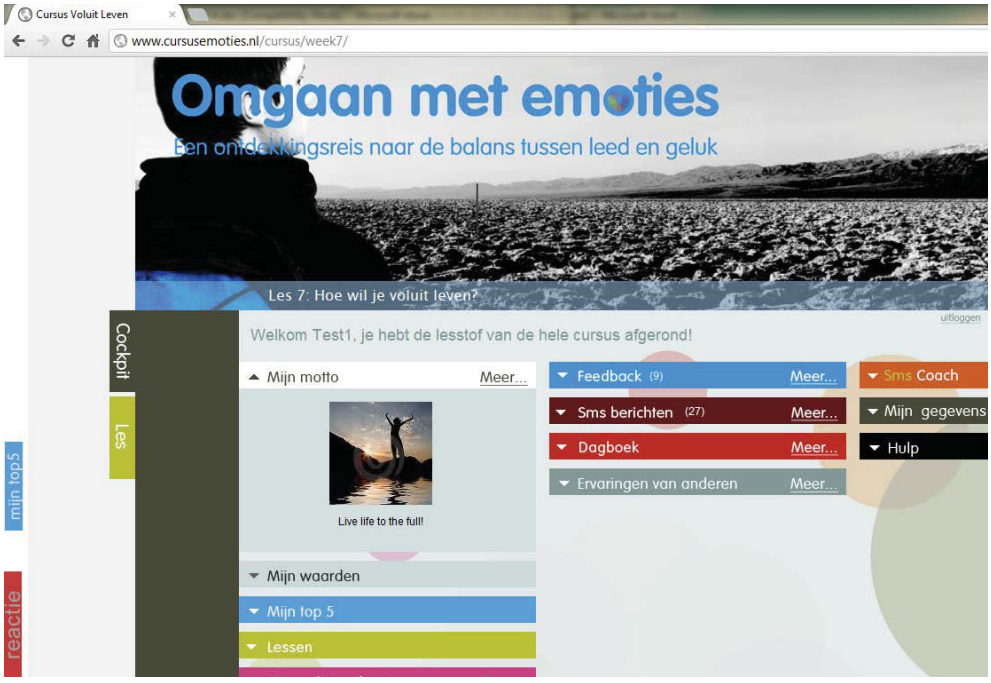


Figure A6. Cockpit of the high personalization condition

Appendix 2. The 2^{5-2}_{III} fractional factorial design with 2-way interactions and confounders

Table 1 - 2^{5-2}_{III} fractional factorial design with 2-way interactions

	A	B	C	D	E	AB	AC	AD	AE	BC	BD	BE	CD	CE	DE
1	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
2	+	+	-	-	-	+	-	-	-	-	-	-	+	+	+
3	+	-	+	-	-	-	+	-	-	-	+	+	-	-	+
4	+	-	-	+	+	-	-	+	+	+	-	-	-	-	+
5	-	+	+	-	+	-	-	+	-	+	-	+	-	+	-
6	-	+	-	+	-	-	+	-	+	-	+	-	-	+	-
7	-	-	+	+	-	+	-	-	+	-	-	+	+	-	-
8	-	-	-	-	+	+	+	+	-	+	+	-	+	-	-

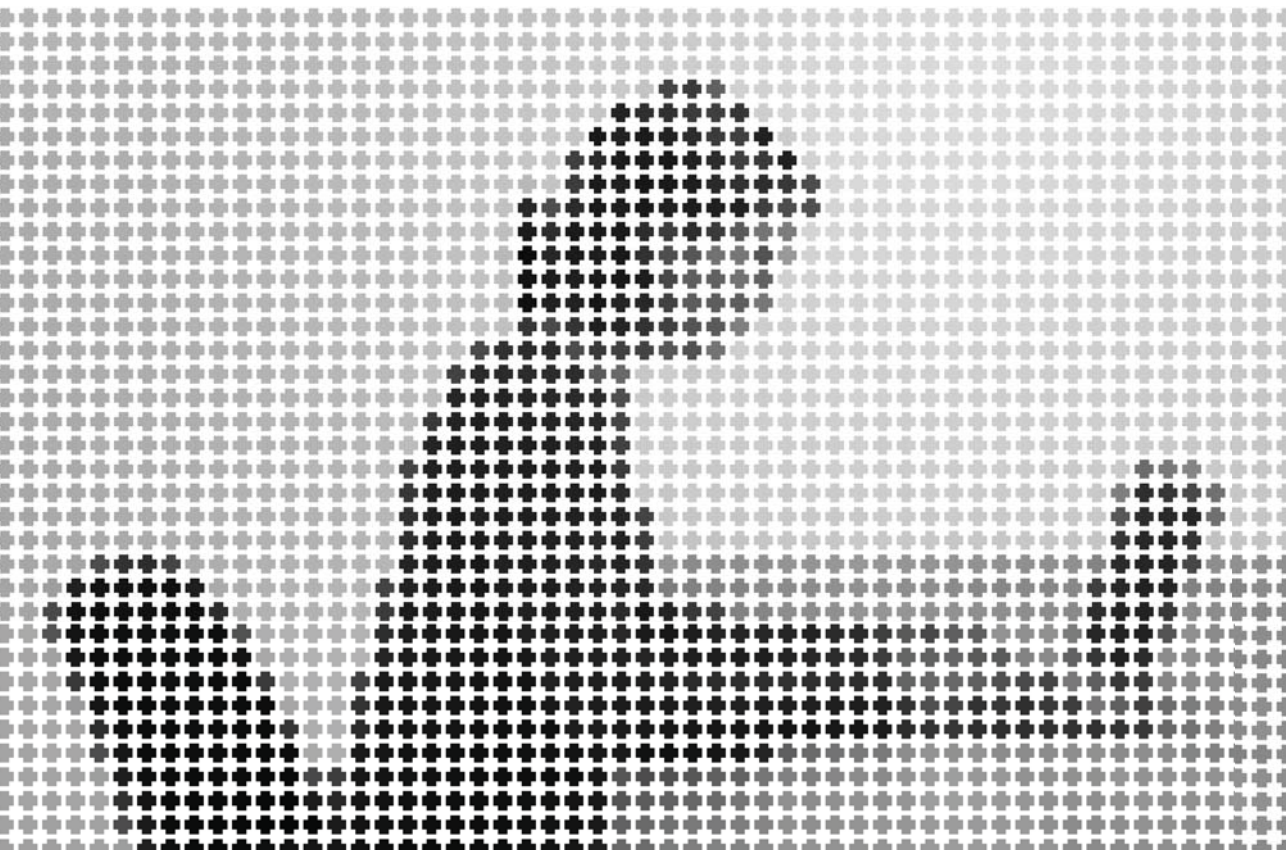
Note: A = support; B = text-message coaching; C = experience; D = tailoring; E = personalisation

The table shows that the pattern of the columns A and DE are the same. Therefore, the effect of support is confounded by the interaction effect of tailoring x personalisation.
The table shows that the pattern of the columns B and CE are the same. Therefore, the effect of text-message coaching is confounded by the interaction effect of experience x personalisation.
The table shows that the pattern of the columns C and BE are the same. Therefore, the effect of experience is confounded by the interaction effect of text-message coaching x personalisation.
The table shows that the pattern of the columns D and AE are the same. Therefore, the effect of tailoring is confounded by the interaction effect of support x personalisation.
The table shows that the pattern of the columns E and AD are the same. Therefore, the effect of personalisation is confounded by the interaction effect of support x tailoring.

Chapter 6

Users, usage and use patterns of a web-based intervention for the prevention of depression

Kelders SM, Bohlmeijer ET, Van Gemert-Pijnen JEWC.
Users, usage and use patterns of a web-based intervention for the prevention of depression.
Submitted



Abstract

Background: Although web-based interventions have been shown to be effective, they are not widely implemented in regular care. Non-adherence, i.e. participants not following the intervention protocol, is an issue. By studying the way web-based interventions are used and whether there are differences between adherers and non-adherers, more insight can be gained into this process of adherence.

Objective: The aims of this study are (1) to give a general impression of how the web-based intervention 'Living to the full' was received; (2) describe the characteristics of users and investigate their relationship with adherence; (3) investigate the utilization of the different features of the intervention and possible differences between adherers and non-adherers; (4) identify what use patterns emerge and whether there are differences between adherers and non-adherers.

Methods: Data of 206 participants that used the web-based intervention 'Living to the full', a web-based intervention for the prevention of depression, were used. Demographic and baseline characteristics of participants were collected using an online survey. Log data were collected within the web-based intervention itself.

Results: 87 comments were made using the 'react'-button within the web-based intervention. The overall intervention and the content received mostly positive comments, while there were a substantial amount of negative comments on system quality (mainly bugs) and service quality (confusion about the flow through the intervention). 118 participants adhered to the intervention. Participants with an ethnicity other than Dutch were more often adherers (χ^2 = 5.470, *P* = .02) and non-adherers, on average, used the internet more hours per day (F = 3.918, *P* = .049). A logistic regression showed that being female (B = 0.704; *P* = .046) and having a higher need for cognition (B = 0.024; *P* = .02) increased the odds of adhering to the intervention. Overall, participants logged in an average of 4 times per lesson, but adherers logged in significantly more times per lesson than non-adherers (F = 20.710; *P* < .001). On use patterns, we saw that early non-adherers seem to use less sessions and less time than late non-adherers and adherers; and less sessions to complete the lesson than adherers. Furthermore, late non-adherers seem to have a shorter total duration of sessions than adherers.

Conclusions: Using log data combined with baseline characteristics and experiences of participants, we have extracted valuable lessons for redesign of this intervention and the design of web-based interventions in general. First, employing a 'react'-button is a useful way of collecting qualitative data on how participants experience the intervention. Second, although characteristics of respondents can significantly predict adherence, their predictive value is small. Third, it is important to design web-based interventions to foster adherence and usage of all features in an intervention.

Keywords

Web-based intervention; depression; use patterns; usage; adherence; design; engagement; attrition

Introduction

Depression has a high prevalence which poses a large burden on the health care system. Research shows that early, easily accessible interventions targeted at people at risk are essential and can be cost-effective [1-3]. Web-based preventive interventions are seen as a possible format for these early, easily accessible interventions and have been shown to be effective in reducing depressive symptoms [4-9].

A web-based intervention has been conceptualized as a primarily self-guided intervention aimed at improving health operated through a website, including program content, multimedia choices, interactive online activities, and guidance and supportive feedback [10]. Although it is stressed that these categories are not mutually exclusive, in this categorization the categories seem to force apart aspects that are entwined by nature. We therefore propose to view a web-based intervention as the whole of the content, system and the service it provides, following Van Gemert-Pijnen et al. [11]. Content corresponds with the earlier mentioned program content; system refers to the technology, with the features the interventions contains, the persuasiveness and user friendliness; service refers to the process of care given through the intervention. In this conceptualization, interaction is neither content, system or service, rather it is an integral part of web-based intervention and depending on the viewpoint, it can be regarded as belonging to either category.

Although web-based interventions have been shown to be effective as stated earlier, web-based interventions are still not widely implemented in regular care [11-14]. An issue is that not all web-based interventions achieve the desired effects and many struggle with the issue of non-adherence (i.e. participants not following the intervention protocol) [11, 12, 15-17]. Although it is difficult to investigate a causal relationship of adherence with the effectiveness of web-based interventions, studies have shown a relation between adherence and increased effect of an intervention (i.e. dose-effect relationship) [18, 19].

Adherence has gained considerable attention the last years. Eysenbach coined the 'law of attrition' [16] and from thereon, there have been studies and reviews into the relationship between characteristics of participants and adherence (e.g. [15, 20]) and between characteristics of interventions and adherence [17, 21, 22]. Although these studies give insight in adherence as an outcome measure and give some recommendations how to plan for adherence, adherence as a process remains unclear. By studying the way web-based interventions are used and whether there are differences between adherers and non-adherers, more insight can be gained into this process of adherence. Furthermore, it may be possible to extract design recommendations from this usage data and 'recommended' use patterns for participants to increase the likelihood of adhering to the intervention.

There has been research into the usage and use patterns of web-based interventions. Descriptive studies of freely accessible interventions have shown that they attract a considerable number of visitors, but that these visitors often interact with or access a

fraction of what is possible in the intervention [23-31]. Furthermore, many studies have found that increased usage of particular features, such as completing assessments and self-monitoring, increased the effectiveness of the intervention [23, 25, 26, 29-32]. However, insight in how individuals use an intervention is still lacking and especially the patterns of individual users through an intervention may provide the foundation for design recommendations and for usage patterns that are most likely to lead to adherence.

Besides adherence as a process, there are still many questions regarding characteristics of respondents that may predict adherence. Studies have investigated the predictive value of demographics and disease related measures (e.g. [15, 20]), but although significant predictors have been identified, the predictive value remains slow and there has been a call for investigation of other characteristics that might prove to be more predictive [11, 15, 17, 20]. The need for cognition and the need to belong might be such characteristics. The need for cognition refers to an individual's tendency to engage in and enjoy effortful cognitive endeavors [33]. It has been shown that people with a high need for cognition are more likely to engage in online activities that are more cognitively challenging [34]. As many web-based interventions rely heavily on text and on cognitive effort to process information, it might be that individuals with a high need for cognition are more likely to adhere to a web-based intervention. Furthermore, it has been proposed that higher levels of interactivity on health websites will lead to greater comprehension of the content, as a function of need for cognition [35], which predicts a relationship between need for cognition and adherence to web-based interventions. The need to belong was introduced by Baumeister and Leary [36] and reflects that this desire to form interpersonal attachments is a fundamental motive which has important consequences for social functioning. Although in that paper the authors argue that the need to belong should be present in some degree in all humans in all cultures, they state that individual differences are naturally to be expected ([36], p. 499). In the context of web-based interventions, which can be social in nature but are often something that is to be done alone, the need to belong may therefore be a predictor for adherence, i.e. in web-based interventions which are low in socialness, a higher need to belong may increase the likelihood for non-adherence.

This paper presents analyses of log data collected in a study into the adherence and effectiveness of a web-based intervention for the prevention of depression, where 118 of the 239 participants (49%) adhered to the intervention (i.e. started all nine lessons) [37]. The aims of the current study are (1) to give a general impression of how the web-based intervention was received; (2) describe the characteristics of users and investigate their relationship with adherence; (3) investigate the utilization of the different features of the intervention and possible differences between adherers and non-adherers; (4) identify what use patterns emerge and whether there are differences between adherers and non-adherers.

Methods

Parent study and participants

The analyses described in this paper are done on data collected in the parent study on the adherence and effectiveness of the web-based intervention for the prevention of depression [37]. The parent study employed a fractional factorial experimental RCT design in which the influence of five components on adherence and clinical effectiveness of the web-based intervention was studied using eight intervention arms. This design entails that of each component, two 'levels' were created and that each level of each component is present in half of the intervention arms. Participants were adults with mild to moderate depressive symptoms (> 9 and < 39 on the Center of Epidemiological Studies – depression scale; CES-D [38]) who completed our online screening procedure. For the current study, the data of all participants that started the first lesson was used. Therefore, we used the data of 206 out of the 239 participants of the parent study. Detailed information on the participants, procedure and design of the parent study can be found in Multimedia Appendix 1.

Intervention

Content

The web-based intervention called 'Living to the full' is based on ACT (Acceptance and Commitment Therapy) [39] and mindfulness [40, 41] and has been published as self-help book [42]. The intervention has been shown to be effective in reducing depressive and anxiety symptoms as a group course and as a self-help course with email support [43-45]. The web-based intervention included nine chronological lessons and each lesson consisted of psycho-educational material and exercises. These nine lessons can be divided into four segments: part 1 (lesson 1) focusses on the view that forms the basis of the course; part 2 (lessons 2 and 3) focusses on becoming aware of coping strategies, their short term effectiveness and lack of long term effectiveness; part 3 (lessons 4, 5 and 6) focusses on learning the skills to accept suffering; part 4 (lessons 7, 8 and 9) focusses on the application of the learned lessons to daily life. Exercises the participants were asked to complete were both online and offline. Online exercises consisted of, among others, free text questions, multiple choice questions and monitoring behavior in the web-based diary. Offline exercises consisted of, among others, practicing mindfulness, performing chosen actions and practicing cognitive defusion.

System

The intervention was developed employing methods from the CeHRes Roadmap for eHealth development [11] and this process is described in a different paper [46]. When logging on to the web-based intervention, participants started in their 'cockpit' (Figure 1). From here, they could access all elements of the intervention. The elements that were included for all participants were: lessons (1), overview of completed exercises (2), feedback

(3), diary (4), success stories (5), my account (6), help (7) and a 'react' button where respondents could comment on the application(8).

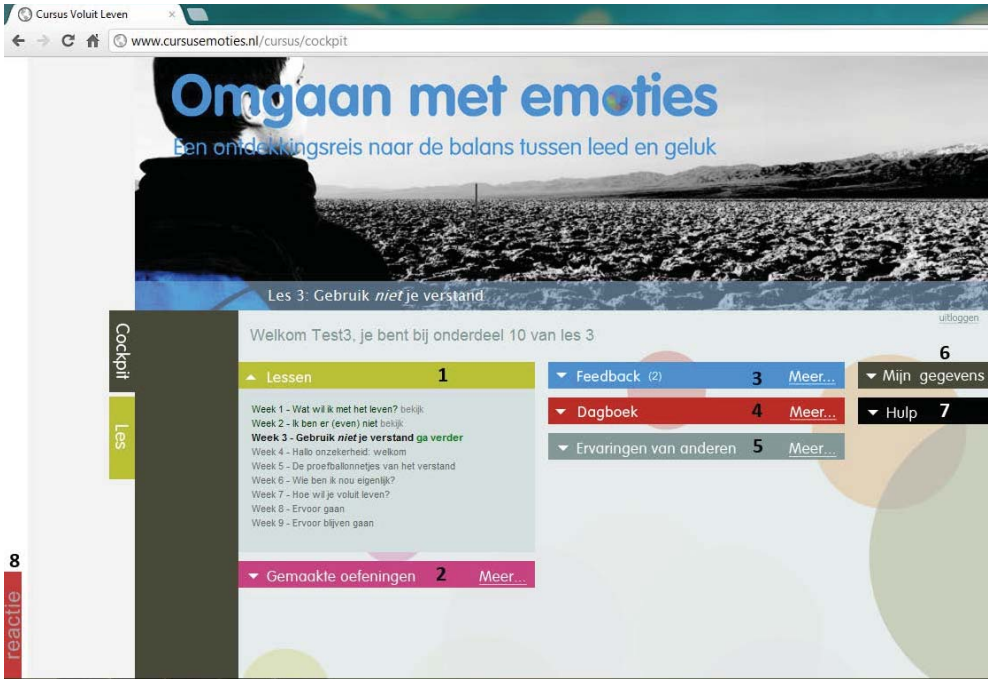


Figure 1. Personal home screen of the web-based intervention with the elements included for all participants.

Service

For this study, the web-based intervention was implemented in a research setting, namely at our University. Participants could access the web-based intervention at any time, from any place, free of charge. After finishing a lesson, participants could proceed to the next lesson after receiving feedback. This feedback was provided when a participant worked on the lesson for at least five days, viewed all psycho-educational material and completed all exercises (see Appendix 1 of Chapter 5 for the exact moment of feedback which differed for the levels of the support component). Participants were instructed to complete one lesson per week, but had twelve weeks in total to complete the nine lessons. Participants were free to choose whether they worked through a lesson in one session or in multiple sessions. It was estimated that participants would spend an average of three hours per week on the intervention (online and offline activities combined).

Interaction

Web-based interaction with the system consisted of doing online exercises, using multimedia content and using personalized features. Interaction in the form of feedback

messages (human or automated) was provided within the system as well. Furthermore, interaction with the system took place through automated email messages which were send to the participants' email address to remind them to start, continue or complete a lesson. For participants who signed up for text message coaching (see following paragraph), interaction also took place via their mobile phone. This interaction was one-directional; there was no possibility to reply. Furthermore, all participants had the opportunity to contact the research staff by telephone although this possibility was hardly used (a total of approximately five phone calls during the intervention period).

Intervention components

Although the components of the intervention are not the focus of this study, this paragraph will give a short overview of each of the levels of the components to be able to place the data presented in this study in its context. A detailed description can be found in Appendix 1 of Chapter 5 and the foundations of these components can be found the parent study [37]. Each of the eight intervention arms employed a different combination of levels of the intervention components. An overview of the composition of each of the intervention arms can be found in Multimedia Appendix 1.

Support

The source of support was either human or automated. To isolate the effect of the source of support, both conditions were designed as comparable as possible regarding length of feedback messages, tailored content and presentation (including a picture of the counselor). To maintain the unique differences between human and automated support (increased possibility for interaction in human support and the increased possibility for timely feedback in automated support), participants in the human support condition had the opportunity to ask questions to their counselor, and participants in the automated support condition received one additional web-based instant feedback message per lesson.

Text message coaching

The text messages in the condition that included text message coaching were written before the study started by the researchers and the content was based on the results of the development study of the intervention [46]. Each week, three text messages were sent containing motivational, mindfulness and content-related information. All text messages were presented in the 'text message' tab of the application, independent of whether the SMS-coach was turned on or off, but only for the participants in the condition that included text messages.

Experience through technology

The high experience condition contained additional multimedia and interactive material in the form of short movies, interactive exercises and multimedia presentations of metaphors.

Tailoring of success stories

The intervention contained a success story for each lesson. For the high tailored condition, each success story was tailored on four of the aspects: gender, age, marital status, daily

activity, most prominent symptom, reason for participating in the web-based intervention. The stories were tailored to a different combination of aspects each week and not on all aspects to maintain the credibility of the stories. In the low tailored condition, a standard success story was presented each week.

Personalization

The high personalization condition included personalized content that is adapted (the system shows the motto and picture selected by the participant; the system shows the most important values selected by the participant) and adaptable (possibility to create a personal 'top 5' of aspects from the course that the participant found most important).

Data collection

Participants had the opportunity to comment on anything in the application using the 'react' button in their cockpit. All messages participants submitted using this method were stored in a database.

Usage of the web-based intervention was measured objectively by log files. The log files contained a record of actions taken by each participant with for each action the following information: user-id; action type; action specification; time and day. The action types that were logged were: login, logout, start lesson, start mindfulness, download mindfulness, view success story, view feedback message, start video, turn on text message coach, turn off text message coach and view text message. Action specifications were for example the name of the mindfulness exercise started or which text message was viewed. From these log files, adherence could be extracted. Adherence was defined as a participant starting lesson 9. Characteristics of participants were collected at baseline using an online questionnaire. Depressive symptoms were measured with the CES-D (20 items, score 0-60; higher scores mean more depressive symptoms [38, 47]), anxiety symptoms were measured with the HADS-A (7 items, score 0-21; higher scores mean more anxiety symptoms [48, 49]). Need for cognition was measured using the Need for Cognition Short Form (18 items, score -54 – 54; higher scores mean more need for cognition [33]). Need to belong was measured using Need to Belong Scale (10 items, mean score 1 – 7; higher scores mean more need to belong [50]). Internet usage was measured using one item (i.e. "On average, for how many hours do you use the internet per day?"). Internet experience was measured using 10 items of the following format: "Do you ever use the following Internet applications?". The 10 items focus on the usage of search engines, webmail, online shopping, online banking, online communities, photo and video websites, (micro)blogs, chat, radio or music websites, and online (health) courses. The score was attained by counting the number of items that were answered with at least 'once in a while' (possible range 0 – 10).

Data analysis

All messages stored in the database which were submitted by participants of the study using the 'react' button in the application were analyzed using a coding scheme following the work of DeLone and McLean [51] and Van Gemert-Pijnen et al.[11]. This coding scheme distinguishes between system quality, content quality and service quality. System quality refers to the user friendliness of the application, including the placement of buttons and the lay-out of the application. Content quality refers to the usefulness and persuasiveness of the information presented in the application, including spelling and understandability of all texts in the application. Service quality refers to the process of care given by the application, including the registration procedure and features that have (not) been included. We supplemented these categories with two broader categories: 'general respondent' (i.e. comments not about the intervention but about the personal situation of the respondent) and 'overall intervention' (i.e. comments about the web-based intervention as a whole).

Statistical analyses were done using PASW 18 (Predictive Analytics Software; IBM, USA). Differences between adherers and non-adherers were investigated using one-way analyses of variance (ANOVA) and χ^2 tests. Logistic regression was used to assess whether baseline characteristics predicted adherence.

Analyses of use patterns were performed on 20 arbitrarily selected participants; 5 early non-adherers (i.e. reached lesson 3 or 4), 5 late non-adherers (i.e. reached lesson 6 or 7) and 10 adherers. Effort was made to ensure that selected participants had the same distribution of demographic characteristics and randomized group as the full sample. See Multimedia Appendix 3 for an overview of demographics, randomized group and lesson reached of these selected participants. Of these participants, we examined all actions in lesson 2 (all selected participants), lesson 5 (late non-adherers and adherers) and lesson 8 (adherers only) to identify emerging use patterns. We chose to examine these lessons because they reflect the three main segments of the content of the intervention and because we wanted to avoid the first and the last lesson for the expected non regular use pattern in these lessons; we expect the participants to explore and get to know the application more in the first lesson and the last lesson is shorter (i.e. less text and exercises) than the other lessons. Of each lesson and for each selected participant, we recorded all actions in between the time they started the lesson under investigation and the time they started the following lesson. Moreover, the number of sessions (a login and following actions until a logout action or a period of 30 minutes of inaction was counted as one session) was derived, as well as the total duration of these sessions and the time between session. Furthermore, the number of sessions used to complete all exercises and content of the lesson were counted.

Results

Experiences of users with the application

There were 39 unique respondents that commented on the web-based intervention using the 'react' button within the application. Table 1 shows the distribution over the categories (general respondent, overall intervention, system quality, content quality and service quality). Additionally, the table shows the number and percentage of negative, neutral and positive comments in each category. Overall we see that 35 out of the 87 (40%) of the comments is about the system quality and 86% of these comments are negative. These comments were mainly about bugs and aspect of the system that were unclear to the respondents. On content quality, 54% of the comments was positive. These comments were mainly on the experiences of respondents with the content of the intervention and the impact it had on their lives. Of the comments on service quality, 56% of the comments were negative. The main themes in these comments were the flow of the respondents through the intervention (e.g. 'When will I get my feedback?") and the availability of the intervention after completion.

Table 1. Classification of comments received through the 'react' button

	Negative (n, %)	Neutral (n, %)	Positive; n (%)	Total (n)
General respondent	0 (0)	5 (100)	0 (0)	5
Overall intervention	3 (25)	3 (25)	6 (50)	12
System quality	30 (86)	2 (6)	3 (9)	35
Content quality	3 (23)	3 (23)	7 (54)	13
Service quality	13 (59)	9 (41)	0 (0)	22
Total	49 (56)	22 (25)	16 (18)	87

User characteristics

Baseline demographics and outcome measures of the 206 participants that used the intervention are shown in Table 2. There were differences between adherers and non-adherers on ethnicity (participants with an ethnicity other than Dutch were more often adherers; $\chi^2 = 5.470$, $P = .02$) and internet usage (non-adherers on average used the internet significantly more hours per day; $F = 3.918$, $P = .049$). On gender there was a difference that approached significance, where women were more often adherers ($\chi^2 = 3.702$, $P = .054$). Furthermore, there was a near significant difference on the need to belong ($F = 3.133$, $P = .08$), where non-adherers have a higher need to belong.

Table 2. Participant characteristics for adherers and non-adherers

Participant characteristic	Adherers (n = 118)	Non-adherers (n = 88)	Total (N = 206)
Age (M years)	45.2	43.9	44.7
Gender (women; %)	78.0[a]	65.9[a]	72.8
Ethnicity (%)			
Dutch	87.3[b]	96.6[b]	91.3
Other	12.7[b]	3.4[b]	8.7
Education			
High	69.5	64.8	67.5
Middle	25.4	26.1	25.7
Low	5.1	9.1	6.8
Marital status			
Married	38.1	30.7	35.0
Divorced	16.9	23.9	19.9
Widowed	2.5	1.1	1.9
Unmarried	42.4	44.3	43.2
Daily activities			
Paid job	58.5	70.5	63.6
Student	7.6	8.0	7.8
No job	33.9	21.6	28.6
CES-D (M)	24.5	25.4	24.9
HADS-A (M)	9.4	10.0	9.7
Need for Cognition	13.9	10.6	12.5
Need to Belong	3.5[a]	3.6[a]	3.5
Internet usage (h/day)	2.3[b]	2.9[b]	2.6
Internet experience	5.7	6.0	5.8

[a] Near significant difference, $P < .10$; [b] Significant difference, $P < .05$

Adherence

The average number of lessons started was 6.9 out of a possible 9 and 57% of the participants in this study completely adhered to the intervention. Table 3 shows the number of participants who reached a certain lesson. From this table you can see that the largest group of non-adherers started to non-adhere in lesson 2, followed by lessons 3 and 6.

To explore the possible predictive value of baseline characteristics for adherence, we performed an exploratory logistic regression with all baseline characteristics showed in Table 2 entered as predictors. Significant predictors in the model ($\chi^2(12)= 28.912$, $P < .01$; Cox & Snell $R^2 = 0.132$; Nagelkerke $R^2 = 0.177$) were gender (B = 0.704; $P = .046$) and need for cognition (B = 0.024; $P = .02$), where being female and having a higher need for cognition increased the odds of adhering to the intervention.

Table 3. Furthest lesson reached for all participants

Lesson reached	n	%	cumulative %
1	11	5.3	100
2	20	9.7	94.8
3	17	8.3	85.1
4	6	2.9	76.8
5	3	1.5	73.9
6	14	6.8	72.4
7	9	4.4	65.6
8	8	3.9	61.2
9	118	57.3	57.3

Usage

From the log-files, the number of times each participant performed an action in the web-based application was extracted (Table 4). Overall, participants logged in an average of 4 times per lesson, but adherers logged in significantly more times per lesson that they started than non-adherers ($F = 20.710$; $P < .001$). Other differences were that adherers downloaded a higher percentage of possible unique mindfulness exercises than non-adherers ($F = 5.888$; $P = .02$) and that adherers in the condition that included text message coaching viewed a larger percentage of the possible text messages than non-adherers in that condition ($F = 7.668$; $P < .01$). To explore whether intervention components influenced the frequency of user actions**,** we compared the percentage of unique success stories that were viewed between participants in the condition with high and low tailored success stories and found that there was no significant difference. However, there was a difference between the total number of unique feedback messages viewed between the conditions with human and automated support (whole group: human support 10.7 unique messages viewed; automated support 5.9 unique messages viewed; $F = 37.322$, $P < .001$) and between the conditions on the number of unique messages viewed per lesson for adherers as well as for non-adherers (adherers: human support 1.7 per lesson, automated support 0.9 per lesson, $F = 17.108$, $P < .001$; non-adherers: human support 1.1 per lesson, automated support 0.6 per lesson, $F = 23.860$, $P < .001$).

Table 4. User actions of adherers and non-adherers

	Adherers (N = 118)	Non-adherers (N = 88)	Total (N = 206)
Login[a]			
total, n	40.2	14.4	29.1
per lesson, n[b]	4.5	3.2	3.9
Feedback messages viewed			
total, n	22.9	6.1	15.7
unique messages, n	12.0	3.8	8.5
unique messages per lesson, n	1.3	0.8	1.1
Mindfulness exercises			
total started, n	7.8	3.6	6.0
unique started, n (%)[c]	3.6 (72.0)	2.0 (74.3)	2.9 (73.0)
unique downloaded, n (%)[c]	2.6 (51.5)	1.1 (37.7)	1.9 (45.6)
unique used, n (%)[c]	4.4 (87.6)	2.3 (81.6)	3.5 (85.0)
Success stories viewed			
total, n	8.8	3.5	6.5
unique, n (%)[c]	5.2 (57.3)	2.8 (61.4)	4.0 (59.1)
Text message coaching[d]			
participants that turned text message coaching on, n[e]	19	7	26
lessons turned on, n[f]	7.9	2.4	6.5
total messages viewed, n	14.3	2.4	9.6
unique messages viewed (n, %)[c]	8.4 (31.0)	1.8 (14.9)	5.8 (24.6)
Movies viewed[g]			
total(n)	5.4	2.0	3.9
unique (n, %)[c]	3.5 (38.6)	1.3 (25.5)	2.5 (38.8)

[a] Logins within 30 minutes of the previous login were not counted to make the logins reflect the number of sessions more. [b] Logins per started lesson, i.e. for non-adherers the number of logons is divided by the number of the last lesson that they have started. [c] % = unique actions / possible actions. For adherers, the number of possible actions is the total number of available actions of that kind in the whole intervention. For non-adherers, the number of possible actions is the total number of available actions in all lessons that the participant started. [d] Only for participants in the condition that included text message coaching; N = 105; adherers N = 63; non-adherers N = 42. [e] The number of participants that turned the text message coach on at least one time. [f] The number of lessons the text message coach was turned on for the participants that turned the text message coach on at least one time. [g] Only for participants in the high experience condition; N = 116; adherers N = 65; non-adherers N = 51.

Use patterns

To examine in more detail the way participants interacted with the system during the lessons, the use patterns of 20 participants (5 early non-adherers, 5 late non-adherers and 10 adherers) on lesson 2 (all selected participants), lesson 5 (late non-adherers and adherers) and lesson 8 (adherers only) were investigated. Multimedia Appendix 4 presents all actions per participant per lesson, organized into sessions. Furthermore, this multimedia appendix

presents the duration of each session, the time in between sessions and an overview of the total duration of sessions and time between sessions per participant per lesson. A summary of this information for early non-adherers, late non-adherers and adherers is presented in Table 5. From this table we can see that there seem to be differences between the use patterns of the three groups. First, early non-adherers seem to use less sessions and less time than late non-adherers and adherers; and less sessions to complete the lesson than adherers. Second, late non-adherers seem to have a shorter total duration of the sessions than adherers, with the difference being more pronounced in lesson 5. Finally, when looking at the adherers, we see that they tend to use less session (total and to complete a lesson) in the later lessons, but there is no visible trend for the duration of sessions and time between sessions, although these seem to be a bit higher for lesson 5. When looking at the data in Multimedia Appendix 4 we observed some notable patterns:

- There are many sessions that involve only a login and a logout action, with less than a minute in between.
- Adherers start the later lessons with a very short first session.
- Many feedback messages are not read the first session after they are available.
- There are many login actions shortly after another action.

Table 5. Mean number of sessions and duration for early non-adherers (n = 5), late non-adherers (n = 5) and adherers (n = 10)

	Early non-adherers	**Late non-adherers**		**Adherers**		
Lesson	2	2	5	2	5	8
Total sessions	2.8 (1.6)	4.4 (1.5)	4.0 (1.6)	5.5 (2.6)	4.3 (1.3)	4.0 (1.9)
Sessions to complete lesson	1.8 (0.8)	2.0 (1.2)	2.8 (1.6)	3.5 (2.0)	2.8 (0.9)	1.9 (0.9)
Total duration of session (min)	36.2 (44.8)	64.0 (45.2)	38.8 (33.3)	101.9 (55.6)	125.6 (99.8)	114.0 (110.4)
Time in between sessions (days)	6.7 (4.1)	10.0 (4.1)	10.8 (1.8)	7.7 (1.7)	10.8 (6.1)	9.6 (5.2)

Note: all values are presented as mean (sd).

Discussion

Principal results

Of the 206 participants that accessed the web-based intervention 'Living to the full', 39 participants commented using the 'react'-button within the application. The result that 6 of the 12 comments on the intervention as a whole were positive and only 3 negative, implies that the intervention was regarded useful for at least some participants, which reflects the positive effect of the intervention on clinical outcomes as reported in a different paper [37].

Furthermore, the large percentage of positive comments on the content quality reinforces this conclusion which is corroborated by the positive evaluation of the self-help version of the intervention 'Living to the full' [44]. Besides collecting qualitative experiences from participants, this 'react'-button was implemented to track down bugs in the system. The number of negative comment on the system quality, which can be attributed to bugs for a large part, showed that participants did use this feature in the way we intended. However, it also shows that, although the intervention was pre-tested and designed with user-participation, there are still many things that are unclear to participants. This finding is strengthened by the comments on service quality, which were only negative and neutral. As part of the design process, we made choices concerning the service the web-based intervention would provide in this research context, but neglected to fully test and clearly communicate this service to the participants.

The participants in this study were mainly Dutch females with a higher education level and a paid job. This group is similar to the group reached by many web-based or eHealth interventions (e.g. [16, 20, 23]) and this was the expected group which we took into account in the development process. When looking at differences between adherers and non-adherers, we see that although we reach only a small percentage of participants with a ethnicity other than Dutch, these participants were more often adherers. Others have stressed the importance and challenge of reaching people with a non-Dutch ethnicity [14]. This study shows that if we can succeed in reaching this population, it may be easier to keep them engaged with a web-based intervention, but this needs further research. Furthermore, non-adherers generally used the internet for more hours per day than adherers. This finding is similar to other studies [20, 52] and is something that deserves more research. One possible explanation is that people who differ in the amount of internet use, also differ in the expectations they have of web-based systems and in this case web-based interventions. It may be that this web-based intervention does not completely fit the mental model of a web application of regular internet users; the web-based intervention for example may require more 'intense' use as opposed to browsing where information is screened and many pages are viewed in a short amount of time. We found a near significant difference on the need to belong between adherers and non-adherers, where adherers scored slightly lower on the need to belong. It seems that in this web-based intervention, the need to belong is not an important factor for adherence. This appears to be reflected in the intervention: it is not social in itself, but does include a social aspect in the form of the success stories. The socialness that participants with a high need to belong are missing, may, in part, be compensated for by these success stories. Our logistic regression model to predict adherence from characteristics of participants had relatively low predictive power (Nagelkerke R^2 = 0.177) where only being female and having a higher need for cognition increased the odds of adhering to the intervention. The finding that women are more likely to adhere was mirrored in the near significant difference between adherers and non-

adherers on gender and may reflect our choice to include more women-users in the development process. Moreover, it strengthens the assumption that it is important to take the target group into account. If we intend to reach and engage men more, we should redesign the intervention using their input. The second significant predictor was the need for cognition, which supports our hypothesis that a higher need for cognition may be beneficiary for completing a web-based intervention that relies substantially on text and on cognitive effort to process information. This implies that if an intervention is not only aimed at participants with a high need for cognition, attention should be paid to make the intervention more suitable for participants with a lower need for cognition. Although this model and other studies [15, 20, 53] show that individual differences play a role in adherence, the predictive value of the characteristics we measure is still small. In the field of persuasive technology, the effectiveness of tailoring persuasive appeals to personality traits has recently been shown [54]. Furthermore, in this field the question why certain individuals are persuaded and others are not has been investigated from a more practical view: by generating an individual 'persuasion profile' from data on actual behavior, the most effective strategy to persuade this individual can be deduced and employed [55]. From thereon, one can theorize where these 'persuasion profiles' come from and whether the can be measured in advance. This might be a practical way to tackle this issue in the field of web-based interventions and eHealth.

Overall, of the 206 participants that have used the application, 118 participants adhered to the intervention. Although we included the percentage of adherers using these numbers, it should be noted that in this paper, we only report on participants that started lesson one. The 'true' adherence derived from all participants (239) is 49% (118/239) [37]. The data showed that most of the participants that did not adhere to the intervention, started to non-adhere during the first three lessons (n = 48; 55% of the 88 participants that started the first lesson, but did not adhere to the intervention). This might reflect the content of the intervention, where the first lesson focuses on whether the participants are really open for the therapy and the next two lessons focus on becoming aware that the coping strategies they use are not effective. This can be very confronting and may therefore explain the high non-adherence in these lessons. Interestingly, there is also a fairly large group of participants that start to non-adhere during lesson 6. This lesson is the last lesson in the segment on learning new skills to accept suffering and this particular lesson focusses on the 'observing self'. Counselors who have given this course know that this is hard lesson for many participants and this may explain the large group of non-adherers in this lesson. For the redesign of this web-based intervention, this finding indicates that this might be a moment when the intervention should provide extra motivation, for example through more interaction or simply by acknowledging that it is known that this is a hard moment to stick with the program.

Our results on the usage of the different features mirror the results of studies into the usage of freely available web-based interventions that participants do not use all the features that they can use [23-31]. It seems that features that are an integral part of the therapy (e.g. the mindfulness exercises in this study) are used more than additional features (success stories, text message coaching, and movies). This is something to keep in mind when (re)designing web-based interventions: be aware that not all features in an application will be used; and try to integrate features into the intervention, instead of adding them onto the intervention. The success stories, for example, could be integrated more in the intervention by inserting them into each lesson. There were significant differences between the user actions of adherers and non-adherers. First, adherers logged in more often per lesson than non-adherers. This indicates that adherers not only have more endurance regarding usage during the full duration of the intervention, but are also more engaged with the intervention compared to non-adherers. Furthermore, adherers downloaded more mindfulness exercises and viewed more text messages than non-adherers, when corrected for the possible exercises downloaded and messages viewed. This further supports the finding that adherers are overall more engaged with the intervention than non-adherers. Additionally, participants in the human support condition viewed more feedback messages than participants in the automated support condition. This finding per se is not surprising because the automated support condition included only one message per lesson, while the human support condition included the possibility to ask questions and request more feedback. Interestingly, the study into adherence and effectiveness of this intervention [37] did not show a significant difference in effectiveness at follow-up between these conditions, even though the feedback was given by a counselor and, as shown is this study, more feedback messages were given. Furthermore, we can see that for adherers as well as non-adherers, the average number of feedback messages viewed per lesson is below one, which means that not all feedback messages have been viewed. For non-adherers, this can partly be explained by participants not viewing the message of the lesson that the did not complete, but that cannot fully explain the average of 0.6 per lesson. For adherers, there is no such explanation, so it must be that although the feedback messages were in the application, not all of them were viewed. Receiving feedback was the most wanted and expected feature of a web-based intervention according to the participants in our development study, which makes this finding even more apparent. It may be that this feature that was thought to be integral to the treatment by the developers was implemented in a way that did not reflect this integral nature; feedback messages were presented in a different section of the system than the lessons (the main part of the therapy) and participants could proceed to the next lesson without viewing the feedback message.

Our analyses of the use patterns of 20 participants of 3 different lessons, provided us with useful insights. This more qualitative analyses confirmed our quantitative results on

user actions: adherers are overall more engaged; they use more sessions and spend more time with the intervention. Moreover, the analyses of the use patterns show us that there seems to be a difference between early non-adherers, late non-adherers and adherers, where late non-adherers are more similar to adherers in the number of sessions, but have a shorter duration of sessions which is more similar to early non-adherers. By identifying differences between adherers and non-adherers, it becomes possible to screen for these 'wrong' patterns and identify participants that might non-adhere soon. This provides the opportunity to intervene, for example by notifying these participants that they have a use pattern that increases the likelihood for non-adherence, or by providing them with more or different interaction. The kind of action that is needed at that time for specific participants should be the focus of future research, but having the ability to identify participants 'at risk', enables us to selectively focus our resources on the participants who are most likely to need it.

Our in depth analyses of the use patterns presented in Multimedia Appendix 4, yielded notable patterns that are useful for the redesign of this specific intervention. For example, the frequent login-logout actions with no user action in between, might be behavior of participants we are waiting for feedback. This hypothesis is supported by the finding that this pattern often occurs after participants have completed a lesson, but have not received feedback. A redesign option is to provide a prominent feature 'when will I get my feedback?' where a timer can be shown with the expected time of feedback. This feature can then also be used to direct the participants to the features that they have not used at time, to support participants to employ all the features to benefit most from the intervention. We saw that many adherers start the later lessons with a very short first session. This reflects the set-up of the intervention, where the next lesson is only available after the users complete the current lesson and a certain time since the start of the lesson has passed. This 'timer' is started as soon as the lesson is started, so this first short session might be done to start the 'timer'. The finding that many feedback messages are not read the first time after they become available reflects the earlier finding that not all feedback messages are being read and might be improved by making it clearer that there is a new feedback message. A known bug in the application which has not been fixed is that a user is logged out of the application when using the 'back' button of the browser. This bug is a likely explanation of the many login actions shortly after another.

For this study, we used the log data of the web-based intervention itself. This allowed us to identify actions of specific users and therefore relate them to whether the participant adhered to the intervention or not. Other studies have advocated the use of Google analytics for example [56], but although this provides valuable information on a general level, it is not possible to identify specific users, which diminishes the value of those methods for web-based interventions that are intended to be used on multiple occasions. However, when developing a web-based intervention, it is important to specify which

information is important to be logged. For example, in our study, sessions were not logged as such, which meant that this had to be done manually, which is a tedious exercise. Furthermore, we manually wrote out all sessions for the selected participants in the selected lessons. Although this method provided valuable information, it is not feasible to do this for all participants for all lessons, which entails that analyses are done on a subset of the data. More advanced methods are needed to make use of all information that is collected. One such approach might be found in the use of Markov-chains as used by Tian et al. [57], although this might be less feasible for web-based interventions that are intended to be used on more occasions. Another approach might be to employ pattern recognition methods from a machine learning perspective to see whether there are different patterns for adherers and non-adherers that can be automatically recognized or learned.

Limitations

A limitation of this study is that we analyzed and interpreted log data without actively involving the users. Although we did use the data from the 'react' button to check for recurring issues or experiences, we did not ask participants why they used the intervention the way they used it. This information may have made it easier to interpret the data and to check whether our interpretation is correct. On the other hand, it is important to use objective log data and not to rely on subjective measures of how participants state that they used the intervention, because subjective data on usage are likely to be less accurate. Another limitation is the issue of generalizability. Our study was done on the data of one intervention for the prevention of depression, which has been used by mainly higher educated Dutch women. The observed use patterns may be specific for this group using this intervention. However, many interventions, especially mental health interventions, have similar characteristics [17] and reach the same audience as stated earlier. Furthermore, the implications regarding designing for adherence, the limited predictive value of regular participant characteristics for adherence and the possibility to intervene based on screening of use patters, seem to be broader than only for this intervention with this audience.

Future research

An interesting area for research can be found in a new way of analyzing the use patterns and investigating whether it is useful and feasible to intervene during the use of the intervention on the basis of the analyses of real time use patterns. An earlier step might be to identify use patterns that are related to adherence and to (re)design interventions in such a way to promote these use patterns. A different area of future research lies in the investigation of a more pragmatic way to identify participant characteristics that may influence or predict adherence, following the 'persuasion profiling' approach [55]. Furthermore, our results indicate that the different content of lessons, may need a different amount or mode of interaction. Here lies an interesting line of research; how can the

content, system, service and interaction of a web-based intervention be attuned to each other to achieve the best match?

Conclusion

Concluding we can say that using log data combined with baseline characteristics of participants and experiences of participants collected with the 'react' button within the intervention 'Living to the full', we have extracted valuable lessons for redesign of this intervention and the design of web-based interventions in general. First, employing a 'react'-button is a useful way of collecting qualitative data on how participants experience the intervention. Second, although characteristics of respondents can significantly predict adherence, their predictive value is small. Therefore, we should look into other ways of classifying participants to make useful predictions about how individual difference may influence adherence. Third, it is important to design web-based interventions to foster adherence and usage of all features in an intervention. A possibility for this is a smarter system that logs the current use pattern of a participant and intervenes when necessary, for example by providing feedback or smart links to features that have not been accessed yet.

Multimedia appendixes

Multimedia Appendix 1. Description of parent study

Multimedia Appendix 2. Characteristics of respondents for analyses of usage patterns

Multimedia Appendix 3. User actions, duration and time between sessions per participant per lesson

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Multimedia Appendix 1. Description of parent study [1]

Participants

Participants were recruited through advertisements in Dutch newspapers between February and March 2011. Inclusion criteria were an age of 18 year or older and mild to moderate depressive symptoms (>9 and <39 on the Center of Epidemiological Studies – depression scale; CES-D) .[2] People with severe depressive symptomatology and/or severe anxiety symptoms [more than 1 standard deviation above the population mean on the CES-D (cut-off score 39)[3] and/or on the Hospital Anxiety and Depression Scale – anxiety subscale (HADS-A;[4] cut-off score 15)][5] were excluded, because of the preventive nature of the intervention. Other exclusion criteria were: receiving psychological or psycho-pharmacological treatment for psychological complaints within the last 3 months; having less than 3 hours per week time to spend on the web-based intervention; poor Dutch language skills. The study was approved by an independent medical ethics committee (METIGG; no. NL33619.097.10) and recorded in the Dutch primary trial register for clinical trials (NTR3007).

Procedure

Interested people visited the study website. After viewing on screen information on the study and having the opportunity to download this information, informed consent was obtained from the participant through a checkbox and a pop-up screen to check whether they were sure to give informed consent. Participants then filled out an online screening questionnaire and were instantly informed whether they fulfilled the inclusion criteria. People who fulfilled the inclusion criteria were emailed a link to the online baseline questionnaire. A total of 239 respondents fulfilled the inclusion criteria, completed the online baseline questionnaire and were automatically randomized to one of eight intervention arms. All participants received an emailed link to the website of the web-based intervention on the same day (25 March). Respondents were not blinded to their randomized arm, but had no in-depth knowledge of the other arms. Participants received an emailed link to the online post intervention questionnaire three months after they could start the intervention. Six months after the start of the intervention period, participants received an emailed link to the online follow-up questionnaire. Participants received up to two automated email reminders when not filling out a questionnaire. Participants had no contact with the research staff, apart from the ability to ask questions via email or telephone.

Experimental design

Based on the MOST method [6], a balanced fractional factorial design with 8 arms was chosen to screen for the effects of the five factors. Each level of each factor is present in half of the intervention arms. This design is called a Resolution III design and allowed for the

estimation of all main effects (of the components), confounded by certain 2-way interactions. The design was intended to be balanced by having the same number of participants in each experimental arm. Due to a programming error, this was not achieved. The actual number of participants in each group is shown in Table 1.

Table 1. Experimental groups of the fractional factorial design and the number of participants

Group	Support	Text messages	Experience	Tailoring	Personalization	Participants (n)
1	Automated	Yes	High	High	High	11
2	Automated	Yes	Low	Low	Low	43
3	Automated	No	High	Low	Low	36
4	Automated	No	Low	High	High	23
5	Human	Yes	High	Low	High	52
6	Human	Yes	Low	High	Low	19
7	Human	No	High	High	Low	35
8	Human	No	Low	Low	High	20

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Multimedia Appendix 2. Characteristics of respondents for analyses of usage patterns

Table MA2.1. Demographics, lesson reached and randomized group of arbitrarily selected participants for analyses of usage patters

No.	Lesson reached	Group	Gender	Age	Education	Internet usage (h/day)	Internet experience
1	3	7	female	23	high	2	6
2	3	5	male	46	medium	8	8
3	3	7	female	34	low	3	6
4	3	2	female	42	high	5	6
5	4	4	male	53	high	2	5
6	6	8	female	60	medium	2	7
7	6	7	male	44	high	8	6
8	6	4	male	56	high	1	6
9	7	3	female	66	high	4	3
10	7	1	female	40	medium	3	5
11	9	6	female	50	high	1.5	7
12	9	5	female	73	high	0.5	3
13	9	8	female	51	high	1	7
14	9	4	male	63	medium	4	6
15	9	5	female	44	high	0.5	2
16	9	8	male	60	high	2	4
17	9	4	male	35	high	5	7
18	9	5	female	36	medium	1	3
19	9	3	female	29	high	2	6
20	9	4	male	42	high	6	8

Multimedia Appendix 3. User actions, duration and time between sessions per participant per lesson

In the following tables, the user actions, duration and time between sessions of the selected participants are presented. There is are two separate tables for each lesson of each group of participants (early non-adherers, late non-adherers and adherers). The first table presents the user actions, divided into sessions. The second table presents the duration of each sessions in minutes and the time between sessions in days. Additionally, the last table presents the total number of sessions, the number of sessions taken to complete the lesson, the number of sessions before feedback was received, the total duration of sessions and the total time between sessions for each participant per lesson.

The following legend applies to all tables.

*****: feedback received between sessions
+: finished lesson in the previous session
mf: mindfulness

Early dropouts, lesson 2

Table MA3.1. User actions per participant per session

User	Session 1		Session 2		Session 3		Session 4		Session 5
1	login; start lesson	*	login; continue lesson; multimedia; mf player 2; download mf 2; feedback 1877	+ *					
2	login; start lesson		login (3x); success story 2, login		login; continue lesson	+ *	login; feedback 2106		
3	login; start lesson, mf player 2; multimedia, logout	* +	login; feedback 3371						
4	start lesson; download mf 2		login; continue lesson; mf player 2 (2x); logout	+	login; feedback 1; success story 2		login	*	login; feedback 2
5	start lesson; login; mf player 2; logout	+ *							

Table MA3.2. Duration of sessions and time between sessions per participant

User	Session 1	Between	Session 2	Between	Session 3	Between	Session 4	Between	Session 5	Between
1	0 min	8 days (*)	22 min	(+ *)			-		-	
2	0 min	3 days	2 min	4 days	0 min	4 days (+*)	1 min		-	
3	22 min	8 days (+*)	1 min				-		-	
4	38 min	2 days	70 min	3 days (+)	6 min	1 day	0 min	12 hours (*)	1 min	
5	18 min	(+*)	-		-		-		-	

Late dropouts, lesson 2

Table MA3.3. User actions per participant per session

User	Session 1		Session 2		Session 3		Session4		Session 5
6	login; start lesson		login; continue lesson	+	login; success story 3; login	*	login; feedback 2146		
7	login; start lesson; multimedia, download mf 2, mf player 2, logout	+	login, logout		login, logout	*	login; feedback 2894; logout		
8	login; start lesson; login; continue lesson; logout	+	login; mf player 2; download mf 2; success story 3; logout	*	login; feedback 2				
9	login, start lesson; login		login; continue lesson; video 2; logout		login; video 2; continue lesson; logout		login; continue lesson; multimedia; mf player 2	+	login; video 2
	Session 6		**Session 7**						
	login; success story 1, 2 (2x); feedback 1; video 2; mf player 2; logout	*	login; feedback 2						
	Session 1		**Session 2**		**Session 3**		**Session4**		**Session 5**
10	login; start lesson; logout		login; feedback 1; continue lesson; download mf 2; sms 5; logout	+	login; feedback 1; logout	*	login feedback 2		

Table MA3.4. Duration of sessions and time between sessions per participant

User	Session 1	Between	Session 2	Between	Session 3	Between	Session 4	Between	Session 5	Between
6	0 min	2 days	0 min	3 days (+)	1 min	2 days (*)	1 min			
7	35 min	7 days (+)	2 min	2 days	0 min	5 days (*)	36 min			
8	22 min	1 day (+)	17 min	6 days (*)	0 min					
9	2 min	1 day	15 min	2 days	31 min	6 hours	18 min	2 days (+)	1 min	1 day
	Session 6		**Session 7**							
	52 min	13 hours (*)	1 min							
	Session 1	**Between**	**Session 2**	**Between**	**Session 3**	**Between**	**Session 4**	**Between**	**Session 5**	**Between**
10	23 min	2 days	16 min	1 day (+)	46 min	12 days (*)	1 min			

Late dropouts, lesson 5

Table MA3.5. User actions per participant per session

User	Session 1		Session 2		Session 3		Session 4		Session 5	
6	start lesson; mf player 5	+	login; feedback 2988	*	login; feedback 3355		login; feedback 3355			
7	start lesson; logout		login; continue lesson, logout		login; logout		login; continue lesson; mf player 5; logout		login; continue lesson; logout	+ *
	Session 6 login; feedback 4487; login									
	Session 1		**Session 2**		**Session 3**		**Session 4**		**Session 5**	
8	start lesson; download mf 5 (2x); logout		login; success story 5, 6; continue lesson	+						
9	start lesson; video 5; logout		login (2x);		login; continue lesson; video 5; logout		login; continue lesson; mf player 5; logout	+ *	login; feedback 5	
10	start lesson; logout		login (2x); continue lesson; mf player 5; sms 13,14,15; logout	+	login; success story 1 and 6; logout	*				

Table MA3.6. Duration of sessions and time between sessions per participant

User	Session 1	Between	Session 2	Between	Session 3	Between	Session 4	Between	Session 5	Between
6	12 min	5 days (+)	0 min	11 hours (*)	0 min	3 days	0 min			
7	0 min	41 min	7 min	6 days	0 min	1 day	8 min	2 days	5 min	4 days (+*)
	Session 6 33 min									
	Session 1	**Between**	**Session 2**	**Between**	**Session 3**	**Between**	**Session 4**	**Between**	**Session 5**	**Between**
8	17 min	11 days	1 min	+						
9	14 min	7 days	6 min	12 hours	52 min	1 day	19 min	1 day (+*)	0 min	
10	1 min	10 days	17 min	2 days (+)	2 min	*				

Adherers, lesson 2

Table MA3.7. User actions per participant per session

User	Session 1		Session 2		Session 3		Session4		Session 5	
11	start lesson; logout		login; feedback 2674 and 2415; login; feedback 2674; logout; login		login; logout		login; continue lesson; download mf 2; mf player 2; logout	+ *	login; feedback 2978; logout	
	Session 6 login; success story 3; mf player 2; sms 5,2,5;	*	**Session 7** login; feedback 3123; logout		**Session 8** login; feedback 3123; mf player 1; login; mf player 2					
	Session 1		**Session 2**		**Session 3**		**Session4**		**Session 5**	
12	start lesson; video 2 (3x); mf player 2; login (4x)	+	login (2x); sms 6,5,4,3,2		login	*				
13	login; start lesson; logout **Session 6** login feedback 1802; 1387; logout		login; continue lesson; logout		login; mf player 1 (2x); download mf 1; logout		login; continue lesson; logout		login; feedback 1371 (2x); logout	+ *
	Session 1		**Session 2**		**Session 3**		**Session4**		**Session 5**	
14	login; start lesson; mf player 2; logout		login (2x); mf player 2; success story 1, 2, 3, 3; logout	+ *	login; feedback 1,2					
15	start lesson; feedback 2196; logout		login; continue lesson; sms 4; logout		login; continue lesson; logout		login; continue lesson; logout		login; download mf 2 (3x); login; download mf 2 (4x); logout; download mf 2 (5x)	+ *
	Session 6 login; download mf 2; multimedia; sms 5									

	Session 1		**Session 2**		**Session 3**		**Session4**		**Session 5**	
16	login; start lesson		login (2x); logout		login; continue lesson; logout		login; feedback 1427; logout		login; continue lesson; mf player 2 (2x); download mf 2; success story 3, 2; logout	+ *
	Session 6									
	login; feedback 1427 (2x), 1814 (5); success story 3									
	Session 1		**Session 2**		**Session 3**		**Session4**		**Session 5**	
17	login; start lesson; logout		login; feedback 1; login; continue lesson; logout		login; continue lesson; download mf 2; logout	+ *				
18	start lesson; logout	*	login; continue lesson; multimedia; logout	+ *	login; feedback 2886; logout		login; feedback 2435; mf player 2 (2x)			
19	login; start lesson; logout		login; continue lesson; multimedia; logout		login; mf player 2 (2x)		login; download mf 2; logout		login; logout	
	Session 6		**Session 7**		**Session 8**		**Session 9**		**Session 10**	
	login; feedback 1; logout		login; continue lesson; multimedia; logout	+	login; multimedia		login; feedback 2; logout		login	
	Session 11									
	login; success story 2, 3	*								
	Session 1		**Session 2**		**Session 3**		**Session4**		**Session 5**	
20	login; start lesson; download mf 2; logout	+	login; logout		login; logout		login	*	login; feedback 2; logout	

Table MA3.8. Duration of sessions and time between sessions per participant

User	Session 1	Between	Session 2	Between	Session 3	Between	Session 4	Between	Session 5	Between
11	6 min	26 min	37 min	1 day	1 min	1 day	1h 48 min	3 days (+*)	1 min	1 day
	Session 6		**Session 7**		**Session 8**					
	30 min	1 day (*)	2 min	2 days	8 min					
	Session 1	**Between**	**Session 2**	**Between**	**Session 3**	**Between**	**Session 4**	**Between**	**Session 5**	**Between**
12	1h 36 min	4 days (+)	3 min	1 day	0 min	*				
13	11 min	2 days	12 min	6 hours	26 min	3 days	8 min	3 hours	30 min	1 day (+*)
	Session 6									
	3 min									
	Session 1	**Between**	**Session 2**	**Between**	**Session 3**	**Between**	**Session 4**	**Between**	**Session 5**	**Between**
14	22 min	5 days	39 min	3 days (+*)	1 min					
15	27 min	1 day	29 min	1 day	12 min	3 days	1h 10 min	1 day	19 min	1 day (+*)
	Session 6									
	19 min									
	Session 1	**Between**	**Session 2**	**Between**	**Session 3**	**Between**	**Session 4**	**Between**	**Session 5**	**Between**
16	0 min	1 day	43 min	1 day	45 min	1 day	3 min	1 day	28 min	4 days (+*)
	Session 6									
	27 min									
	Session 1	**Between**	**Session 2**	**Between**	**Session 3**	**Between**	**Session 4**	**Between**	**Session 5**	**Between**
17	26 min	6 days	6 min	8 hours	13 min	+*				
18	8 min	5 days (*)	26 min	4 days (+*)	1 min	2 days	5 min			
19	15 min	4 hours	8 min	21 min	1 min	5 hours	1 min	1 day	46 min	2 hours
	Session 6		**Session 7**		**Session 8**		**Session 9**		**Session 10**	
	18 min	9 min	18 min	5 days (+)	8 min	1 day	2 min	10 hours	0 min	1 day
	Session 11									
	3 min	*								
	Session 1	**Between**	**Session 2**	**Between**	**Session 3**	**Between**	**Session 4**	**Between**	**Session 5**	**Between**
20	24 min	1 day (+)	9 min	2 days	14 min	3 days	0 min	1 day (*)	1 min	

Adherers, lesson 5

Table MA3.9. User actions per participant per session

User	Session 1		Session 2		Session 3		Session 4		Session 5
11	login; start lesson; logout		login; logout;		login; continue lesson		logout; login; mf player 5; download mf 5; success story 6; logout	+	login; sms 15; logout
	Session 6		**Session 7**						
	login; logout	*	login; feedback 4390						
	Session 1		**Session 2**		**Session 3**		**Session 4**		**Session 5**
12	login; start lesson; video 5; logout		login; continue lesson; mf player 5	+ *	login; feedback 2496, 4598; login (2x); feedback 4598, 4411, 4522, 4411, 3489; login (2x); feedback 4598		login; feedback 4598		login; feedback 4418 (sequence 3x); login; feedback 4598
13	login; start lesson; logout		login; continue lesson; logout		login; continue lesson; mf player 5; logout		login; continue lesson; logout	+ *	login; feedback 2990; logout
14	login; start lesson; logout		login; continue lesson; logout		login; continue lesson; download mf 5 (8x); mf player 5; logout; login; logout	+ *			
15	login; start lesson; feedback 3610, 3276, 3361, 3477, 3610; logout		login; continue lesson; logout		login (2x); download mf 5 (8x); logout; login; logout	+ *			
16	start lesson; feedback 2656 (2x); logout		login; continue lesson; mf player 5; download mf 2; logout; login; success story 6, 5; mf player 5; logout	+	login; feedback 2656	*	login; feedback 3335; logout		
17	login; start lesson; mf player 5 (2x); logout		login; feedback 4; continue lesson; download mf 5	+ *	login; feedback 5 (2x)				
18	start lesson; logout		login; continue lesson; download mf 5; success story 5, 6; logout	+	login; logout		login; logout	*	login; feedback 4445

19	start lesson	login; continue lesson; mf player 5; download mf 5	+ *	login; feedback 5; login						
20	login; start lesson; logout	login; logout		login; continue lesson; download mf 2 (2x); logout		login; continue lesson; logout	+ *	login; feedback 5		

Table MA3.10. Duration of sessions and time between sessions per participant

User	Session 1	Between	Session 2	Between	Session 3	Between	Session 4	Between	Session 5	Between
11	4 min	2 days	3h 38 min	18 min	0 min	3 hours	22 min	3 days (+)	5 min	1 day
	Session 6		**Session 7**							
	3 min	3 days (*)	0 min							
	Session 1	**Between**	**Session 2**	**Between**	**Session 3**	**Between**	**Session 4**	**Between**	**Session 5**	**Between**
12	20 min	3 days	14 min	5 days (+*)	28 min	3 days	1 min	3 days	3 min	
13	7 min	7 hours	12 min	2 hours	16 min	2 days	30 min	1 day (+*)	4 min	
14	1 min	5 days	3 min	2 days	35 min	+*				
15	18 min	2 days	39 min	2 days	1h 11 min	+*				
16	13 min	8 days	54 min	1 day (+)	34 min	3 days (*)	2h 58 min			
17	54 min	23 days	9 min	2 days (+*)	6 min					
18	3h 51 min	4 days	28 min	2 days (+)	5 min	4 days	1 min	2 days (*)	0 min	
19	0 min	4 days	48 min	6 days (+*)	1 min					
20	11 min	1 day	10 min	1 day	18 min	5 days	1 min	4 days (+*)	0 min	

Adherers, lesson 8

Table MA3.11. User actions per participant per session

User	Session 1		Session 2		Session 3		Session4		Session 5	
11	Start lesson; download mf 8; logout		login; feedback 4688; continue lesson	+ *	login; feedback 4811					
12	start lesson; login; video 8 (4x); feedback (28x); login (4x); success story 9, 8; login (2x)	+	login (3x); feedback 2496; login (3x); video 3; login (5x);		login; logout		login (2x); download mf 5,6,8; login	*	login; download mf 1; login (3x)	
	Session 6 login; feedback 4892									
	Session 1		**Session 2**		**Session 3**		**Session4**		**Session 5**	
13	login; start lesson; success story 7, 8; logout		login; continue lesson; mf player 8; logout		login; continue lesson; feedback 3800; logout	+ *	login; feedback 4173; success story 7; logout	*	login; feedback 4052; logout	*
	Session 6 login; feedback 4278, 4384; logout		**Session 7** login; feedback 4278, 4384							
	Session 1		**Session 2**		**Session 3**		**Session4**		**Session 5**	
14	login; start lesson; mf player 8; download mf 8 (8x)	+ *								
15	lesson start; mf player 8 (2x); logout	+	login (2x); sms 23, 23, 24; logout	*	login (2x); feedback 4707					
16	start lesson; logout		login; continue lesson; download mf 5; success story 9,8; logout	+	login; logout		login		login; feedback 4176; logout	*
	Session 6 login; feedback 4497									
	Session 1		**Session 2**		**Session 3**		**Session4**		**Session 5**	
17	login; start lesson; download mf 8; logout	+ *	login; feedback 6, 7, 8, 7							

18	start lesson; logout		login; continue lesson; logout		login; continue lesson; mf player 8; download mf 8; sms (24x); logout	+	login; logout		*	
19	login; start lesson; download mf 8, 5, 6		login		login; continue lesson; login	+	login		login	
20	start lesson; download mf 8; logout		login; continue lesson; logout	+	login (3x)	*				

Table MA3.12. Duration of sessions and time between sessions per participant

User	Session 1	Between	Session 2	Between	Session 3	Between	Session4	Between	Session 5	Between
11	26 min	2 days	12 min	6 days (+*)	0 min					
12	1h 26 min	3 days (+)	48 min	2 days	1 min	5 hours	1h 51 min	1 day (*)	27 min	5 days
	Session 6									
	0 min									
	Session 1	**Between**	**Session 2**	**Between**	**Session 3**	**Between**	**Session4**	**Between**	**Session 5**	**Between**
13	24 min	3 days	16 min	2 days	25 min	6 days (+*)	4 min	1 day (*)	15 min	4 days (*)
	Session 6		**Session 7**							
	4 min	2 days	0 min							
	Session 1	**Between**	**Session 2**	**Between**	**Session 3**	**Between**	**Session4**	**Between**	**Session 5**	**Between**
14	13 min	+*								
15	1h 26 min	5 days (+)	42 min	7 days (*)	2h 33 min					
16	9 min	7 days	3h 23 min	2 days (+)	12 min	3 days	0 min	1 day	11 min	3 days (*)
	Session 6									
	0 min									
	Session 1	**Between**	**Session 2**	**Between**	**Session 3**	**Between**	**Session4**	**Between**	**Session 5**	**Between**
17	8 min	9 days (+*)	0 min							
18	1 min	1 day	8 min	3 days	2h 10 min	1 day (+)	0 min	*		
19	39 min	3 hours	0 min	7 days	2 min	5 hours (+)	0 min	1 day	0 min	
20	11 min	4 days	13 min	4 days (+)	0 min	*				

Table MA3.13. Total number of sessions, number of sessions to complete the lesson, number of sessions before feedback was received, total duration of sessions and the total time between sessions for each participant per lesson

User	Lesson	Sessions			Duration of sessions (min)	Time between sessions (days)
		Total	Complete	Feedback		
1	2	2	2	1; 2	22	8
2	2	4	3	3	3	11
3	2	2	1	1	23	8
4	2	5	2	4	115	6.5
5	2	1	1	1	18	0
6	2	4	2	3	2	7
	5	4	1	2	12	8.5
7	2	4	1	3	73	14
	5	6	5	5	53	11
8	2	3	1	2	39	7
	5	2	2	-	18	11
9	2	7	4	6	120	7
	5	5	4	4	91	9.5
10	2	4	2	3	86	15
	5	3	2	3	20	12
11	2	8	4	4; 6	193	9
	5	7	4	6	252	9
	8	3	2	2	38	8
12	2	3	1	3	99	5
	5	5	2	2	66	14
	8	6	1	4	273	11.5
13	2	6	5	5	90	6.5
	5	5	4	4	69	3.5
	8	7	3	3; 4; 5	88	18
14	2	3	2	2	62	8
	5	3	3	3	39	7
	8	1	1	1	13	0
15	2	6	5	5	176	7
	5	3	3	3	128	4
	8	3	1	2	281	12
16	2	6	5	5	146	8
	5	4	2	3	279	12
	8	6	2	5	235	16
17	2	3	3	3	45	6.5
	5	3	2	2	69	25
	8	2	1	1	8	9
18	2	4	2	1;2	40	11
	5	5	2	4	265	12

	8	4	3	4	139	5
19	2	11	7	11	120	9
	5	3	2	2	49	10
	8	5	3	-	41	8.5
20	2	5	1	4	48	7
	5	5	4	4	40	11
	8	3	2	3	24	8

Chapter 7

General discussion

Discussion

In the introduction of this thesis it is argued that non-adherence is an issue in web-based interventions and that this issue is fostered by eHealth interventions, in particular the technology within these interventions, largely being a black box. This black box seems to be maintained by research that is focused only on the content of interventions, causing limited insight in the working mechanisms of these interventions; and development that is ad hoc and lacks stakeholder involvement, causing a lacking fit between the content, system and service of these interventions. In this thesis, opportunities to understand and overcome these issues are explored by focusing on gaining insight into: differences between adherers and non-adherers; the needs and goals of participants related to web-based interventions; the role technology plays in adherence; and usage and use patterns of participants within web-based interventions. In this general discussion, first, the findings of the studies presented in this thesis, regarding the mentioned opportunities to understand and overcome non-adherence, will be commented on. Second, the main implications of the findings of this thesis will be discussed. Moreover, the used methods and the strengths and limitations of the thesis will be considered. As many research projects, the results of this thesis have led to new research questions, some of these will be addressed in the paragraph on future research directions.

Conclusions

Differences between adherers and non-adherers

Different groups, but no universal predictors

The studies presented in Chapter 2 and 6 explored whether there were differences in characteristics of users and non-users, and adherers and non-adherers, respectively. Both studies showed that there were differences between the groups. This is not only a finding of this thesis, but has been shown in other studies (e.g. [1-3]). However, there does not emerge a stable profile of adherers or non-adherers. In both studies of this thesis and in, for example, a study of Postel et al. [3], increased age was positively related to adherence, however, in the review of Christensen et al. [1], younger age was positively related to adherence in the included trials on depression. Contrary, a trial on a PTSD (post-traumatic stress syndrome) intervention included in the same review, showed higher adherence for older persons. Being healthier was predictive of usage in the study into the Healthy Weight Assistant (Chapter 2) and, similarly, less symptoms were found to be predictive of adherence in the review of Christensen et al. [1] and in the study of Postel et al. [3]. However, this finding was not replicated in the study on 'Living to the full' (Chapter 6). In addition to not providing a stable profile of adherers and non-adherers, the predictive power of these characteristics is relatively low (Nagelkerke R^2 = 0.32 and 0.18 for the

Healthy Weight Assistant and Living to the Full, respectively). It seems that there are no universal characteristics of participants that predict adherence, but rather the match between the characteristics of participants and the intervention may predict adherence. In 'Living to the full', being female and having a higher need for cognition predicted adherence. This matches the fact that more women were involved as prospective participants, which probably led to the development of a more 'women-centered' intervention. The higher need for cognition mirrors the focus on information and text in this intervention. For the Healthy Weight Assistant, it must be noted that the reported differences are between users and non-users, not adherers and non-adherers. One-time-users are classified as users, which entails that the curiosity motive of using an intervention cannot be disregarded [4]. Nonetheless, in this study (Chapter 2), not having a chronic condition and underestimating actual behavior were related to usage. This mirrors that the intervention provided a tool to gain insight in your own behavior for healthy adults. Concluding, this thesis does not provide a final answer to how adherers and non-adherers are different, but it has been shown that they are different. This difference seems to lie in the match between characteristics of participants and the web-based intervention, instead of a certain characteristics being universal predictors for adherence.

Needs and goals of participants

Participants expect a web-based intervention to support them in achieving their goals and to have the advantages that the Internet has to offer

Chapters 2 and 4 give insight into why participants plan to use web-based interventions. In the study presented in Chapter 2, it seemed that the goals of the participants (gaining insight in their behavior) did not correspond with the goals of the developers of the technology (supporting healthy behavior). This mismatch was proposed to be the main reason for the high non-adherence. The development study presented in Chapter 4 was intended to avoid the pitfall faced in Chapter 2 and moreover, to anticipate on the expected needs of the participants. It has been found that participants expect to be supported, that the intervention is user friendly, the content has added value and the service that will be given through the web-based intervention has the advantages that the Internet has to offer (e.g. flexible time planning and independence of time and place). These high level needs are likely to present the values that a participant finds important regarding a web-based intervention [5] and as such are not directly useful in obtaining requirements for a web-based intervention under construction. However, the process of elicitation of comments from the participants on early prototypes and ideas for web-based interventions, not only provides information on these values, but also information on how the participants feel these values should be implemented. This more specific feedback was seen in the study in Chapter 4 on, for example, the usefulness of the features text message coaching and feedback messages. The process of this requirements engineering with attention to the needs and values of stakeholders has been described in a recent paper [6]. Concluding, it

has been shown that participants expect a web-based intervention to support them in achieving their goals and to have the advantages that the Internet has to offer (e.g. flexible time planning and independence of time and place). Moreover, non-adherence can easily be a consequence of a web-based intervention not matching the goals and characteristics of its users. Specific requirements to implement the values of participants in a web-based intervention need to be investigated with the involvement of these prospective participants.

The role of technology in adherence

Persuasive design does matter, but in what way?

The systematic review presented in Chapter 3 provides evidence for the influence of intervention characteristics and persuasive design on adherence to web-based interventions. By analyzing 83 web-based interventions, a regression model was found that explained 55% of the observed variance in adherence. Significant predictors within this model were on the level of the study (an RCT study opposed to an observational study predicted a higher adherence percentage), on the level of intervention characteristics (increased interaction with a counselor, more frequent intended usage and more frequent updates predicted a higher adherence percentage), and on the level of persuasive design (more extensive employment of dialogue support predicted a higher adherence percentage). Of these significant predictors, especially more frequent intended usage (i.e. the extent to which individuals should experience the content of the intervention, as defined or implied by its creators), more frequent updates and more extensive employment of dialogue support are salient. These aspects provide the opportunity to improve interventions without the need for more human involvement, which may increase the cost-effectiveness of web-based interventions. However, the review also showed that current web-based interventions employ persuasive design principles only sparsely, which, especially for dialogue support, seems a missed opportunity. The study presented in Chapter 5 further explored the possible influence of five intervention components (human versus automated support; text message coaching versus no text message coaching; high versus low experience through technology; high- versus low-tailored success stories; high versus low personalization) on adherence. The results of this study showed that none of the components influenced adherence, which seems contradictory to the results of the review and shows that knowledge on the way technology influences adherence is still limited. Of the features that were screened in Chapter 5, only text messages can truly be classified as dialogue support from the PSD-model (as reminders) [7]. Based on the review, an effect of adding these messages was expected. However, as seen in Chapter 6, although text-messages were read, the SMS-coach was hardly used, meaning that the 'reminding' effect of these messages was virtually non-existent because they were only seen when already logged in. Furthermore, based on the review, the human support condition was expected to achieve a better adherence percentage, but this was not supported by the data. However, it

may be that the automated support condition made up for the lack of interaction with a counselor by employing dialogue support features: the automated feedback messages included praise and the included picture of a counselor combined with the feedback may have given the system a social role as a counselor. Nonetheless, the study in Chapter 5 has shown that participants seem to evaluate the intervention that included text messages or high experience (i.e. movies and interactive exercises) more positive than interventions that did not include these components. Together with the finding that adherers evaluated the intervention more positive than non-adherers, this point towards a possible positive effect of adding these features. However, the exact effect is unclear and this should be the subject of future research in which it should be investigated what a specific component does in a specific intervention at the levels of content, system, service and interaction.

Usage and use patterns

Participants do not use everything; adherers use more than non-adherers

The study presented in Chapter 6 confirmed earlier findings on usage of web-based interventions: participants do not use all the features that they can use and that the developers of these interventions expect them to use [8-17]. This is unfortunate, because studies have shown that increased usage of particular features, such as completing assessments and self-monitoring, can increase the effectiveness of interventions [9, 11, 12, 16-19]. Non-use was not only apparent for features that were additional to the intervention content (e.g. success stories), but also for integral features of the content of the intervention such as feedback messages, although it seemed that the more the features were integral to the content, the more they were used. Furthermore, the data showed that participants, overall, need more than one session to complete a weekly module. To our knowledge, the study presented in Chapter 6, is the first study to confirm this hypothesis by investigating usage and use patterns on an individual level. This insight has important implications for how to design interventions, which will be elaborated on in later paragraphs. In a previous paragraph, it was concluded that adherers and non-adherers are different groups, although there seem to be no characteristics that are universal predictors for adherence. On a behavioral level, this difference is noticeable in usage as well as in the use patterns, as early as the first lesson. Overall, adherers seem more involved with the intervention; they spend more time, use more features and more sessions to complete each lesson. This finding is strengthened by the results of Chapter 5, that showed that adherers score significantly higher on task enjoyment, involvement and satisfaction with the web-based intervention.

Implications for research and development

The main implication of this thesis is a call to design for adherence. As shown, adherence is an issue and will not dissolve on its own accord. However, with the insights and possible

solutions from this thesis, the opportunity arises to not only hope for adherence, but to plan for adherence. In the following paragraphs, designing for adherence during the development process, designing for adherence as an outcome and as a process, research methods and persuasive technology will be addressed.

Design for adherence: development

When developing a web-based intervention, attention should not only be paid to the content of the intervention, but also to the system and the service the intervention should provide. Attuning these aspects to the goals of an intervention and to the goals of the participants will likely increase adherence. To achieve such a match, a structured development process is advisable and the CeHRes Roadmap provides a practical guideline for such a development process [5]. In this process, the technology should not be taken for granted, but should be designed with the participants (in mind). The recent CONSORT statement for trials in eHealth research and the list of contributors to the statement [20], shows that the importance of both system and service is recognized by the broader eHealth community. The statement provides guidance on what to report when publishing on eHealth interventions and is an answer to the problem of varying reporting standards and level of detail in publications which, according to Eysenbach in his editorial on the CONSORT statement, hampers progress and impedes knowledge transition [20]. Interestingly, many of the directions in the statement concern reporting of the technology (e.g. CONSORT checklist item 1a i: Identify the mode of delivery in the title) and of the service the intervention provides (e.g. 5x: Clarify the level of human involvement; and 5xii: describe any co-interventions [incl. training/support]). Furthermore, a recent tutorial on data extraction for systematic reviews in eHealth adds important aspects on, for example, the implementation (setting and strategy) of the technology and service [21]. This checklist and the tutorial are not only useful when reporting or systematically reviewing web-based interventions, additionally, they seem to be very useful for the process of development, because all points reflect choices to be made. When using these, the pros and cons of each choice can be assessed and choices can be made consciously instead of being accepted as a given.

Design for adherence: outcome

Based on this thesis, it can be concluded that it is important to design for adherence as an outcome: create a web-based intervention that is likely to achieve a high adherence rate. It has been shown that intervention characteristics and persuasive design of web-based interventions have an effect on adherence. More extensive employment of dialogue support might be relatively easy to implement in a web-based intervention and deserves more attention than it has been given until now. Additionally, as more frequent updates of content in a web-based intervention and more frequent intended usage have been shown to be related to better adherence, these aspects deserve attention when designing web-

based interventions. Furthermore, the results on automated support in 'Living to the full', implicate that attention should be given to the question whether human support is needed in a web-based intervention. The assumption that the inclusion of human support will lead to more adherence and increased clinical effectiveness, should not be made without thought. In general, the assumption that adding or implementing a certain feature leads to better adherence should not be made. At this time, it cannot be stated that a certain design or feature will always lead to better adherence, therefore, whenever possible, the effect of different designs or features should be tested. However, it is possible to extrapolate the results of the systematic review in Chapter 3 by using the regression model to predict the percentage of participants who will adhere to an intervention. When applying this model to the 'Living to the full' intervention, the predicted adherence percentages are 61% and 63% for the condition with human and automated support, respectively, while the observed adherence percentages were 48% and 51%. Although there is a substantial difference between the predicted and observed percentages, the model did not predict a large difference between the conditions. It may be useful to use this model as a first indication as to whether proposed differences in the design are likely to lead to differences in adherence. This strategy is currently used in a project on blended care (investigating the optimal fit between online and offline care) in eMental health in The Netherlands [22].

Design for adherence: process

The last design implication is a call to design for adherence as a process. As stated before, the process of adherence and non-adherence has gained limited attention. It seems that there is still a lot to be gained. In each web-based intervention, all content is added with a goal to be beneficial to the participants. Numerous studies have found a relationship between exposure to the content of an intervention and the effect of the intervention (see [23] for a systematic review). Furthermore, the study presented in Chapter 6 showed that more extensive use of the materials in an intervention is related to adherence. Therefore, it seems unfortunate that participants use only a fraction of the possible material. This may be an area where the design of interventions, especially persuasive design, can play an important role. According to Fogg, a behavior happens when there is motivation, ability and a trigger [24]. When motivation is low, the behavior can still happen, providing the behavior is very simple (i.e. the participant has a high ability) and is triggered at the right time. Applying this principle to 'Living to the full' might look like this: It has been observed that when participants complete a lesson and have not received feedback, they tend to log on just to check whether their feedback is there. If a button 'When will my feedback be ready' would be included, participants will be triggered to perform the easy behavior to click on the button. When clicking, the participants will not only see a timer that shows when their feedback will be ready, but they will also see a message that states: 'We have noticed that you have not read this week's story of a participant, why not read it now?' and includes a

link to the story. This persuasive design is likely to increase the usage of features that have not been accessed.

A different possibility to adapt the design of web-based interventions to enhance adherence can be found in use patterns. It has been observed that adherers and non-adherers seem to have different use patterns. With this insight, it is possible to act: either on the level of the intervention or on the level of the participant. On the level of the intervention it may sometimes be advantageous to adapt to the observed patterns (i.e. 'pave the cowpaths': "look where the paths are already being formed by behavior and then formalize them, rather than creating some kind of idealized path structure that ignores history and tradition and human nature and geometry and ergonomics and common sense" [25]), while on the other hand, it may sometimes be more prudent to adapt the design of the intervention to increase the likelihood of preferred patterns. On the level of the participant, the intervention can be designed to provide guidance to the participant to increase the likelihood of employing a preferred pattern (e.g. by providing feedback on the usage pattern or providing links to features that should be accessed on the home page) or intervene when the chance of the participant becoming a non-adherer is high, either through the intervention itself or through, for example, a phone call from a care professional. Adaptive interfaces [26] seem to provide a method of achieving this flexibility. When redesigning an intervention in this manner, attention should be paid not only to the system, but also to the content and service as it is likely that changing one aspect influences the other aspects. Losing the 'holistic' overview may lead to a deterioration of usage and adherence instead of the desired improvement [5].

Research methods

Although the randomized controlled trial is a very solid method of assessing the effects of an intervention, there are drawbacks and limitations of using only this method. First, the finding that adherers and non-adherers are different groups implies that intention-to-treat (ITT) analyses, which are the golden standard in RCTs, may not be sufficient. To understand these different groups, it seems valuable to supplement ITT analyses with separate analyses on adherers and non-adherers. When not supplemented by other methods, RCTs provide limited insight in how or why an intervention works or does not work [15, 27]. Not only is an RCT not able to extract working ingredients of an intervention, the formal research setting itself also influences adherence as shown in Chapter 3. Furthermore, data on usage is an essential first step to understand why an intervention does or does not work. In this thesis, a different version of an RCT has been employed, namely an experimental RCT with a fractional factorial design. Although this method provides the opportunity to screen for the effects of several variations of the intervention in one study, the untangling of the specific effects (or lack thereof) proved to be harder than anticipated in a field where there is still much uncertainty on the effects of adding (multiple) features [28]. It may be valuable to explore possible effects of features first in a more experimental setting (e.g. a persuasive

eHealth-lab) and include the most promising features separately in a 'full' intervention that is implemented in a care setting. Moreover, it is needed to check whether the variations or features actually do what is expected of them. This manipulation check can help in understanding why certain features do or do not achieve a certain effect.

Regarding the systematic review (Chapter 3), the problem was encountered that interventions are described poorly and adherence is defined in various ways which made it hard to compare interventions. In the study, this problem was managed by refining the definition of adherence and using a detailed coding scheme to classify interventions. With the CONSORT eHealth statement [20] and with a recent tutorial on data extraction for systematic reviews in eHealth [21], a step has been made to make this comparison easier. The systematic review proved to be a valid way to learn from the work that has already been done on web-based interventions. More standardization on reporting on web-based interventions, will hopefully help the field to learn more from the work that is already been done.

The qualitative methods used in the development process of Chapter 4 proved to be useful for the development of the web-based intervention. Moreover, it increased understanding of who the target audience is and what they need to successfully use a web-based intervention. This understanding helped in interpreting the results of the studies in Chapter 5 and 6 and made us more aware of especially the service that we were trying to give. Of course, the development process reported in Chapter 4 is only an example; in a different context with a different goal and different stakeholders, another application of the methods in each phase may be more useful. However, the principles will remain the same and ideas for methods can be found in this study and other examples [29, 30]. Moreover, the development process is not finished, the results of the last two studies and especially the results on the usage and use patterns, provide input for the next round of the iterative development of the intervention. Furthermore, in the development process, we made the decision to develop the intervention, for now, for the research context. Although this has implications for the generalizability of the results, this research context gave us the ability to experiment with the intervention. It may be that this research context, with room for experimentation, is needed to further develop our knowledge and understanding of web-based interventions. Lastly, the CeHRes roadmap provided the tools and a guideline to do this experimentation focused on design and implementation [5].

Persuasive technology

One of the major findings in this thesis is that persuasive technology plays a role in the adherence to web-based interventions and possibly in the effectiveness of these interventions. These possibilities are not yet fully exploited, as shown in the systematic review. When applying persuasive technology elements, it was found fact that the effects are not as simple as may have been expected. An overarching theory that gives insight into how, when, for whom and in what way persuasive technology can work is lacking. Many of

the elements that have been investigated as persuasive technology are not new, but have been investigated in the context of persuasive communication. From persuasive communication we have learned that there are different ways to frame information that can make it more persuasive (e.g. source factors as credibility and liking [31]), and that there are different ways in which information is processed which influence the effectiveness of certain persuasive strategies (see e.g. [32]). Although it has been proposed that many of these principles are valid when applied to technology aimed at improving health, it is likely that there are additional mechanisms at work in this different context [33, 34]. These theories are not created to capture the relationship between people and technology in a context; they are likely not dynamic enough to capture this complex relationship. Here, research into the interaction of people with technology in their context can provide valuable information to adapt these theories to accommodate this relationship. Inserting information from case studies into existing theories may help to better understand the influence of persuasive technology in eHealth and in our lives. Fogg's functional triad [35] and more recent and more elaborate, the Persuasive System Design-model (PSD-model) [7] provide a practical step towards understanding the way persuasive technology works in a specific context and how the different persuasive elements are connected. However, more work needs to be done on validating and testing these models. On the PSD-model, recent studies into validating this model have shown promising effects [36, 37]. Furthermore, these studies show the crucial role of dialogue support in the persuasiveness of web-based interventions, which concurs with the finding of the systematic review that dialogue support is a significant predictor for adherence.

Strengths and limitations

A general limitation of the studies presented in this thesis is that the participants are self-selected. They are not a representation of the general public, but are a very select sample of mainly higher educated women. This means that the results cannot be generalized to the wider population of possible participants of web-based interventions. However, the group that participated in the studies in this thesis is seen as participants in many web-based interventions [3, 10, 38, 39] and this points towards a limitation of not only this thesis, but of research into web-based interventions in general. It seems that, at the moment, web-based interventions reach mainly higher educated people, and women especially. This is something that should be taken into account when developing these interventions. In the development of 'Living to the full' we decided to 'accept' this group as our target group, but thereby almost excluded lower educated men (47% higher educated women versus 2% lower educated men). It should be investigated whether there is a need for web-based interventions or other forms of eHealth technology for these neglected groups and if there is a need, this should be addressed.

This points towards a second limitation of this thesis: the focus has only been on web-based interventions. Although this form of eHealth technology is widely used, mobile technology and integrated (using different forms of technology) or blended interventions (a combination of online and face-to-face interaction) are rapidly becoming more dominant. On the one hand it seems that this thesis is overtaken by technology in that purely web-based interventions almost seem as something from the past, but on the other hand, it seems plausible that the conclusions of this thesis can be applied to mobile technology as well. Especially through the introduction of tablets, the differences between mobile technology and personal computers is fading. However, there remain differences, especially on the settings in which these technologies are used. The extent to which these differences influence adherence needs to be tested in future research.

A strength of this thesis is that the topic has been approached through a variety of methods and through different web-based interventions on different topics. This combination of methods and interventions allowed to verify the conclusions of the different studies in other settings and strengthened the findings. Moreover, the practical and objective measure of adherence allowed the comparison of different interventions and allowed the approach of the topic in a consistent way.

Future research directions

A major implication of this thesis is the call to design for adherence. However, this design should be accompanied by research to investigate whether this design will actually lead to better adherence. Although this may sound simple, as argued in our development study (Chapter 4), it may not be feasible to compare a web-based intervention that is designed for adherence with an intervention that has not been designed for adherence. Rather, the effects of this design may have to be investigated iteratively, as the second working principle of the CeHRes roadmap prescribes [5]. After an intervention has been implemented for a while and adherence has been measured, a (re)design step to increase adherence can be taken and the effects (on adherence as an outcome and as a process) can be measured.

In this thesis it has been shown that adherers and non-adherers are different groups that differ on characteristics, on usage patterns and appraise the web-based intervention differently. This seems to imply that non-adherers are a more or less homogeneous group that is less involved with the intervention. This, however, seems to contradict the results of earlier research into the reasons for non-adherence as mentioned by the participants themselves. For example, the key reasons for non-adherence of a web-based intervention for problem drinkers, according to these non-adherers, were personal reasons, dissatisfaction with the intervention, and satisfaction with their own improvement [3]. Of these reasons, the less overall involvement found in non-adherers, seems to mirror only the

dissatisfaction with the intervention. Both other reasons seem to contradict the finding that non-adherers are less involved with the intervention from the start. Future research should investigate whether the group of non-adherers can be divided in different groups and how large the group of non-adherers is that can be persuaded to adhere.

In Chapter 5 it was found that, on follow-up, human and automated feedback in the web-based intervention for the prevention of depression 'Living to the full' did not differ on clinical effectiveness. This finding deserves further research, first of all because of the implications for the cost-effectiveness of preventive interventions. If a web-based intervention can be as effective without care provider involvement, then it would be possible to deliver these interventions at low costs to many people. However, it should be investigated when automated feedback can be this effective. Is it because of the specific group reached by this intervention, or because of the content of the intervention, or because of the way the automated feedback was implemented? Furthermore, it should be investigated what the implications are: what happens when this care can be given without human involvement? Implications need to be investigated on legislation, implementation and on the care setting. As pointed out in the thesis of Nijland [40] and the viewpoint paper on the holistic framework [5], neglecting to focus on these aspects will likely hinder the uptake of the technology. Lastly, insight into the process of improvement for participants with human or automated support is needed, especially because of the difference in this process of improvement shown in Chapter 5. Answers to these questions may make it possible to replicate these results in different web-based interventions and to make this leap in cost-effectiveness.

In this thesis, it has been stressed that the content, system and service of web-based interventions are interdependent and that interaction can be viewed as an integral part which, depending on the viewpoint, can be classified as belonging to each of the aspects. However, in the development process, these aspects are often developed separately instead of as the interdependent aspects that they should be. An interesting area for future research is to create a match between these aspects and thereby fully utilize the strengths of the combination, by developing these aspects of an intervention as one.

Lastly, a future research direction lies in the persuasive technology area. Studies on the validation of the PSD-model [36, 37] have shown the relationship between the perceived level of support on the categories (primary task support, dialogue support, credibility support and social support) and the overall persuasiveness of a web-based intervention. This concept of perceived persuasiveness raises the question to whether more extensive employment of persuasive elements in an intervention increases the perceived persuasiveness. It may be that different people perceive elements of the PSD-model differently and this perceived persuasiveness may explain why elements have a different effect on different people.

Conclusion

In conclusion, this thesis has shown that: adherers and non-adherers are different groups, but there are no universal predictors; participants expect a web-based intervention to support them in achieving their goals and to have the advantages that the Internet has to offer; persuasive design does matter; and participants do not use all features of a web-based intervention, but adherers use more than non-adherers. With these insights, the opportunity arises to not only hope for adherence, but to plan for adherence. Although a substantial part of this thesis has focused on a web-based intervention for the prevention of depression, that does not mean that the results are limited to eMental health. A shown in the systematic review, the health care area per se does not influence adherence, rather intervention characteristics and design influence adherence. Therefore, the results seem very applicable to, for example, ePublic health [41]. For this area, the finding that human involvement in a web-based intervention does not always lead to better adherence and clinical effectiveness is promising. Especially in ePublic health, where the large target audience renders human involvement for the whole audience unfeasible, a smart design employing persuasive technology is promising.

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Samenvatting

(summary in Dutch)

Samenvatting

In **hoofdstuk 1** werd beschreven dat eHealth (het gebruik van informatie- en communicatie technologie om gezondheid en welzijn te ondersteunen) al lange tijd als veelbelovend wordt gezien om de gezondheidszorg goedkoper, gemakkelijker en beter te maken. Echter, voor een innovatie die zo veelbelovend is, is het gebruik van eHealth nog weinig wijdverspreid en is de impact op de gezondheidszorg beperkt. Een belangrijke reden hiervoor lijkt te zijn dat eHealth technologie in veel opzichten nog een 'black box' is: we meten wat er in gaat en wat er uit komt, maar wat in de 'box' gebeurt krijgt weinig aandacht en is daardoor onbekend. Deze black box lijkt aan de basis te liggen van een bekend probleem binnen eHealth: non-adherentie. Non-adherentie verwijst naar het feit dat ook al starten er veel mensen met het gebruik van een eHealth interventie, niet iedereen de interventie zal afmaken en daardoor ook niet maximaal zal kunnen profiteren van de interventie. De black box draagt bij aan dit probleem doordat wanneer we niet weten wat er gebeurt tijdens het gebruik van de interventie door de deelnemers, we dit proces ook niet kunnen begrijpen en niet kunnen ingrijpen. Veel onderzoek naar eHealth interventies richt zich op de inhoud van deze interventies, maar daarbij wordt vaak over het hoofd gezien dat de technologie, en de dienst die geleverd wordt door middel van de technologie, zelf ook invloed heeft en niet alleen maar een middel is. Begrijpen hoe de inhoud, technologie en de service worden gebruikt en ervaren, kan een eerste stap zijn naar het verbeteren van adherentie. Ook tijdens het ontwikkelingsproces van eHealth interventies zou, meer dan nu, de nadruk gelegd moeten worden op de combinatie van inhoud, technologie en service. Dit kan gedaan worden door de doelgroep te betrekken bij het ontwikkelproces en dit proces gestructureerder te laten verlopen dan nu vaak het geval is. Onderzoek om meer inzicht te krijgen in de black box zal verder moeten gaan dan voor- en nametingen bij een interventie en zal kwalitatieve data en data over het gebruik van eHealth interventies moeten combineren. Dit proefschrift richt zich op web-based interventies. Dit zijn eHealth-interventies op het gebied van gezondheid (zowel voor leefstijl als chronische aandoeningen als mentale gezondheid) die worden aangeboden via een website. Deze web-based interventies bestaan uit de samenhangende elementen: inhoud, technologie en de service die wordt geleverd. Daarnaast is interactie met het systeem en/of met een hulpverlener een belangrijk aspect. Uit onderzoek weten we dat web-based interventies een positief effect kunnen hebben, maar dat dit effect niet altijd wordt gerealiseerd. Non-adherentie is een probleem binnen web-based interventies en kan het effect van deze interventies verkleinen. Het is belangrijk om adherentie te onderscheiden van 'drop-out', aangezien deze laatste term slaat op deelnemers die zich niet aan het onderzoeksprotocol houden (bijvoorbeeld door geen vragenlijsten in te vullen). Daardoor is drop-out alleen in een onderzoekssetting van belang. Bij adherentie gaat het erom of de deelnemer de interventie ervaart in de mate waarin hij/zij het zou moeten ervaren om optimaal te profiteren, volgens de makers van de interventies. Hierbij is het dus belangrijk

om expliciet aan te geven hoe een interventie gebruikt zou moeten worden. Verder werd in hoofdstuk 1 de CeHRes (Center for eHealth Research and Disease Management) Roadmap geïntroduceerd, die een handvat biedt voor het slimmer ontwikkelen van eHealth interventies waarbij alle belanghebbenden worden betrokken en de technologie wordt ontwikkeld in de context van de zorgsetting waar het voor bedoeld is. De Roadmap is ontwikkeld om de adoptie en impact van eHealth technologie te vergroten en kan gebruikt worden voor zowel de ontwikkeling als de evaluatie van eHealth technologie. Ook werd het begrip persuasieve technologie geïntroduceerd: de mogelijkheid van technologie om gedrag en attitudes van mensen te beïnvloeden. Het Persuasive System Design-model (PSD-model) classificeert technologie aan de hand van de persuasieve functies die het kan vervullen in de categorieën: ondersteuning van de primaire taak, ondersteuning van de dialoog, sociale ondersteuning en ondersteuning van de geloofwaardigheid. Hoofdstuk 1 eindigde met een beschrijving van doelen van dit proefschrift. Om adherentie te begrijpen en te beïnvloeden is het nodig om antwoord te krijgen op de volgende vragen: [1] wie zijn de mensen die wel en geen adherentie vertonen aan web-based interventies (hoofdstuk 2 en 6)?; [2] om welke redenen en met welke doelen gebruiken mensen web-based interventies (hoofdstuk 2 en 4)?; [3] wat is de rol van de technologie bij adherentie (hoofdstuk 3 en 5)?; en [4] hoe worden web-based interventies gebruikt (hoofdstuk 6)?

In **hoofdstuk 2** werd een onderzoek beschreven naar de gebruikers en de effecten van de Gezond Gewicht Assistent van het Voedingscentrum. Dit is een web-based interventie voor het bevorderen van gezonde eet- en beweeggewoonten. Onderzoek heeft aangetoond dat web-based interventies potentie hebben voor het veranderen van deze gewoonten. Het is echter niet bekend hoe interventies voor die veranderingen kunnen zorgen. Ook is non-adherentie een probleem en is er weinig bekend over welke kenmerken van deelnemers gebruik kunnen voorspellen. De waarde van een model (met sociale en economische factoren, aandoening gerelateerde factoren, patiënt gerelateerde factoren, redenen voor gebruik van de interventie, en tevredenheid) voor het voorspellen van welke deelnemers gebruik maken van de interventie en welke niet werd onderzocht. Ook werden de effecten van de interventie op zelf gerapporteerd eet- en beweeggedrag onderzocht. Dit werd gedaan met behulp van een gerandomiseerd onderzoek met controlegroep (RCT) met 150 deelnemers in de wachtlijst conditie en 147 deelnemers in de interventie conditie. Aan alle deelnemers werd gevraagd online vragenlijsten in te vullen aan de start van het onderzoek en na de interventieperiode van 12 weken. Deelnemers in de controle conditie werden na het invullen van de nameting in de gelegenheid gesteld om de interventie te gebruiken. Objectieve gegevens over het gebruik van de interventie werden verzameld in de web-based interventie zelf. De resultaten lieten zien dat 64% (81/147) van de deelnemers in de interventie conditie de interventie daadwerkelijk had gebruikt. Van deze mensen had 49% (40/81) de interventie maar één keer gebruikt. Een hogere leeftijd en het niet hebben van

een chronische aandoening vergrootten de kans op het hebben gebruikt van de interventie. In de interventiegroep hadden de gebruikers een betere score op eetgedrag en kennis over gezond gedrag dan niet-gebruikers. Ook onderschatten gebruikers hun gedrag vaker dan niet-gebruikers en overschatten niet-gebruikers hun gedrag vaker dan gebruikers. Vergelijking van de deelnemers in de controle en interventie conditie (intention-to-treat analyse) liet geen betekenisvolle verschillen zien. Bij het vergelijken van de verschillen tussen voor- en nameting tussen de controle groep, de gebruikers en de niet-gebruikers zagen we dat de niet-gebruikers significant verbeterden op eetgedrag, terwijl op beweeggedrag alleen de gebruikers significant verbeterden. Concluderend werd gevonden dat de deelnemers de interventie niet gebruikten zoals bedoeld. Van het voorgestelde model voorspelden een sociale en economische factor (leeftijd) en een aandoening gerelateerde factor (chronische aandoening) gebruik. Verder waren de gebruikers over het algemeen gezonder en hadden meer kennis over gezond gedrag dan niet-gebruikers. Er werd geen duidelijk effect gevonden van de interventie, maar het lijkt erop dat het kiezen om wel of niet de interventie te gebruiken tot verschillende uitkomsten leidt. In combinatie met de verschillen tussen de gebruikers en niet-gebruikers op de voormeting, lijkt het er op dat deze groepen echt verschillend zijn en ook zo behandeld zouden moeten worden.

In **hoofdstuk 3** werd een systematische review naar adherentie aan web-based interventies beschreven. Uit onderzoek blijkt dat web-based interventies om gezondheid te bevorderen effectief kunnen zijn, maar dat non-adherentie een probleem is. Technologie om de inhoud van een interventie over te brengen is nog weinig onderzocht en blijft vaak een black box. In dit hoofdstuk werd de technologie gezien als een vitaal onderdeel van een web-based interventie en werd de rol van technologie bij adherentie onderzocht. Het doel van de studie was te onderzoeken of kenmerken van web-based interventies en persuasief design de adherentie aan web-based interventies beïnvloeden. Dit is gedaan door gepubliceerde studies naar web-based interventies voor gezondheidsbevordering systematisch te onderzoeken. Per interventie werden de kenmerken, persuasieve design elementen en adherentie gecodeerd. Met behulp van een multipele regressie analyse werd gekeken of deze variabelen adherentie konden voorspellen. In de studie werden 101 artikelen naar 83 interventies geïncludeerd. Een typische web-based interventie is bedoeld om één keer per week gebruikt te worden, heeft een modulaire setup, wordt één keer per week geüpdatet, duurt 10 weken, heeft interactie met het systeem, met een counselor en met lotgenoten via een website, bevat enkele persuasieve technologie elementen, en ongeveer 50% van de deelnemers zijn adherent. Qua persuasieve technologie zagen we dat ondersteuning van de primaire taak het meest voorkomt (gemiddeld 2,9 van de maximale 7 elementen per interventie). Dialoog ondersteuning en sociale ondersteuning komen minder vaak voor (respectievelijk 1,5 en 1,2 van de maximale 7 elementen per interventie). Bij het vergelijken van de verschillende gezondheidsgebieden (leefstijl, chronische aandoeningen en mentale

gezondheid) vonden we significante verschillen wat betreft bedoeld gebruik, setup, updates, frequentie van interactie met een counselor, met het systeem en met lotgenoten, duur, adherentie, en het aantal elementen van ondersteuning van de primaire taak. Het uiteindelijke gevonden regressiemodel verklaart 55% van de variantie in adherentie. In dit model voorspellen de volgende variabelen significant betere adherentie: een RCT studie (tegenover een observationele studie), meer interactie met een counselor, frequenter bedoeld gebruik, frequentere updates en meer elementen van dialoog ondersteuning. Concluderend kunnen we zeggen dat een substantieel gedeelte van de variantie in adherentie verklaard kan worden door kenmerken van interventies en persuasieve technologie. Hoewel we zagen dat er verschillen zijn tussen gezondheidsgebieden op de kenmerken van web-based interventies, is het gezondheidsgebied op zich geen voorspeller voor adherentie. De resultaten van deze studie kunnen gebruikt worden om web-based interventies te ontwikkelen die een grotere kans hebben op een goede adherentie.

In **hoofdstuk 4** werd een onderzoek beschreven naar de ontwikkeling van de web-based interventie 'Voluit Leven', een interventie voor de preventie van depressie. De hoge prevalentie van depressie zorgt voor een grote belasting op de publieke gezondheidszorg. Om deze belasting te verminderen zijn vroege interventies gericht op mensen met een verhoogd risico op het ontwikkelen van een depressie noodzakelijk en uit onderzoek blijkt dat deze interventies kosteneffectief kunnen zijn. Web-based interventies kunnen deze zorg geven, maar er is geen overeenstemming over hoe dit soort interventies het beste ontwikkeld kunnen worden. Vaak wordt de technologie als een vaststaand gegeven gezien en wordt daar weinig aandacht aan besteed. Dit lijkt één van de redenen dat web-based interventies niet hun volle potentieel behalen. De studie in dit hoofdstuk beschrijft de ontwikkeling van de web-based interventie 'Voluit Leven' aan de hand van de CeHRes Roadmap. De doelen waren het ontwikkelen van een gebruiksvriendelijke applicatie die voldoet aan de waarden van de belanghebbenden en het evalueren van het proces van ontwikkeling. De gebruikte methoden zijn een literatuurstudie en discussie in de 'contextual inquiry'; interviews, rapid prototyping en een requirement sessie in de 'value specification' fase; en usability evaluatie door gebruikers, usability inspectie door experts en een requirement sessie in de 'design' fase. De 'contextual inquiry' liet zien dat er behoefte is aan laagdrempelige interventies voor de preventie van depressie en dat web-based interventies deze behoefte lijken te kunnen vervullen. De 'value specification' fase heeft verwachte behoeften van potentiële deelnemers, opmerkingen over het nut van voorgestelde functies, en opmerkingen over twee voorgestelde ontwerpen van de interventie opgeleverd. De 'design' fase leverde waardevolle opmerkingen op over het systeem, de inhoud en de service van de web-based interventie. Concluderend kunnen we zeggen dat we door het ontwikkelen van de technologie, het systeem, de inhoud en de service van de web-based interventie hebben kunnen ontwikkelen en aan kunnen passen aan de waarden

van de belanghebbenden. De voornaamste lessen die we hebben geleerd van de procesevaluatie zijn: door het betrekken van gebruikers, experts, onderzoekers, designers en technische programmeurs bij het ontwikkelingsproces kan betrokkenheid worden gecreëerd; om verwarring en vertraging te voorkomen is het belangrijk om de rollen van het multidisciplinaire team van te voren te bepalen; onderzoek is een onderdeel van het ontwikkelingsproces, maar geeft ook overzicht over het gehele project; elk project heeft zijn eigen voorwaarden en alleen wanneer deze voorwaarden expliciet worden gemaakt, kan er mee omgegaan worden.

Hoofdstuk 5 beschreef een studie naar persuasieve technologie, effect en adherentie van de web-based interventie 'Voluit Leven' waarvan de ontwikkeling in het vorige hoofdstuk beschreven is. Zoals eerder beschreven, zijn web-based interventies voor de preventie van depressie nodig en laten ze veelbelovende effecten zien. Het is alleen nog onduidelijk wat de actieve componenten zijn in deze interventies. In deze studie werden de effecten van verschillende vormen van begeleiding (door een persoon en geautomatiseerd), een SMS-coach (wel of geen), beleving door technologie (uitgebreid of minimaal), informatie aangepast aan de deelnemer (ervaringsverhalen van fictieve deelnemers die op een aantal aspecten overeenkomen met de deelnemer of standaard ervaringsverhalen) en personalisatie (wel of geen mogelijkheid tot personalisatie) op klinische uitkomsten en op adherentie onderzocht. Ook werd gekeken naar hoe de deelnemers de interventie waarderen. De studie is opgezet als een 'fractional factorial RCT', wat betekent dat de deelnemers willekeurig toegewezen werden aan één van acht varianten van de web-based interventie. Elke variant heeft een andere combinatie van de vijf genoemde componenten, waarbij elk niveau van een component bij vier van de acht varianten voorkomt. Aan de studie namen 239 mensen deel met milde tot matige depressieve klachten. De web-based interventie bestaat uit lessen, oefeningen, feedback, een dagboek en ervaringsverhalen. Het is gebaseerd op 'Acceptance and Commitment Therapy' en op 'Mindfulness'. Aan de deelnemers werd gevraagd de 9 lessen binnen 12 weken af te ronden. De adherentie werd gemeten met behulp van log-data van de applicatie zelf. Depressieve en angstsymptomen werden gemeten aan het begin van de studie, direct na de interventie (na 12 weken) en bij de follow-up (6 maanden na de start van de interventie) door middel van online vragenlijsten. Direct na de interventie werden ook procesmaten meegenomen in de online vragenlijst ('task enjoyment', betrokkenheid, vertrouwen en tevredenheid). De resultaten laten zien dat er een significant interactie-effect was tussen begeleidingsconditie en tijd op de klinische uitkomsten. Dit verschil was echter alleen op het verloop van de verandering, niet op de mate van verbetering. Er werden geen effecten gevonden op adherentie en op de andere componenten. Wel was er een trend die liet zien dat begeleiding door een persoon, wel een SMS-coach en uitgebreide beleving marginaal positiever werden gewaardeerd, met significante verschillen alleen op betrokkenheid. Concluderend kunnen

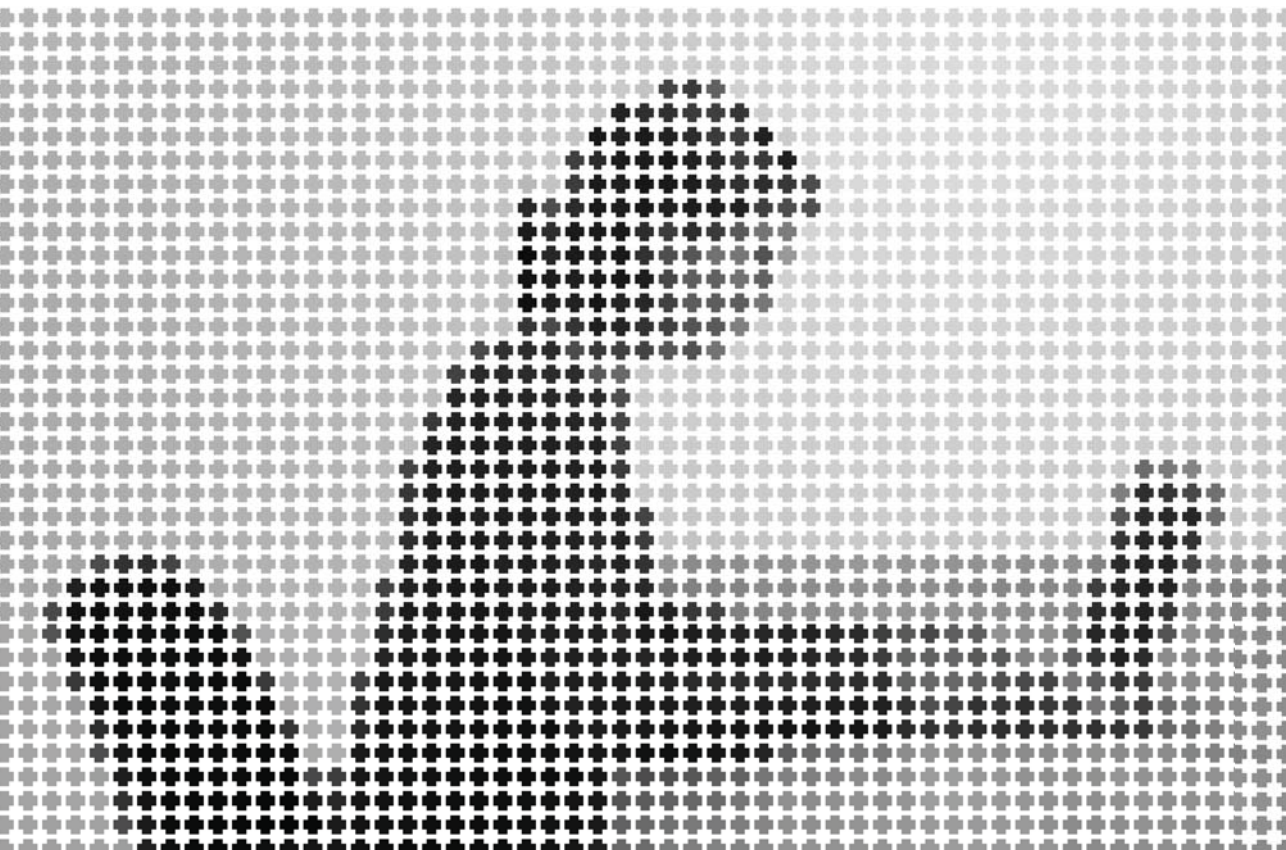
we zeggen dat geautomatiseerde begeleiding even effectief kan zijn als begeleiding door een persoon, zonder een verlies van adherentie. Dit kan web-based interventies kosteneffectiever en makkelijker implementeerbaar in de reguliere gezondheidszorg maken. Het niet vinden van effecten van de andere componenten laat zien dat het uitelkaar halen van de actieve componenten van web-based interventies complex is en dat er voorzichtig moet worden omgegaan met het doen van aannames over het effect van het toevoegen van componenten op effectiviteit en adherentie.

Hoofdstuk 6 beschreef een studie naar de gebruikers, het gebruik en gebruikspatronen van de web-based interventie 'Voluit Leven' waarvan de ontwikkeling en evaluatie in de vorige twee hoofdstukken is beschreven. We weten dat non-adherentie een probleem is bij web-based interventies. Door te onderzoeken hoe deze interventies gebruikt worden en of er verschillen zijn tussen mensen die wel en niet adherent zijn, krijgen we meer inzicht in het proces van adherentie. De doelen van deze studie zijn: het geven van een globale indruk van hoe de interventie ontvangen is; het beschrijven van de kenmerken van gebruikers en onderzoeken of er een relatie is met adherentie; het gebruik van de verschillende onderdelen van de interventie onderzoeken en kijken of er verschillen zijn tussen mensen die wel of niet adherent zijn; het identificeren van gebruikspatronen en verkennen of er verschillen zijn in gebruikspatronen tussen mensen die wel en niet adherent zijn. Voor dit onderzoek werden de gegevens geanalyseerd van 206 deelnemers aan de studie in hoofdstuk 5 die de web-based interventie gebruikt hadden. Hierbij ging het om gegevens die verzameld waren via een online vragenlijst aan het begin van de studie en om log-data uit de interventie zelf. Tijdens de studie zijn er 87 opmerkingen gemaakt via de 'reactie'-knop in de web-based interventie. Opmerkingen over de interventie als geheel en over de inhoud waren met name positief. Er was een substantieel aantal negatieve opmerkingen over de kwaliteit van het systeem (voornamelijk 'bugs') en over de kwaliteit van de service (voornamelijk verwarring over de procedures binnen de interventie). In totaal waren 118 deelnemers adherent. Deelnemers met een etniciteit anders dan Nederlands waren vaker adherent. Deelnemers die niet adherent waren, gebruikten het internet gemiddeld meer uren per dag. Een logistische regressie liet zien dat de kans op adherentie vergroot is bij vrouwen en bij mensen met een hogere 'need for cognition'. Gemiddeld logden de deelnemers vier keer per les in, maar mensen die adherent zijn, logden significant vaker in dan mensen die niet adherent zijn. Bij de gebruikspatronen zagen we dat mensen die vroeg non-adherent zijn, minder sessies en minder tijd gebruikten dan mensen die laat non-adherent zijn, en minder sessies gebruikten om een les af te ronden dan mensen die adherent zijn. Concluderend kunnen we zeggen dat log-data, gecombineerd met kenmerken en ervaringen van gebruikers waardevolle informatie opgeleverd hebben voor het verbeteren van deze interventie en voor het design van web-based interventies in het algemeen. Het toevoegen van een 'reactie'-knop bleek een nuttige manier om kwalitatieve

data te verzamelen over hoe deelnemers de interventie waarderen. Verder zagen we dat kenmerken van deelnemers adherentie kunnen voorspellen, maar de voorspellende waarde is klein. Als laatste hebben we gevonden dat het belangrijk is om web-based interventies zo te ontwerpen dat adherentie en het gebruik van de verschillende onderdelen gestimuleerd wordt.

In **hoofdstuk 7** werden de resultaten van de vorige hoofdstukken bediscussieerd en werden implicaties en aanbevelingen voor vervolgonderzoek besproken. Dit proefschrift heeft laten zien dat er verschillen zijn tussen mensen die wel en niet adherent zijn, maar deze verschillen zijn niet telkens hetzelfde. Het lijkt erop dat de afstemming tussen kenmerken van deelnemers en de interventie voorspellend is voor adherentie en niet de kenmerken van deelnemers op zich. Verder hebben we gezien dat deelnemers verwachten dat een web-based interventie hen ondersteunt bij het bereiken van hun doelen en dat deze interventies de voordelen van het internet hebben, zoals een flexibele tijdsplanning en onafhankelijkheid van tijd en plaats. Non-adherentie kan een gevolg zijn van het niet overeenkomen van de interventie met de doelen van de deelnemers. Daarom is het noodzakelijk om toekomstige gebruikers te betrekken bij het ontwikkelen van web-based interventies. Daarnaast hebben we gevonden dat een persuasief design van web-based interventies een positieve invloed heeft op de adherentie, alhoewel we geen effect hebben gevonden van het toevoegen van meer of minder persuasieve componenten aan een interventie. Het blijft de vraag op welke manier persuasieve technologie precies de adherentie van web-based interventies beïnvloedt. Als laatste laat dit proefschrift zien dat deelnemers aan een web-based interventie niet alle onderdelen van een interventie gebruiken die ze kunnen gebruiken. Wel hebben we gezien dat mensen die adherent zijn meer betrokken lijken te zijn bij de interventie: ze besteden meer tijd aan de interventie, gebruiken meer sessies om een les af te ronden en gebruiken meer onderdelen dan mensen die niet adherent zijn. Een belangrijke aanbeveling van dit proefschrift is om web-based interventies op zo'n manier te ontwerpen dat adherentie gestimuleerd wordt. In dit hoofdstuk werden aanbevelingen gedaan om dit te doen tijdens de ontwikkeling van een interventie, voor adherentie als een uitkomstmaat en voor het proces van adherentie. Vervolgonderzoek is nodig om te bepalen of het uitvoeren van deze aanbevelingen ook het gewenste effect heeft. Daarnaast is vervolgonderzoek nodig op het gebied van persuasieve technologie (wat werkt voor wie, op welke manier en in welke context), naar de groep die niet adherent is (hoe groot is de groep die kan worden overtuigd om adherent te zijn), naar geautomatiseerde feedback (wanneer kan dit even effectief zijn als feedback door een persoon) en naar het als een geheel ontwikkelen van de inhoud, de technologie en de service van een web-based interventie.

Dankwoord



Toen ik klaar was met studeren twijfelde ik of een promotie wel iets voor mij was. Ik was een beetje bang voor mijn spookbeeld van promoveren: vier jaar lang in je eentje op een kamertje bezig zijn met een onderwerp dat niemand begrijpt en interesseert. De werkelijkheid kon hier niet verder vanaf liggen en daarvoor wil ik graag iedereen bedanken waarmee ik heb samengewerkt en die ik ben tegengekomen in de afgelopen vijf jaar. Een aantal mensen wil ik in het bijzonder bedanken.

Als eerste wil ik Lisette van Gemert-Pijnen, mijn dagelijks begeleider, bedanken. Lisette, wat ben ik blij dat jij me, samen met Erwin Seydel, vijf jaar geleden hebt aangenomen en dat ik op de UT bij deze groep ben terecht gekomen. Je hebt me al die tijd ontzettend veel vrijheid gegeven om me te richten op de dingen die ik interessant vind. Je hebt me daarbij altijd gemotiveerd en geïnspireerd en het vertrouwen gegeven dat we er samen iets moois van kunnen maken. Vanaf dag één heb je me ingewijd in de wereld en het netwerk van eHealth en me daarmee de basis gegeven voor het doen van de onderzoeken in dit proefschrift. Ook bij de laatste stukken van dit proefschrift heb je me telkens de begeleiding en vrijheid gegeven die ik nodig had. Ik ben erg blij dat we nog een tijd collega's kunnen blijven en ik verheug me op het vervolg!

Natuurlijk wil ik mijn promotor Prof. dr. Ernst Bohlmeijer ontzettend bedanken. Ernst, bedankt voor het vertrouwen dat je me hebt gegeven. Niet alleen heb je me de ruimte gegeven om zomaar te experimenteren met Voluit Leven online, ook heb je me altijd het vertrouwen gegeven om in zowel onderzoek als onderwijs mijn eigen lijn te bepalen.

Hier wil ik ook graag de leden van de promotiecommissie bedanken. Prof. dr. Erwin Seydel, bedankt voor de begeleiding tijdens de eerste jaren van mijn promotie en voor het voorzitten van de promotiecommissie. Prof. dr. Harri Oinas-Kukkonen, thank you for taking part in my graduation committee. I'm looking forward to the collaboration with you and with your research group. Prof. dr. Hermie Hermens, Prof. dr. Heleen Riper en Prof. dr. Marjolijn Sorbi, we zijn elkaar meerdere keren tegengekomen op eHealth congressen en symposia en ik ben dan ook erg blij dat jullie deel uitmaken van mijn commissie; bedankt! Ook wil ik Prof. dr. Vanessa Evers en Prof. dr. Jantine Schuit heel erg bedanken voor hun deelname aan de promotiecommissie.

Hans Ossebaard, jou wil ik bedanken voor het partnerschap in dit RIVM SOR-project, maar ook voor de ruimte die je mij en het onderzoek hebt gegeven.

Ook Ipportunities wil ik bedanken voor de samenwerking bij het ontwikkelen van Voluit Leven. Wat super dat al onze ideeën ook daadwerkelijk uitgevoerd konden worden!

Graag wil ook alle collega's van PGT bedanken. Iedereen bedankt voor de collegialiteit, lekkers-bij-de-koffie momenten en gesprekken in het keukentje. Wendy, ontzettend bedankt voor de fijne samenwerking bij het ontwikkelen van Voluit Leven. De collega's van de eHealth-club: Lisette, Hans, Nicol, Nienke, Lex, Jobke, Maarten, Olga, Marjon, Marloes, Michael, Nienke, Elly en Joyce ontzettend bedankt voor de inspiratie, gezelligheid bij alle congressen en symposia en steun bij van alles en nog wat! Ook de studenten die ik de afgelopen jaren heb begeleid bij hun afstuderen wil ik op deze plek bedanken voor het werk dat ze gedaan hebben, maar ook voor de nieuwe inzichten en vragen die ervoor gezorgd hebben dat je altijd kritisch blijft kijken naar de dingen die je doet. Jobke en Robin, wat super dat jullie collega's (al dan niet op de afdeling) zijn geworden!

Nicol, wat is het fijn om zo'n collega en vriendin te hebben! Vanaf mijn eerste werkdag heb je er, samen met Fenne, voor gezorgd dat ik me direct thuis voelde op de UT. Bedankt voor alle super leuke momenten tijdens congressen (of het nu door de sneeuw wandelen is in Tromsø, of tempels en krokodillen bekijken in Mexico), high tea's, etentjes of gewoon even bijkletsen! Natuurlijk wil ik ook Fenne en de rest van de Jaaarclub bedanken voor de gezellige high tea's en andere feestjes.

Ook de dames van de gang wil ik hier noemen. Sanne, Jojanneke, Martine, Laurien, Stephy, Roos, Marloes, Pia, Ingrid, Rilana, Maria, Petra, Hester en Roos: bedankt voor de gezellige lunchwandelingen, de etentjes, borrels, koffie halen en nog veel meer!

Jojanneke en Sanne, wat super dat jullie mijn paranimfen zijn! Jojanneke, al vanaf de eerste dag dat je op de kamer kwam, klikte het gelijk. Wat wil je ook wanneer je het op dag één al kan hebben over Bloc Party ☺. Sanne, ik kan me onze kamer zonder jou al niet eens meer voorstellen! Heerlijk om 's ochtends te kunnen beginnen met 'goeiemorgen' en samen koffie/thee te kunnen halen. Bedankt voor alle leuke etentjes, nieuwe muziek en natuurlijk alle gewone kamer-momenten. Op welke andere kamer wordt er nu gejongleerd, moet muziek altijd vaker geluisterd worden en wordt een beker van de IBR-Poster Award gebruikt om snoepjes in te bewaren? Op deze plek wil ik jullie ook allebei bedanken dat ik jullie paranimf mocht en mag zijn. Fantastisch om niet alleen collega's maar ook vrienden te zijn.

Collega's van Chaviv: ook jullie wil ik bedanken voor jullie belangstelling en de gezellige etentjes waar het eens niet over mijn werk hoefde te gaan!

Mies, Guy, Hugo en Vera, en Giorah, Jenny en Daniëlle, bedankt voor jullie belangstelling voor het hele promotietraject en alle gezellige weekenden.

Martijn & Ellen en Sander, wat ben ik blij met zulke broers en fijne schoonzus. Heerlijk dat we het overal over kunnen hebben! Mam, wat ben ik trots op je. Ik vind het fantastisch hoe je overal van geniet en de dingen doet je echt wilt doen. Pap, ik had je natuurlijk ontzettend graag dit boekje willen geven. Ik denk niet dat je verrast geweest zou zijn dat ik ben gaan promoveren en denk dat je het onderwerp erg leuk had gevonden. Voor mij ben je er altijd bij.

Lieve Chaviv, wat ben ik blij dat ik je ben tegengekomen. Bedankt dat je er altijd voor me bent. Het is heerlijk om bij jou thuis te komen en ik had dit niet zonder jou kunnen doen.

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