UNIVERSITY OF TWENTE.

The influence of persuasive technology in modern health care

A systematic review of the influence of persuasive technology on the effectiveness of health interventions and its influence on adherence

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10 EC Thesis

Master thesis

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March, 2016

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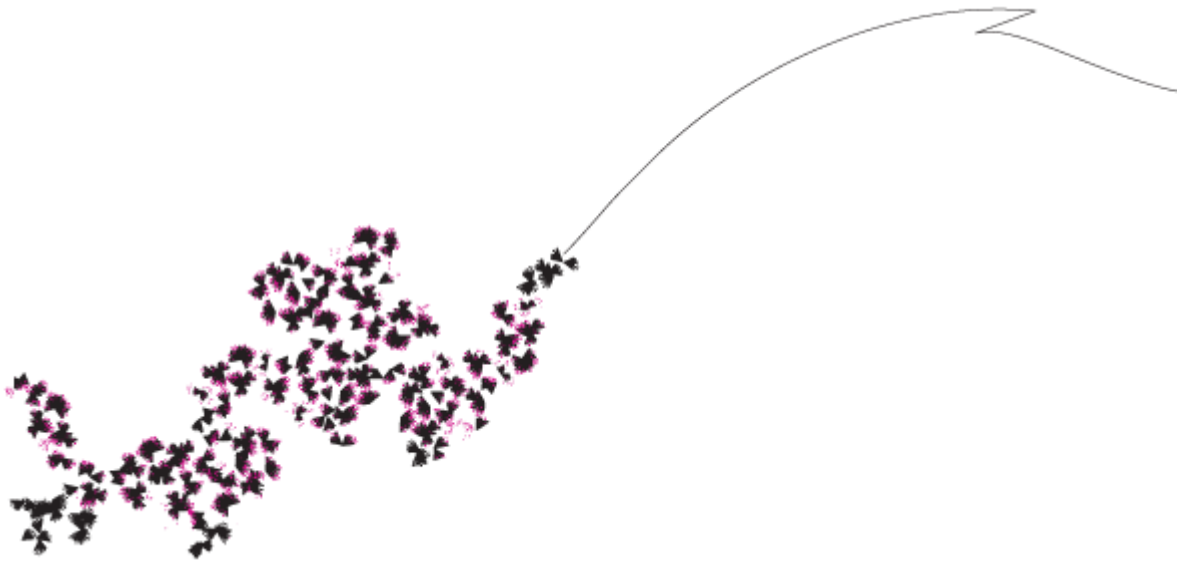
Abstract

Introduction: Although many interventions and studies have shown that persuasive technology is effective in multiple ways, there is little knowledge about the general influence of this technology. Previous reviews show the results of persuasive technology in narrow circumstances like limited health care domains. Nevertheless, there is little knowledge about the general influence of persuasive technology in health interventions. This systematic review gives a general overview of the influence of persuasive technology based on former reviews.

Methods: A systematic review of previous reviews with regard to the influence of persuasive technology on health interventions was conducted. Per included review the characteristics, limitations and main findings with regard to the effectiveness or adherence of persuasive technology were examined.

Results: 12 reviews with a pool of 313 papers were included in this review. Lifestyle interventions seem to be more persuasive than other domains. Furthermore, a high use of tailoring and primary task support was noted.

Conclusion: Because not all interventions make proper use of persuasive designs, there is little knowledge about the whole effect of persuasive technology. Right now, we have gathered all the information there is about persuasive technology. This means there is a high need for new information. Future research should focus on experimental interventions with regard to more features and categories of persuasive technology.



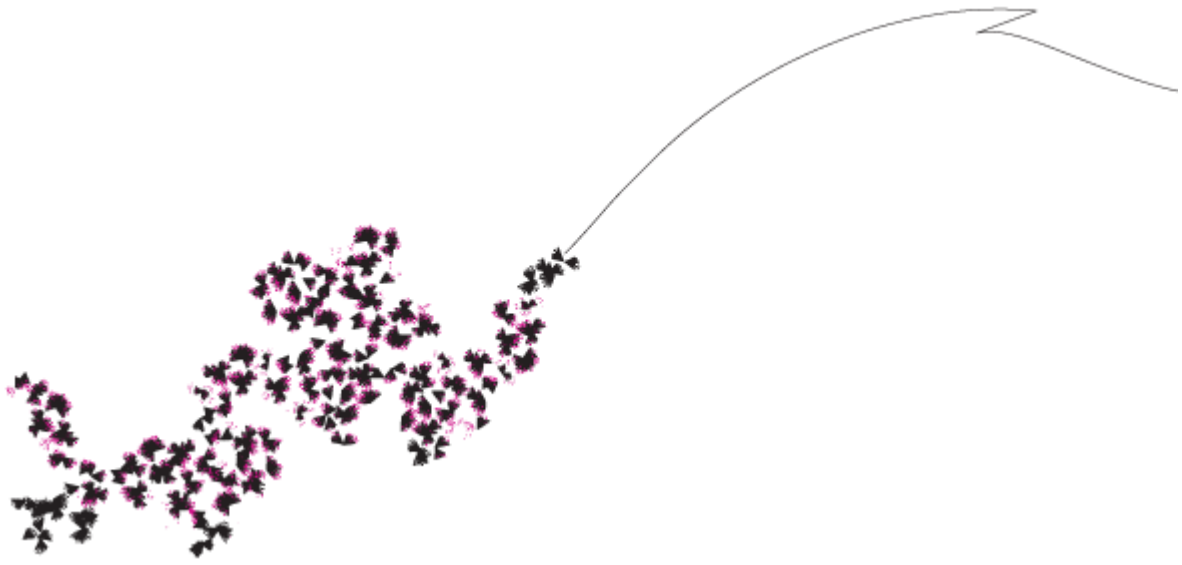
Samenvatting

Introductie: Er is weinig kennis over de generale invloed van persuasieve technologie, hoewel er veel onderzoek binnen de richting persuasieve technologie bestaat. Eerder onderzoek houdt zich voornamelijk bezig met de vraag of persuasieve technologie onder bepaalde omstandigheden effectief is. Om een goed overzicht te krijgen van wat wij tot nu toe over persuasieve technologie weten, wordt een literatuuronderzoek over eerdere literatuuronderzoeken uitgevoerd. Hierbij wordt ook onderzocht welke invloed deze technologie op verschillende soorten interventies in het gezondheidsvlak heeft.

Methods: Dit onderzoek is een literatuuronderzoek over eerder literatuuronderzoek. Voor elk onderzoek uit de selectie zijn karakteristieken, limitaties en het hoofd resultaat met betrekking tot de onderzoeksvraag verkregen.

Resultaten: Er zijn 12 verschillende literatuuronderzoeken gebruikt die in totaal 313 artikelen onderzoeken. Interventies over “lifestyle” bleken meer persuasieve te zijn dan interventies van anderen domeinen. Verder is een hoog gebruik en effect van “tailoring” en “primary task support” opgevallen.

Conclusie: Niet alle interventies gebruiken persuasieve technologie op een gepaste manier. Dit is een reden waarom wij op dit moment beperkte informatie hebben over de daadwerkelijke effect hiervan**.** Om het effect van persuasieve technologie verder te kunnen onderzoeken hebben wij nieuwe experimenten en verder onderzoek nodig dat zich richt op alle aspecten en categorieën van persuasieve technologie.



1. Table of Contents

1. Introduction

This systematic review attempts to obtain a general overview of the influence of persuasive technology on the effectiveness and adherence of health interventions. In short, persuasive technology combines behaviour-changing theories with technology to influence the participants behaviour.

Nowadays, persuasive technology is often used in health care interventions for prevention of depression (Langrial, Oinas-Kukkonen, Lappalainen, & Lappalainen, 2014), obesity (Caon et al., 2014) and substance abuse (VanDeMark et al., 2010). For example Zamboni et al. (2011) use serious computer games to promote healthy and safe drinking behaviour in nightlife activities. Up to now, there are multiple reviews about the effect of persuasive technology in certain health care interventions (Chang, Kaasinen, & Kaipainen, 2013; Cugelman, Thelwall, & Dawes, 2011; Xu, Chomutare, & Iyengar, 2014b). Although it has been proven that persuasive technology is effective in health interventions, it is time to look at the general effect of persuasive technology. To the researchers knowledge, former reviews examined merely one domain. To see the possible differences in each domain, this review gets a broader overview of the effectiveness of persuasive technology. One effective way of gaining deeper insight in different health care domains regarding persuasive technology and adherence would be the analysis of already existing meta-analyses and reviews. Therefore, this systematic review summarizes all the relevant information found in former reviews to get a general overview over the influence of persuasive technology. The following paragraphs give further information about the benefits of this systematic review, the domains it refers to, and persuasive technology itself.

1.1 Background

Persuasive technology could be one useful tool in health care for the challenges of the ageing trend of the human population. The use of technology can hold in many resources. Aside from economical reasons, persuasive technology could support older people with a chronic disease to live more independently. According to a report of the United Nations (2012), by 2050 the western population may have more individuals of over 60 years than children and younger adults. As older people have higher risks for “chronic” diseases as Alzheimer’s disease or stroke, more resources are needed to treat them. As a consequence of the low expected birth rate in the future population, it will be more difficult to find enough qualified personnel to

treat people in need. The question that results is how to treat more people with fewer resources, and less personnel.

Using technology could be an answer. Nearly everybody in the Netherlands owns technology with an internet connection and more than half of them use it for health reasons (CBS, 2014). This means that technology such as the internet could be an important instrument for health care. Some online interventions offer ways of increasing health and health-related behaviour and seem to be effective (Barak, Hen, Boniel-Nissim, & Shapira, 2008; Cuijpers, van Straten, & Andersson, 2008; Spek et al., 2007). Currently, there are numerous online interventions for health care and many of them produced the desired results and show significant effects. Some researchers have already conducted systematic reviews and found that persuasive technology does play a role in the effectiveness of interventions (Azar et al., 2013; Lehto & Oinas-Kukkonen, 2009; Lehto & Oinas-Kukkonen, 2011; Xu et al., 2014b). However, there is still much about persuasive technology we do not know. What is it that makes persuasive technology effective? Do we really know whether persuasive technology is effective at all? If persuasive technology does have beneficial effects, what features of persuasive technology make those interventions effective and do those features differ per domain or intervention? To answer those questions, the current review is a review of former reviews. With the information of previous reviews we try to find out if persuasive technology has a general effect on the results of health interventions at all. And if there is an effect we try to examine the possible differences between the domains and the usage of certain features of persuasive technology. The resulting findings could be used to create more effectiveness and usage of persuasive technology in future interventions.

1.2 Persuasive technology

To review the effectiveness of persuasive technology it is important to understand the theory it is based on. The most commonly used definition of persuasive technology is made by Fogg (2003), who refers to it as an technology that changes a user's attitude and behaviour through persuasion without using coercion.

To persuade the users attitude and behaviour, persuasive technology is based upon different theories (Oinas-Kukkonen & Harjumaa, 2009) such as the Theory of Planned Behavior (Ajzen, 1991) and the Elaboration Likelihood Model (Petty & Cacioppo, 1986). Both theories describe the path in changing behaviour and attitude by influencing the person's motivation and beliefs. Referring to the Theory of Planned Behavior, a person's behaviour is the result of certain beliefs (Ajzen, 1991). Ajzen (1991) distinguishes between three different

kinds of beliefs, such as beliefs created by a person's social environment, that give the intention to adopt a certain behaviour. Persuasive technology makes use of this knowledge and combines it with technology to change the users' behaviour, for example, to improve health and well-being.

To embed persuasive technology in interventions, different models of persuasive technology are used. One current model is the persuasive system design model (PSD-model) by Oinas-Kukkonen and Harjumaa (2009). In short, this model differentiates between four categories of features to change the behaviour of the person through persuasive technology.. To explain this design we will use the example of the "Fit4life" intervention (Purpura, Schwanda, Williams, Stubler, & Sengers, 2011). This study uses persuasive design to improve the lifestyle of participants, concentrating on weight control. A list of all categories and features of the persuasive system design can be found in the appendix

The first category is "primary task support". This term includes techniques to support the primary task. The primary task of Fit4Live is to promote individual healthy behaviours in weight control. It makes use of primary task support using "reduction", a sort of simplification, as a technique. In this example the entire intervention can be seen as simplification "of the complex task of weight management" (Purpura et al., 2011, p. 424).

The next category of the persuasive system design is "dialogue support". It refers to different computer-, human-, interaction-, and communication technologies to set an individual intervention goal for the user. The Fit4life intervention also uses dialogue support techniques such as "reminders" and "suggestion" through a Fit4life earpiece. The earpiece gives the participant direct feedback, such as telling him how many calories he has consumed or giving suggestions as "Dave, your schedule seems to be filling up. Would you like to schedule time for a walk by the river today?"(Purpura et al., 2011, p. 426)

The third category is "credibility support". It refers to the credibility and trustworthiness of the system. In Fit4life, there are also hints of credibility support. At the beginning of the intervention the system determines an individual fitness plan for every user using the given age and weight. By means of this feature, Fit4life assures the user about the programme's competence and ability to transfer useful knowledge. This is the so-called "expertise" technique.

The final category is the "social support". The social support contains techniques that motivate the user through social influences as comparisons and competition. This category is clearly implemented in the intervention of Purpura et al. (2011). Fit4life makes use of Facebook posts to praise the users, but in this case, Facebook is also used as a medium to

connect the participants and let them communicate with each other. One example of a motivating message between users is “Wow! You look great! You’re Fit4Me!” (Purpura et al., 2011, p. 426).

As seen above, persuasive technology has many different techniques at its disposal. However, we still do not know what category works best in which context. For the development of future interventions, some thinking is necessary in order to achieve better results and outcomes. The following passages demonstrate such thoughts.

1.3 Adherence

According to recent research, non-adherence impairs the average results of effectiveness of online interventions (Donkin et al., 2011; Manwaring et al., 2008). The current review uses adherence as a term that refers to the proportion of people that completely follow the intervention.

Non-adherence can have multiple reasons. One reason could be something unpredictable like illness, but it could also happen on purpose, by freely choosing not to follow the intervention anymore. Online interventions have been shown to have problems with low adherence. For example the online interventions of Bolier et al. (2014), although having good potential in reaching a high number of participants, also show a high level of non-adherence.

One reason of non-adherence could be the sort of intervention. As online interventions are primarily self-guided they enable the participants high freedom in making decisions (Eysenbach, 2005). According to this, it is important to get the users more attached to the technology and persuade them to continue the intervention. This is what persuasive technology does. Former studies already have proof that persuasive technology increases the adherence of interventions (Kelders, Kok, Ossebaard, & Van Gemert-Pijnen, 2012). Keeping this in mind, next to the influence on effectiveness, this review also focusses on the influence of persuasive technology on adherence.

1.4 Health care domains

Persuasive technology has been used in different health care domains (Chang et al., 2013; Xu et al., 2014b; Zhu, 2007). The current review investigates if persuasive technology is effective in general. It is important to see if the effectiveness varies in the different health care domains. Interventions for various health care domains do not only differ in purpose of the intervention and participants. The features of persuasive technology during the intervention could also vary in different health care domains. Those differences could lead to a different

effectiveness in each health care domain. On the one hand, the effectiveness of persuasive features can differ in every domain and on the other hand, it is important to see if an effective feature in one health care domain could also be effective in another domain. For example, many lifestyle interventions make use of the persuasive tool self-monitoring (Balmford, Borland, & Benda, 2008; Brouwer et al., 2010; Buis et al., 2009; Lenert et al., 2003), whereas some mental health interventions did not make use of self-monitoring (Andersson, Estling, Jakobsson, Cuijpers, & Carlbring, 2011; Hedman et al., 2011; March, Spence, & Donovan, 2009; Titov et al., 2009). Self-monitoring helps the user to keep track of its own achievements and goals. This feature is not only important for lifestyle interventions but also for mental health interventions. Users suffering a mental disorder, such as a depression, may find it difficult to notice their own achievements. If self-monitoring is one of the features making lifestyle interventions effective it may also be effective in mental health interventions.

To get more knowledge about those differences it is important to get a general overview of persuasive technology in different health care domains. The current review distinguishes between three domains: lifestyle, mental health and chronic care. Chronic care includes all reviews focussing on medical treatment for long-term illness, for example elderly care or diabetes. The mental health domain implies papers focussing on treatment of mental illnesses, like depression, anxiety disorders or substance abuse. Lifestyle papers review interventions trying to help the user living a healthier life. This could help in enhancing physical activity or losing weight.

1.5 Aim of research

Until now, there has been little research about the general effect of persuasive technology in health care interventions. Former reviews answer the questions if there is any influence of persuasive technology regarding adherence (Kelders et al., 2012) and weight loss (Xu et al., 2014b) or in enhancing physical activity (Zhu, 2007). A question that remains is not only if persuasive technology itself works in one specific intervention, but also whether there are more or less effective features. Moreover, what specific element of persuasive technology causes this effect? What is inside that “black box” of persuasive technology? Furthermore, there is little research about the influence of persuasive technology in more than one health care domain. Is there a possibility that one domain shows more effect using persuasive technology than another one? If we notice such an effect, what causes it? For example, there could be one persuasive feature that shows significant effect in lifestyle interventions whereas it shows no effect in mental health at all. Where does persuasive technology really have

influence on and how? In addition, it would be interesting to see what kind of persuasive techniques are used. Maybe some of them are not in interventions at all, even though they have high potential.

Apart from that, adherence also seems to play a great role in successful interventions. Donkin et al. (2011) stated that adherence can influence the outcomes of an intervention. It is possible that persuasive technology does not show significant influence in the effect of the intervention but that it has an influence in increasing adherence.

Summing up, the research question of this systematic review is:

According to previous reviews, what is the influence of persuasive technology on effectiveness and adherence of health interventions?

This review will focus on reviews in the domains, mental health, lifestyle and chronic care.

2. Methods

2.1 Search strategy

In 2015, Kelders conducted the electronic literature search in four different online databases. The used databases are Web of Science, PsycInfo, Scopus and ScienceDirect. The systematic search used a combination of the words “persuasive technology” and “health” and synonyms. The research considered only articles published in English. Articles that are individual papers, such as full conference proceedings or the description of a workshop were excluded, as well as articles not published in English. Papers not targeted at health related behaviour and without a link to persuasive technology were excluded. The exact query can be found in the Appendix. This review is based on the literature search by S. M. Kelders and includes 270 papers.

2.2 Literature selection

The abstracts and titles of the 270 papers were screened. All papers not reviewing studies and interventions with regard to persuasive technology were excluded (Step 1). In the second step, two articles were excluded because no full text was available. The remaining 26 papers were screened by its full text with the following exclusion criteria (Step 3). Papers not giving any information about the research question were excluded. Reviews with no focus on either adherence or one of the health care domains like lifestyle, mental health or chronic care, were excluded.

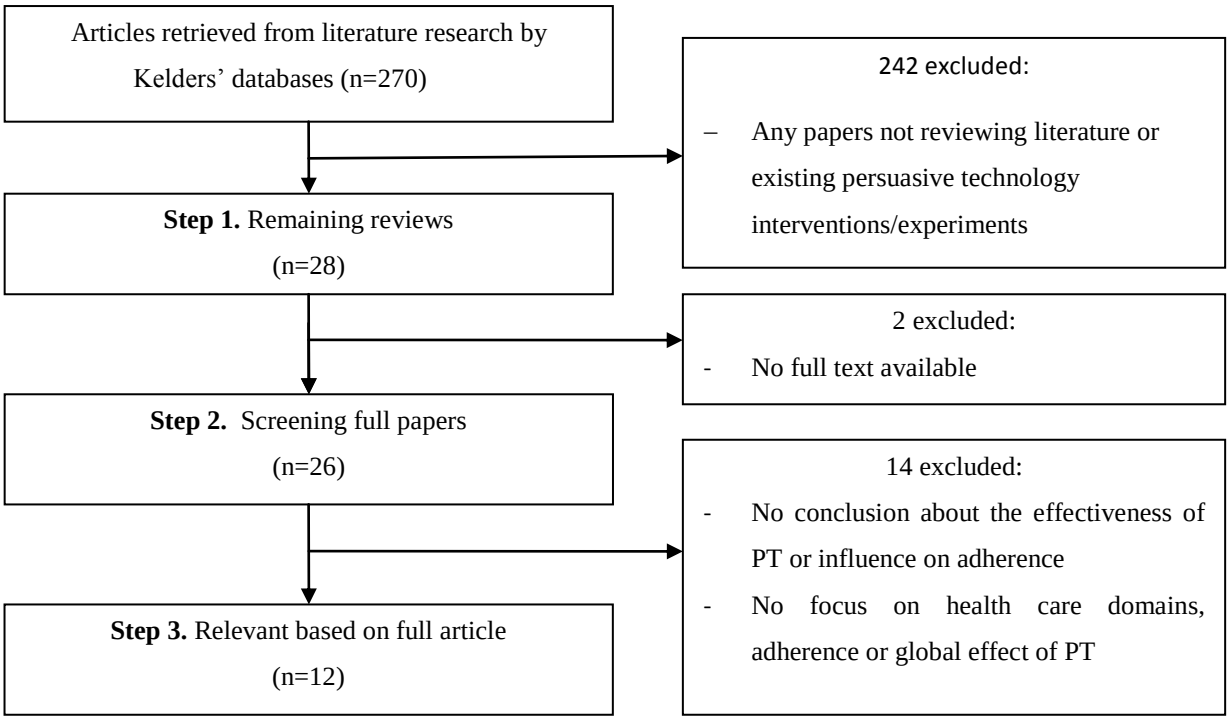


Figure 1. Selection procedure

2.3 Data extraction

All 12 reviews were categorized in three different health care domains. The three different categories are "chronic care", "lifestyle" and "mental health". Chronic care includes all reviews focussing on medical treatment for long-term illness, for example elderly care or diabetes. The mental health domain implies papers focussing on treatment of mental illnesses like depression, anxiety disorders or substance abuse. Lifestyle papers review interventions trying to help the user to live a healthier life. This could be helping in enhancing physical activity or losing weight.

2.3.1 Characteristics

After categorizing the papers, the characteristics of each paper were issued. The data was extracted on author, publication date, number of included articles or interventions, used platform, type of research, and limitation.

Used platform

The used platform shows if the results vary per framework. The two main platforms are web-based interventions (online-, computer-based interventions), and mobile applications

(interventions via mobile phones or tablets) and others such as personal health records. Other platforms are explained in the results.

Type of research

The type of research gives short information about the context of the review. It was distinguished between a systematic review, meta-analysis', and other such as scoping review. The categorization is based on the term named in the review itself.

Limitations

To see what could have influence on the results of each review it is important to point out the limitations of the review. Therefore, the discussion of each review was screened and the major limitation, as mentioned by the author, extracted.

2.3.2 Primary outcomes

The primary outcomes were categorized in the three health care domains and adherence. In addition, the data was extracted on subdomain, most used persuasive technology feature, major findings, details of the major findings, and discussion.

Subdomain

To see if there are any differences inside one health care domain the subdomain of the reviewed interventions are stated such as physical activity.

Most used persuasive technology feature

The features that were present as mentioned by the authors of the included reviews were extracted. A description of different persuasive features, as mentioned by Oinas-Kukkonen and Harjumaa (2009), is deposited in the appendix. However, some papers may refer to other models or use other terms, in those cases a short explanation of the used feature is given by the author in the results.

To select the most used persuasive features, the current review made use of the following criteria. All persuasive features mentioned as "used most" or similar in the included review are registered. If there is no such information, the five most used features according to the findings of the review are mentioned. When different features are used the same number of times, up to six most used features may be listed. If there is neither a table nor a further description of the most used persuasive features, the most useful information mentioned in the review is stated here.

Major findings

To extract the major findings of the included reviews, information about the effectiveness of persuasive technology in the corresponding domain or its influence on adherence was extracted.

Details

The details give more information about the major findings. For example, one review says that persuasive technology has positive influence on adherence. In this case, the details could give more information over the feature of persuasive technology that causes the effect.

Discussion

The discussion gives more information about the topics that are important when interpreting the major findings.

3. Results

3.1 Characteristics

The current review includes in total 12 papers. 10 reviews are about the influence of persuasive technology on the effectiveness of interventions (table 1) and 4 reviews are about the influence of persuasive technology with regard to adherence (table 2). There is an overlap of 2 reviews that give information about both topics.

Table 1 shows four reviews about the influence of persuasive technology in lifestyle interventions, three articles refer to mental health and two articles to chronic care. One review addresses all three health care domains.

Table 1.
Domains of reviews with regard to effectiveness and the number of included articles (n)

Lifestyle (LS)	Chronic Care (CC)	Mental Health (MH)	Other
General (n=1)*	Elderly care (n=1),*	Alcohol abstinence (n=1)	No specific domain (n=1),
Weight Control (n=2)	Medication use (n=1)	Smoking abstinence (n=1)	
Physical activity (n=1)		Well-being (n=1)	

**Review with regard to effectiveness and adherence*

Table 2 shows the domains of the four reviews with regard to adherence. Two reviews address all three health care domains, one review is about lifestyle interventions in general and one review about interventions for elderly care.

Table 2.
Domains of reviews with regard to adherence and the number of included articles (n)

Lifestyle (LS)	Chronic Care (CC)	Mental Health (MH)	Other
General (n=1)*	Elderly care (n=1)*	-	No specific domain (n=2)

**Review with regard to effectiveness and adherence*

Table 3 summarizes the characteristics of the included reviews. To get a good overview of the included reviews, each review was assigned a code from A1 to A12. The oldest publication date is 2006 and the most current date is 2014. The number of included articles varies per review. The smallest pool includes six articles whereas the largest pool consists of 83 articles.

Most of the included reviews analyse web-based interventions (n=5) and two reviews analyse mobile applications. A8 is about online interventions in general which includes web-based or web- and email-based interventions. Although not clearly mentioned, three reviews may additional include web-based interventions (A3, A4, A7). A12 gives no further information about the used platforms, A3 focusses on behavioural-based interventions (the interventions do not only focus on weight loss, but also includes a lifestyle or behavioural component), A4 focusses on medication adherence interventions (interventions that aim to improve medication adherence), and A7 is about personal health records (PHRs). PHRs are "a set of computer-based tools that allow people to access and coordinate their lifelong health information and make appropriate parts of it available to those who need it"(Markle Foundation, 2008).

Most of the reviewed articles are systematic reviews (n=8). However, the current review also contains one meta-analysis, a scoping review, an empirical review and one theory-based content analysis. The theory-based content analysis tries to analyse if the content of the included interventions, in this case mobile applications, is based on proven theory.

One main limitation for almost every review was the individual coding of persuasive elements. As not every reviewed intervention clearly mentioned the used persuasive features, most included reviews coded the persuasive features according to the description of the article or the intervention themselves. Further individual limitations of each paper are stated in table 3.

Table 3.
Characteristics of included studies

No	Author	Publication Date	Included Articles	Used Platform	Type of research	Domain Articles	Limitations
A1	Zhu	2007	9	Web-based interventions	Systematic review	LS	Interface and usability not evaluated
A2	Kelders, Kok, & Gemert-Pijnen	06/2011	9	Web-based interventions	Systematic review	LS , A	Persuasive features are coded according to the description
A3	Xu, Chomutare, & Iyengar	2014	17	Behavioural-based interventions	Systematic review	LS	Use of persuasive features in same system,
A4	Xu, Chomutare, & Iyengar	03/2014	40	Medication adherence intervention	Systematic review	CC, A	Interventions used different measurement instruments, Search limited to English language publications
A5	Lehto, Oinas-Kukkonen	2009	6	Web-based Interventions	Systematic review	MH	Limited languages, no outside evaluators
A6	Kelders, Kok, Ossebaard, & Van Gemert-Pijnen	2012	83	Web-based interventions	Systematic review	CC , LS, MH, A	Strict exclusion and inclusion criteria for studies Coding for PT elements based on description. Only focus on published data, no grey data
A7	Saparova	2012	22	Personal health records (PHR)	Scoping review	CC	Only non-control group quantitative studies Only one database No follow-up findings
A8	Cugelmann, Thelwall, & Dawes	2011	31	Online interventions	Meta-analysis	LS, A	Coding of influence components → control conditions were rarely described
A9	Azar et al.	2013	10 applications tested	Mobile Applications	Theory-Based Content Analysis	LS	No use of app in clinical setting
A10	Lehto, Oinas-Kukkonen	2011	23	Web-based interventions	Systematic review	MH	Possible bias in the interpretation of articles

A11	Chang, Kaasinen, & Kaipainen	2013	12	Mobile applications	Multidisciplinary expert review	MH	Coding of persuasive features
A12	Hamari, Koivisto, & Pakkanen	2014	51	No specific platform	Systematic review	No specific domain	Publication bias of the studies (positive findings are more likely to be published than negative findings), only Scopus as database problem of comparison

LS=Lifestyle; CC= Chronic Care, MH= Mental Health, A= Focus on Adherence

3.2 Effectiveness

3.2.1 Lifestyle

Table 4 shows the outcomes of the four studies regarding the effectiveness of persuasive technology in lifestyle interventions. Two reviews are about weight control interventions: one about physical activity and one is a general overview of lifestyle interventions. All four reviews examine in total 67 interventions, mobile applications and papers. The overlap of articles could not be determined due to a lack of information on the reviews.

Most of the interventions made use of primary task support. Three papers stated out the used techniques in detail (A1, A3, A8), whereas one paper only gave scarce information about the details of the persuasive techniques used (A9). All three papers stated out that tailoring was one of the most used techniques in the interventions. A3 and A8 determined that personalization is often used and A1 and A3 noted self-monitoring and tunneling as a highly used technique in lifestyle interventions. Although most of the papers reported primary task support as the key technique (A1, A3, A8), some papers also mentioned dialogue support techniques like rewards and techniques not listed in the PSD-model (A1,A3, A8). These include feedback on performance, and intervening. The authors refer in both features to Fogg (2003). Feedback on performance gives the user a feeling of relationship. It can be compared to features of dialogue support. Intervening refers to technology that interferes in the user's behaviour. This could be in forms of giving suggestions or reminders.

All four reviews found a positive influence of persuasive technology in lifestyle interventions. Out of four papers, three papers actually found a significant effect of certain persuasive technology procedures. According to A3, tailoring has a significant effect on long-term weight loss. Even if they are not significant, they found a positive, but modest effect of personalization, competition and reminders. A8 also discovered a significant effect of tailoring and feedback on performance in enhancing the lifestyle of the participants. A9 found a significant effect of self-monitoring and time recording in improving weight loss.

Discussing the results, there are different topics that are worth mentioning. At first, A9, a paper reviewing mobile interventions, mentions that there is rare use of persuasive technology. Furthermore, A1 states that the mean age of the participants is lower than 40, which again could influence the results. Furthermore, tailoring and feedback on performance is used in nearly every intervention reviewed by A8, which may explain the high significance of those techniques.

Table 4.
Primary outcomes of reviews with regard to lifestyle interventions

No	Sub-domain	Included articles	Used platform	Most used PTF	Major findings	Details	Discussion
A1	Physical Activity	9	Web-based interventions	Tailoring, tunneling, intervening, self-monitoring	PT faster effect on weight, no long-term effect between groups	1/9 studies using persuasive technology showed effectiveness.	Average age >40 could be main reason No framework of captology
A3	Weight Control	17	Behavioural based intervention	Self-monitoring, personalization, tunneling, tailoring, rewards,	Successful interventions have higher average number of persuasive elements8	8/21 effective interventions, Tailoring significant effect on long-term weight loss, Positive but modest effect performance, reminders and competition	PT shows more effect if more often present in Intervention
A8	General	31	Online interventions	Mostly primary task support like tailoring, personalization, but also feedback on performance	PT increases significant the effect of online intervention	Tailoring ($p<.001$) and feedback on performance ($p=.001$) have significant effect Similarity (not often used) shows effect	Tailoring and Feedback on performance nearly both used in every intervention

A9	Weight control	10 applications tested	Mobile applications	Most Apps focus mainly on user interface, information and the fluent work of the technique.	PT can help improving weight loss	Self-monitoring and time recording significant improving weight loss Frequent monitoring of food intake associated with twice as much weight loss	Few behavioural strategies have been included in intervention

PTF= Persuasive technology feature

3.2.2 Chronic Care

Table 5 shows the result of the two included reviews regarding the effectiveness of persuasive technology in chronic care interventions. One included review focusses on elderly care whereas the other one *f*ocusses on medication use. Both reviews examine in total 62 interventions. The overlap of articles could not be determined due to a lack of information on the reviews.

Both reviews show great use of primary task support, like personalization. A4 noticed a high use of tailoring followed by reduction, simulation, and rehearsal. A7 also noticed a high use of self-monitoring. In addition, both reviews did find a high use of the dialogue support and reminders.

When looking at the major findings of both reviews, a positive effect of persuasive technology is noted. Again, tailoring is significantly more used in successful interventions and seems to be an effective persuasive tool (A4). Although not significant, A4 noticed a higher use of rehearsal, reminders and suggestion in successful interventions. However, A7 stated that the effectiveness of persuasive tools varies according to the design of the intervention. He noticed a significant effect of personalization, tailoring, and recommendations in some interventions, but those effects were not consistent. Studies with random controlled trials provided evidence that Personal Health Records (PHRs) did not have any effect at all, regardless of the used persuasive technique.

Even though the findings of both reviews vary, both of them state that Persuasive Technology could have potential in making chronic care interventions more effective. A7 also mentioned that the effect of PHRs could increase if there is a better interoperability between

user and system. He stated that reminders could increase the effect of the intervention when they are not only used within the system, but also externally, by emails or SMS.

Table 5.
Primary outcomes of reviews with regard to chronic care interventions

No	Subdomain	Included articles	Used platform	Most used PTF	Major finding	Details	Discussion
A4	Elderly care	40	Medication adherence interventions	Tailoring, reduction, simulation, rehearsal, reminders, personalization	Successful interventions greater number of PT	Tailoring more used in successful interventions, (p=0.038) Also: Rehearsal, reminders, Suggestion (p>0.05)	PT great potential as mean to develop intervention
A7	Medication use	22	PHRs	Personalization, reminders, self-monitoring	Efficiency of Personal Health Records (PHRs) varies.	Personalization increased motivation and promoted behaviour change Tailoring, recommendations and guidance can enhance effect of intervention Positive attitude towards PHRs in some studies, but no evidence for effectiveness in studies using RCTs	PHRs may more effect with better interoperability. Extern reminders may enhance effect of intervention.

PTF= Persuasive technology feature

3.2.3 Mental Health

Table 6 shows three reviews about mental health interventions. Two papers review articles about alcohol abstinence and one of them examines articles focussing on smoking abstinence. The third paper reviews mobile applications for well-being. All three reviews examine in total 41 different online interventions, mobile applications and papers, without any noticeable overlap of articles.

The most used persuasive features in mental health focus on primary task support. In two cases, the most used technique is self-monitoring, followed by reduction. But other

features such as personalization and simulation are mentioned by A5. The dialogue support task reminders were also mentioned, as well as the credibility support tasks trustworthiness, expertise, and surface credibility. A5 could not find any effect in fostering users' long-term behaviour change. They criticized the sparse use of primary task support, especially the use of tailoring. They stated that without tailoring the user could feel "the (intervention) content is not designed for her/his needs" (T. Lehto & Oinas-Kukkonen, 2009, p. 325), which could lead to non-adherence. Furthermore, most of the reviewed interventions did not seem to make as extensive use of persuasive technology as might be possible. This again could have influenced the results of the reviews that are being examined in this work.

A10 found a significant effect of the interventions compared to the control group. However, they did not find enough information which persuasive features precisely affected the results.

Although A11 noticed that, applications using persuasive technology are the most versatile, persuasive design was not used widely in mobile applications for mental well-being. Furthermore, A11 stated that, even though rarely used, emotional support from peers could have great impact on supporting well-being of the participants.

Table 6.
Primary outcomes of reviews with regard to mental health interventions

No	Subdomain	Included articles	Used platform	Most used PTF	Major finding	Details	Discussion
A5	Alcohol abstinence	6	Web-based interventions	Self-monitoring, reduction, trustworthiness, expertise, surface credibility	Persuasiveness lacks in fostering individuals long-term behaviour change	- Without defined target groups and minimal tailoring for those groups little effect is expected - Primary task support relatively little used: Little use of tailoring	Evaluated web-based interventions do not seem to be really persuasive
A10	Smoking abstinence, Alcohol abstinence	23	Web-based interventions	Reduction, self-monitoring, simulation, personalization, reminders	The mere presence of persuasive features is not enough	Tailoring could play a role in effectiveness of interventions Little use of dialogue support, much use of primary task support	All studies persuaded the user in some way. However, there is not enough knowledge about the amount of PT to see what precisely affects the results.
A11	Well-being	12	Mobile applications	primary task support used most	Most PT using apps are most versatile apps	Although used scarce, emotional support from peers can have a great impact on well-being.	Persuasive Design not used widely.

PTF= Persuasive technology feature

3.2.4 General

Table 7 shows the outcomes of A12. A12 focusses on the influence of persuasive technology on the effectiveness of health interventions in general. The most used features of persuasive technology were alluded to in review A12. Altogether, it seems that different forms of feedback were often used with social features and reminders. In finding an effect of persuasive technology, the author gives more information about the context in which persuasive technology seems to be effective. A12 states that persuasive technology is most

used in a context to motivate the user to receive a goal mainly desired by the designer of the intervention.

Table 7
Primary outcomes of reviews with no specific domain

No	Included articles	Used platform	Most used PTF	Major findings	Details	Discussion
A12	51	No specific platform	Visual and audio feedback, social features, progress and persuasive messages, and reminders.	Persuasive technology indeed seems to persuade people into various behaviours.	Persuasive technology most used in context of difficulties to start or continue working on ones goal.	Persuasive technology could help persuading the user into behaviour that is mainly valuable for the designer.

PTF= Persuasive technology feature

3.3 Adherence

Table 8 lists the outcomes of the reviews regarding the effect of persuasive technology on adherence. All four reviews examine in total 163 interventions, mobile applications and papers. A possible overlap of articles could not be determined due to a lack of information on some reviews.

Three out of four papers state that persuasive technology has a positive effect on adherence. One paper ventures the guess that persuasive technology could increase the motivation of the users and therewith the adherence too (A10). Even though A10 noted little influence of persuasive technology, the authors state that there is still not enough knowledge to see what precisely affects the results.

As already seen in other articles, all four papers show a high use of primary task support features like tunneling (n=3), tailoring (n=4) and personalization (n=2). Dialogue support is represented with reminders (n=2) and suggestion (n=1). For the first time, social support with social facilitation is represented as one of the most used persuasive features (A6). Those findings are also confirmed by A2 who say that most attention is laid on primary support tasks. To improve the effect of persuasive technology there should be more attention to all forms of persuasive technology (A2).

A6 mentioned similar results. According to them, the amount of dialogue support used is a significant predictor of adherence. Although dialogue support plays an important part in enhancing adherence, A6 noticed that the mean use of dialogue support was 1.5 out of possible seven elements of persuasive technology. Therefore, a higher amount of dialogue support elements would be a good strategy to increase adherence (A6).

Next to dialogue support, A4 noticed a significant effect of tailoring in improving adherence. Furthermore, A4 stated that simulation has great potential to influence adherence in a positive way. A8 noticed that time plays a great role in predicting adherence. They said, the longer the duration of the intervention, the more people will stop following and the lower the adherence. In this case, the focus of persuasive technology should be laid on goals, commitment and self-efficacy (A8).

Table 4
Primary outcomes of reviews with regard to adherence

No	Included articles	Used platform	Most used PTF	Major finding	Details	Discussion
A2	9	Web-based interventions	Self-monitoring, tunneling, suggestion, tailoring, reduction	Positive effect of PT on Adherence	Most attention to PTS, less attention on DS and SP	More attention should be on all forms of PT
A4	40	Medication adherence intervention	Tailoring, reduction, simulation, rehearsal, reminders , personalization	Positive effect of PT on Adherence	Tailoring significant improving adherence (p=0.009) Simulation has potential improving adherence (p=0.22)	PT great potential as framework to analyze medication adherence interventions
A6	83	Web-based interventions	Tunneling, Tailoring, reminders, social facilitation	PT has positive effect on adherence	DS significant predictor of adherence (p=.006) SP, PTS no predictor (in this study)	Increasing dialogue support seems to be a good way to increase intended use (also predictor) to increase adherence.
A8	31	Online interventions	primary task support: tailoring, feedback on performance, and personalization	Adherence could be increased by addressing dimensions of motivation	Focus should be on user's goal-commitment and self-efficacy (e.g. via tailoring)	Duration of intervention is a significant factor in increasing adherence

PTF= Persuasive technology feature, PT= Persuasive Technology, PTS= primary task support; DS= dialogue support, SP= social support

4. Discussion

Nowadays, multiple reviews research the influence of persuasive technology in certain health care domains and frameworks of interventions. However, to see whether persuasive technology has a general effect on the outcome of an intervention, and to see which parts of persuasive technology work best, we need a global review of the effectiveness of persuasive technology. Another important factor with regard to persuasive technology is adherence (Kelders et al., 2011). If there is proof that adherence increases with a higher amount of persuasive features it could also have influence on the effectiveness.

This systematic review examined in total 12 reviews to study the general influence of persuasive technology on the effectiveness of health interventions and on adherence.

4.1 The effectiveness of persuasive technology

To see the influence of persuasive technology on the effectiveness of health interventions, 9 reviews of 3 different health care domains were examined. All nine reviews noted at least a positive potential of persuasive technology. Only one out of nine reviews could not find a clear effect of persuasive technology (Lehto & Oinas-Kukkonen, 2011). Another important discovery was that most of the interventions were scarcely persuasive. Two reviews, which concentrated on mobile applications, determined that most of the mobile applications make little use of persuasive features (Azar et al., 2013; Chang et al., 2013). We noted that self-monitoring, personalization and tailoring were particularly mentioned in the included reviews. Those three features belong to the category of primary task support in the persuasive system design model (PSD-Model). Meanwhile, some of the included reviews mentioned a high use of primary task support (Chang et al., 2013; Cugelman et al., 2011; Lehto & Oinas-Kukkonen, 2011), and little use of social support, even though this has been highly recommended (Chang et al., 2013). If there is little use of other persuasive technologies apart from primary task support, there can be no evidence of the whole influence of persuasive technology. That means, the knowledge we currently possess is mostly based on the knowledge we have about primary task support.

Nevertheless, why do most of the interventions focus their persuasive technology on primary task support? One reason could be that interventions are mostly goal orientated. Creators of interventions want positive results. This is one of the reasons why they may consider the most obvious category and fewer categories that have an indirect effect on the results of the interventions, such as social support. Furthermore, primary task support could be easier to implement in an intervention than other categories. If interventions want to make

use of social support they need a new feature that make it possible for users to interact with each other. Nonetheless, persuasive technology consists of more than only one category. If future interventions employ all categories of the PSD-Model, there is a chance that a higher effect of persuasive technology will be achieved and perceived.

Furthermore, lifestyle interventions seem to show more use of primary task support and a broader use of dialogue support than other interventions. One reason for those findings could be that lifestyle interventions are more goal-orientated than other interventions. To seek a user's interest in lifestyle interventions, such as weight control and physical activity, it is important to observe quick results. Compared to this, mental health or chronic care interventions may lay more attention to inform the user and to create a feeling of security. Furthermore, there is a possibility that those interventions are not merely web-based but are combined with face-to-face therapy. This could be a reason why those interventions are less persuasive than lifestyle interventions. However, future health interventions should not only be informative, but also able to motivate the user in changing unhealthy behaviour. The theory of planned behavior states that people do not always trust in their own abilities (Self-efficacy) and attach great importance to opinions of their social environment (Subjective norm) (Ajzen, 1991). This means, even if the user has enough information to change his behaviour, there is still a possibility that people do not make use of it. Dialogue support, such as praise, suggestions and rewards the intervention could increase the user's self-efficacy. Social support, such as social comparison, social learning and social facilitation gives the user the opportunity to experience other people's way of thinking.

The results also showed that specific features could play a role in the effectiveness of interventions. Several reviews noted that tailoring plays a role in the effectiveness of health interventions (Cugelman et al., 2011; Tuomas Lehto & Oinas-Kukkonen, 2011; Saparova, 2012; Xu et al., 2014a, 2014b). This leads to the question why tailoring shows more effect than other features of persuasive technology? The effect of tailoring may be influenced by the fact that almost every review stated it as one of the most used persuasive technology. The more the feature is used, the more we do know about it, and the more influence of this feature is noticeable. This means that tailoring is probably not the only effective feature of persuasive technology, but a feature we know the most about. If we had more information about other features, even features of dialogue support or social support could show a high influence of the effectiveness. For example, Cugelman et al. (2011) noticed a significant effect of feedback on performance and Saparova (2012) stated that personalization increases the motivation of the users. Xu et al. (2014a, 2014b) saw within two different domains a positive effect of

reminders. This means that not only primary task support has potential to be effective but also features of other categories of persuasive technology. However, without enough interventions making use of more persuasive categories we can only guess what the whole influence of persuasive technology may be.

With regard to those findings, future research should lay its focus on interventions with more persuasive features. Right now reviews have gathered all the information there is about the influence of persuasive technology on the effectiveness of health interventions. We know that primary task support, especially tailoring, has influence on the effectiveness of an intervention, but we know little about the influence of other categories. There is a high need for new experimental research that focusses on the effect of the whole persuasive design model and not only about the features of primary task support.

4.2 The influence of persuasive technology on adherence

This review examined four reviews to discover the influence of persuasive technology on adherence. The main findings were that persuasive technology has a positive effect on adherence. Once again, tailoring plays an important role in improving adherence. Xu et al. (2014a) noticed a significant effect and Cugelman et al. (2011) recommended the use of tailoring to enhance the users' motivation. One explanation could be that tailoring makes complex tasks for the user easy to understand. If the user understands the tasks of the intervention he may be more confident in actually solving the task, which creates a higher self-efficacy. If the user is confident about his skills, he is more motivated to follow the intervention.

Even though most of the reviews reported high use of primary task support (Kelders et al., 2012; Kelders et al., 2011; Xu et al., 2014a), Kelders et al. (2012) noted that dialogue support, though not often used, is a significant predictor of adherence. Dialogue support consists of useful features like reminders and suggestions that help the users stay focused on the task. One reason for non-adherence could be the missing motivation of the user. Another reason could be that the user simply forgets to follow the intervention. If online interventions make use of reminders, that for example send messages to mobile phones, the user will more likely continue to follow the intervention. Furthermore, if the system makes suggestions on how to reach difficult goals the user could be more motivated to follow tasks in order to reach those goals. To counteract non-adherence, not only theory but also Kelders et al. (2012) show that dialogue support should be more included in health interventions.

Furthermore, almost no review included credibility support in the results. However, Lehto and Oinas-Kukkonen (2011) referred to one intervention, where it is said that credibility is in the eye of the beholder (Danaher, & Seeley, 2009). Regarding this, there is a possibility that most researchers act on the assumption that most interventions adequately transact credibility. However, with this assumption we still do not know whether credibility is adequately used in health interventions and whether it is effective at all. Of course, it is important for an intervention to appear secure, credible and show signs of expertise. If the intervention does not show any signs of credibility at all, it will most likely not be attractive to the user to follow the intervention. This means, low credibility will most likely result in non-adherence. However, according to the fact that almost no included review gave information about credibility at all this review cannot give further information about the positive effect of credibility support on adherence.

The question is what would be the influence of persuasive technology on adherence if all categories of the PSD-Model were used adequately? At present we can only say with certainty that persuasive technology with a high use of primary task support influences the adherence of interventions, but we have little information whether other features of persuasive technology, if used, could increase this influence. Again, we recommend that future interventions should be more persuasive in all four categories of the PSD-Model. Furthermore, to our knowledge, it is important to distinguish the terms adherence and dropout. Adherence refers to the amount of people that make full use of the intervention, whereas dropout refers to people who do not fulfil the research protocol (Cugelman et al., 2011; Kelders et al., 2012). However, the current review could not always determine the differences due to a lack of information within the included reviews. Future studies may give more information about the circumstances of adherence and at best distinguish between different adherence and dropout.

4.3 Strengths and limitations

Even though there are noteworthy limitations, this systematic review deals with some important questions. First of all, this review is, to the researcher's knowledge, the only study making a general overview of the influence of persuasive technology in different healthcare domains and adherence. With the information given in the current review, future interventions may place more attention on certain persuasive features like tailoring and may not only focus on primary task support, but also on dialogue support and social support.

It is considered that the type of literature research undertaken in this review holds several advantages. This research is a review of former reviews. The advantage of the current review is to have views from 12 different groups of researchers. With this, we can give an objective view of the findings. Furthermore, thanks to all the reviews, we have results from a large pool of 313 papers. This allows us to have a broader view on health interventions than other reviews. However, this advantage does also include limitations. The fact that there are 12 different reviews results in an overlap of the reviewed papers. In this case, the number of overlapping reviews could not be determined due to missing information.

Furthermore, the quality of each review varies in the information given. Some reviews gave little information about the instruments used, the characteristics of the included interventions and the reviewed articles. This makes it difficult to compare the included reviews and to sort the results. With regard to persuasive technology, it is interesting to see whether there are differences in the characteristics and results of each paper and whether those differences influence the results. If there is inadequate information of the circumstances of each review, we only have a limited view on the influence of persuasive technology.

Another limitation is the individual interpretation of every researcher. Even though most of the researchers made use of the same definition of persuasive features, there is a possibility that those definitions were interpreted in different ways. This again makes it difficult to compare the different results of each paper. To prevent this from happening future interventions should describe in detail which persuasive features are used and where they are used.

4.4 Conclusions and implications

In summary, this review has been necessary to arrange all the information about persuasive technology collected in the last 10 years. This arrangement makes clear what we currently know and in which areas more knowledge and research is required.

With regard to the research question, the following conclusions are drawn. This review has proof that persuasive technology shows effect in every health care domain and influences the adherence of an intervention. Lifestyle interventions seem to make higher use of persuasive technology especially primary task support than other health care domains. One of the mainly used persuasive features is tailoring, which is also reported as the one having the greatest effect. The positive effect of tailoring is noted in nearly every review, regardless of the corresponding health care domain. Furthermore, tailoring influences not only the effectiveness but also the adherence of an intervention. Most of the reviews noted a high use

of primary task support and low use of other persuasive categories, such as dialogue support and social support, even though they may result in a bigger influence on both the effectiveness (Chang et al., 2013) and adherence (Kelders et al., 2012).

The findings of this review are also important for future interventions with regard to the fact that persuasive technology has positive influence in many ways. However, at this moment all the knowledge we have about persuasive technology is mostly about primary task support. If persuasive technology even shows an effect when hardly used, the actual effect, if used in a proper way, could be much higher. The Theory of Planned Behavior by Ajzen (1991) states that to change behaviour you need to include all categories of beliefs and not only one. This could be also true for persuasive technology. We need research that focusses on all categories to see whether the whole design of persuasive technology influences interventions.

As mentioned before, most of the Dutch people are retrieving information via the internet. This happens, amongst others, by mobile phones or tablets (CBS, 2014). This means that mobile applications will grow in importance in the coming years. One finding of this systematic review is that mobile applications still seem to make little use of persuasive technology. By letting mobile applications use more of this technology, their effectiveness could increase and we could reach more people in need of such interventions. This review does not only show the effect of persuasive technology but it could also become the basis of future interventions, to constitute the embedment of an adequately amount of persuasive elements. So why is persuasive technology not used widely in modern health care? One possible reason could be the limited knowledge about the influence of persuasive technology. Currently, science examined all the information we have about persuasive technology. The future needs new information about the possibilities and development opportunities the technology has. Future research should focus on experiments and implement all categories of persuasive technology in health interventions.

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Appendix

Keywords literature search

((TITLE-ABS-KEY ("persuasive technology" OR "persuasive system" OR "Persuasive strateg*")) OR ((TITLE-ABS-KEY (persuasive) AND TITLE-ABS-KEY (bcss OR "behavio*r change support system" OR application OR mobile OR "internet delivered" OR "web based" OR "internet based" OR "internet mediated" OR "internet supported" OR "medical informatics" OR "information technology" OR "e health*" OR ehealth* OR "e therap*" OR telemedic* OR telecare OR telehealth OR "e mental health" OR "emental health")))) AND (TITLE-ABS-KEY (health* OR well*being OR "behavio*r change" OR lifestyle OR disease OR "self help" OR "self control" OR self*management OR "self care"))".

Feature of persuasive technology and definition according to PSD framework (Oinas Kukkonen & Harjumaa, 2009)

Element	Definition
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.
Tunneling	Using the system to guide users through a process or experience provides opportunities to persuade along the way.
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.
Personalization	A system that offers personalized content or services has a greater capability for persuasion.
Self-monitoring	A system that keeps track of ones own performance or status supports the user in achieving goals.
Simulation	Systems that provide simulations can persuade by enabling users to observe immediately the link between cause and effect.
Rehearsal	A system providing means with which to rehearse a behavior can enable people to change their attitudes or behavior in the real world.
Dialogue Support	
Praise	By offering praise, a system can make users more open to persuasion
Similarity	People are more readily persuaded through systems that remind them of themselves in some meaningful way
Liking	A system that is visually attractive for its users is likely to be more persuasive.
Social Role	If a system adopts a social role, users will more likely use it for persuasive purposes.
Reminders	If a system reminds users of their target behavior, the users will more likely achieve their goals.
Suggestion	Systems offering fitting suggestions will have greater persuasive powers.
Rewards	Systems that reward target behaviors may have great persuasive powers.
Social Support	
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.
Social learning	A person will be more motivated to perform a target behaviour if (s)he can use a system to observe others performing the behavior.
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.
Normative influence	A system can leverage normative influence or peer pressure to increase the likelihood that a person will adopt a target behavior.
Cooperation	A system can motivate users to adopt a target attitude or behaviour by leveraging human beings' natural drive to cooperate.
Competition	A system can motivate users to adopt a target attitude or behaviour by leveraging human beings' natural drive to compete
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.
Credibility Support	
Trustworthiness	A system that is viewed as trustworthy will have increased powers of persuasion
Expertise	A system that is viewed as incorporating expertise will have increased powers of persuasion
Surface credibility	People make initial assessments of the system credibility based on a firsthand inspection.
Real World Feel	A system that highlights people or organization behind its content or service will have more credibility.
Authority	A system that leverages roles of authority will have enhanced powers of persuasion
Third party endorsements	Third-party endorsements, especially from well-known and respected sources, boost perceptions on system credibility.
Verifiability	Credibility perceptions will be enhanced if a system makes it easy to verify the accuracy of site content via outside sources.