Does the Number of Persuasive Technology Principles Used in Web-Based Interventions Concerning Mental Health Affect the Effectiveness: a Meta-Analysis

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Abstract

Background: Research has shown that web-based interventions concerning mental health can be effective, although there is a broad range in effect sizes. Why some interventions are more effective than others is not clear. Persuasive technology is one of the aspects which has a positive influence on changing attitude and/or behavior, and can contribute to better outcomes. According to the Persuasive Design Model there are various principles that can be deployed. It is unknown whether the number of principles used in a web-based intervention affect the effectiveness. Another issue in web-based interventions is adherence. Little is known about the relationship of adherence on the effectiveness of web-based interventions.

Objective: This study will examine whether there is a relationship between the number of persuasive technology principles used in web-based interventions and the effectiveness. Also the influence of the adherence rate on effectiveness of web-based interventions is investigated.

Methods: A within-group (WG) and between-group (BG) meta-analysis were performed and subsequently a subgroup analysis regarding the relationship between the number of persuasive technology principles and effectiveness. The influence of adherence on the effectiveness was examined through a meta-regression analysis.

Results: For the WG meta-analysis 40 treatment groups were included. The BG meta-analysis included 19 studies. The mean pooled effect size in the WG meta-analysis was large and significant (Hedges' g = 0.94), while for the BG meta-analysis this was moderate to large and significant (Hedges' g = 0.78) in favor of the web-based interventions. With regard to the number of persuasive technology principles the differences between the effect sizes in the subgroups were significant in the WG subgroup analysis for the total number of principles as well as the number of principles in the three categories Primary Task Support, Dialogue Support, and Social Support. In the BG subgroup analyses only the difference in the Primary Task Support was significant. An increase in the total number of principles and Dialogue Support principles yielded larger effect sizes in the WG subgroup analysis, indicating that more principles lead to better outcomes. The number of principles in the Primary Task Support (WG and BG) and Social Support (WG) did not show an upward trend but had varying effect sizes. The association between adherence and effectiveness was not significant.

Conclusions: Despite several limitations in this study it can be concluded that the number of persuasive technology principles affects the effectiveness of web-based interventions concerning mental health. An increase in adherence rate does not seem to be associated with larger effect sizes. The findings of this study give direction to future research.

Samenvatting

Achtergrond: Onderzoek heeft aangetoond dat internet interventies aangaande geestelijke gezondheid effectief kunnen zijn, hoewel de effectgroottes grote variaties vertonen. Waarom sommige interventies effectiever zijn dan andere is niet duidelijk. Persuasieve technologie is één van de aspecten die een positieve invloed hebben op het veranderen van attitude en/of gedrag, en kunnen bijdragen aan betere uitkomsten. Volgens het Persuasive Design Model zijn er meerdere principes die ingezet kunnen worden. Het is onbekend of het aantal principes dat gebruikt wordt in internet interventies de effectiviteit beïnvloeden. Een ander probleem in internet interventies is adherentie. Er is weinig bekend over de relatie tussen adherentie en de effectiviteit van internet interventies.

Doel: Deze studie zal onderzoeken of er een relatie is tussen het aantal persuasieve technologie principes en de effectiviteit. Ook de invloed van het adherentie percentage op de effectiviteit van internet interventies zal onderzocht worden.

Methode: Een within-group (WG) en between-group (BG) meta-analyse en vervolgens subgroep analyses inzake de relatie tussen het aantal persuasieve technologie principes en effectiviteit zijn uitgevoerd. De invloed van adherentie op de effectiviteit is onderzocht door middel van een meta-regressie analyse.

Resultaten: In de WG meta-analyse zijn 40 behandelingsgroepen geïncludeerd. De BG meta-analyse bevatte 19 studies. De gemiddelde gepoolde effectgrootte in de WG meta-analyse was groot en significant (Hedges' g = 0.94); voor de BG meta-analyse was dit gemiddeld tot groot en significant (Hedges' g = 0.78) in het voordeel van de internet interventies. Wat betreft het aantal persuasieve technologie principes zijn de verschillen tussen de effectgroottes in de subgroepen significant in de WG subgroep analyses voor het totale aantal principes alsmede het aantal principes in de categorieën Primaire Taak Ondersteuning, Dialoog Ondersteuning, en Sociale Ondersteuning. In de BG subgroep analyses was enkel het verschil in de Primaire Taak Ondersteuning significant. Een toename in het aantal totale principes en Dialoog Ondersteuningsprincipes leverden grotere effectgroottes op in de WG subgroep analyse, wat aangeeft dat meer principes tot betere uitkomsten leiden. Het aantal principes van de Primaire Taak Ondersteuning (WG en BG) en Sociale Ondersteuning (WG) liet geen opwaartse trend zien, maar variërende effectgroottes. De associatie tussen adherentie en effectiviteit was niet significant.

Conclusie: Het aantal persuasieve technologie principes beïnvloedt de effectiviteit van internet interventies. Een toename van het adherentie percentage lijkt niet geassocieerd te zijn met grotere effectgroottes. Deze bevindingen geven richting aan vervolgonderzoek.

Contents

Introduction

Since several years the development and deployment of web-based interventions are a topic of interest in health care. Barak, Klein and Proudfoot (2009) defined a web-based intervention as "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" (p. 5). Web-based interventions are assumed to have benefits like reducing costs and increased convenience for the patient considering time and location of treatment, anonymity, reaching isolated or stigmatized groups, and bridging gaps in the provision of care (Griffiths, Lindenmeyer, Powell, Lowe, & Thorogood, 2006; Musiat, Goldstone, & Tarrier, 2014). Also, the use of technology can be important by delivering greater efficiency, lower health service costs and better health outcomes (Griffiths et al., 2006; European Commission, 2012).

Nowadays, there are many online interventions available in various health areas including lifestyle, chronic conditions, and psychological conditions (Kelders, Kok, Ossebaard, & van Gemert-Pijnen, 2012). The interventions which are aimed at psychological conditions are a part of eMental health. In eMental health, information and communication technology is used to support and improve mental health conditions and mental health care, including care for people with substance use and comorbid disorders (Riper et al., 2010). Research has shown promising results in the effectiveness of web-based interventions for depression (Perini, Titov, & Andrews, 2009), social phobia (Andersson et al., 2006), anxiety (Andersson, Estling, Jakobsson, Cuijpers, & Carlbring, 2011; March, Spence, & Donovan, 2009), panic disorder (Carlbring et al., 2006), and posttraumatic stress disorder (PTSD) (Spence et al., 2011). However, not all web-based interventions are successful and there is a broad range in effect sizes. The average weighted effect sizes Barak, Hen, Boniel-Nissim, and Shapira (2008) found in their meta-analysis of the effectiveness of internet-based psychotherapeutic interventions varied from a minimum of -0,10 to a maximum of 1.68. Why some interventions are more effective than others is not clear. Most of the studies focus on the outcome results and not on the process of what happens during the interventions. Investigating what happens in the 'black box' between input and output, and what design features and functionalities are contributing to the effectiveness of a web-based intervention has become a growing field in the research of web-based interventions. Gaining more insight in the process and its aspects is important for the design and implementation of web-based

interventions and can help to optimize the success of these interventions. Two of those aspects of the process are the use of persuasive technology and the issue of non-adherence. Both aspects are subjects of the present study.

Persuasive technology

Persuasive technology is defined by Fogg (2003) as "any interactive computing system designed to change people's attitudes or behaviors" (p. 1), and is based on several principles that are used to make computers act as persuasive instruments. According to Fogg's functional triad (Fogg, 2003), computers can take on different roles. Computers can serve as tools to increase capability. They can create a relationship acting as a social actor. And functioning as media, they can provide experience. Fogg's definition, however, is limited to human-computer interaction. As patients, using web-based interventions, also have the possibility to communicate with persons, like a counselor or in a support group, it is important to expand this definition with computer-mediated communication. These two concepts are combined in the Persuasive Systems Design (PSD) model, a framework for designing and evaluating persuasive systems (Oinas-Kukkonen & Harjumaa, 2009). Persuasive systems are computerized software or information systems which, without the use of coercion or deceptions, have three potential successful outcomes namely to voluntarily reinforce, change ore shape attitudes or behaviors or both (Oinas-Kukkonen & Harjumaa, 2008).

The PSD model is based on seven postulates regarding users, persuasion strategies and system features (Oinas-Kukkonen & Harjumaa, 2009). First, information technology is never neutral, always influencing attitudes and behavior of people in some way. Second, it must be taken into account that people like their views about the world to be organized and consistent. Third, there are direct and indirect routes that people follow to process the information offered to them. Fourth, persuasion is often incremental. The remaining three postulates concern the system features namely the openness and unobtrusiveness of persuasive systems, and that these systems should be both useful and easy-to-use. The PSD model can be used to analyze and evaluate the persuasion context: intent, event and strategy (Oinas-Kukkonen & Harjumaa, 2009). For the persuasion context regarding intent, it is important to determine who the persuader is, and what kind of change in attitude and/or behavior is aimed for. Understanding the use context (which problem domain), user context (user's goals, motivation, lifestyle and others) and technology context, is important concerning the event. How to deliver the message is part of the strategy.

The persuasion techniques are derived from the principles of Fogg (2003) and four categories are distinguished, based on their key benefits: Primary Task Support (PTS), Dialogue Support (DS), System Credibility Support (SCS) and Social Support (SS) (Oinas-Kukkonen & Harjumaa, 2008). Every category consists of seven principles. Primary Task Support facilitates the performance of the user in carrying out the primary activities. The principles include reduction, tunneling, tailoring, personalization, self-monitoring, simulation, and rehearsal. The principles of Dialogue Support aim at keeping the user active and motivated in using the system in such a manner that it will keep the user involved in reaching the intended behavior. Dialogue Support employs praise, rewards, reminders, suggestion, similarity, liking, and social role. The design principles of System Credibility Support are trustworthiness, expertise, surface credibility, real world feel, authority, third party endorsements, and verifiability. With the use of these principles a web-based intervention can be designed to be perceived as more credible and therefore become more persuasive. Using Social Support principles motivates users by leveraging social influence. This category consists of the following principles: social learning, social comparison, normative influence, social facilitation, cooperation, competition, and recognition (Oinas-Kukkonen & Harjumaa, 2009). The definitions of the principles of the different categories can be found in Appendix A.

Recently more research has focused on the underlying mechanisms of persuasive technology for web-based interventions. Persuasive technology seems to have a positive influence on changing attitude and/or behavior. Hamari, Koivisto and Pakkanen (2014) reviewed studies that addressed persuasive technology in a diverse array of applications and target behaviors. Persuasive technology was integrated in a concept which related motivational affordances to psychological and behavioral outcomes. They found that of the studies that targeted behaviors in the health and exercise domain, 55.6% reported positive results, 37.7% partially positive results and 6.7% negative or other results. The four categories of the PSD model seem to have a significant impact on perceived persuasiveness and actual system usage in a web-based intervention focused on weight loss (Drozd & Oinas-Kukkonen, 2012). Through a component-based structural equation model approach, using the partial least squares method, the relationship between constructs of persuasive technology was investigated. The results showed that DS plays a central role by having direct connections with perceived persuasiveness, perceived credibility and PTS. Keeping the user motivated and active, through appropriate feedback and counseling, has a positive effect on perceived credibility and these two are both positively related to perceived persuasiveness. PTS, which helps the user performing the task through focusing on the targeted behavior and not on side issues, has

a positive relation with DS but does not have a direct relationship with perceived persuasiveness (Drozd & Oinas-Kukkonen, 2012). Beside positive effects, also some negative aspects of persuasive technology were found, such as frustration, cognitive overload, anxiety and peer pressure (Hamari et al., 2014).

Not all principles of the PSD model are deployed in web-based interventions. Of the different categories the principles that are most often used and reported are from PTS. Principles for DS and SS have been less often used, whereas SCS principles are the least used (Lehto & Oinas-Kukkonen, 2010; Lehto & Oinas-Kukkonen, 2011; Torning & Oinas-Kukkonen, 2009). In mental health interventions the principles tunneling and tailoring from the PTS category are most frequently used, followed by reduction and self-monitoring. Reminders were most often used from the DS category, followed by similarity. From the SS category the principles social learning and social facilitation are most commonly applied, followed by social comparison (Kelders et al., 2012). Little is known about how combinations of principles affect the outcomes. In the study by Räisänen, Lehto, and Oinas-Kukkonen (2010) the findings showed that on the one hand various PSD principles work well together and on the other hand some principles do not work very well together. Using paired principles that supplement each other can strengthen the persuasive effects. Yet, it must be avoided to weaken persuasiveness by implementing principles that have low synergy. For example, rewards can supplement suggestions, and abundant use of reduction makes tunneling redundant. Another aspect is the overlap of some of the principles from SS, like where does social comparison start and social learning end (Räisänen et al., 2010). It has indeed been put forward that not all of the principles of the model have to be used to reach the most optimal effect (Lehto & Oinas-Kukkonen, 2010). Not much research has been found that investigates a relationship between the amount of persuasive technology principles and the effectiveness of an intervention. The results of the study by Xu, Chomutare, and Iyengar (2014) showed that successful weight loss interventions contained a higher number of persuasive technology principles, although this was not statistically significant. It is still unknown if there is a relationship between the amount of persuasive technology principles and the effect size. Can higher effect sizes be reached by increasing the number of persuasive technology principles and does this apply for the number of principles used in every category?

Adherence

Persuasive technology seems to be of value for adherence as well. Adherence is found to be low in web-based interventions (Eysenbach, 2005). In web-based interventions the usage and

continuation of usage largely depend on the participants themselves and adherence rates are often low because the participant can choose to discontinue very easily (Eysenbach, 2005). Research in adherence often focuses on whether the characteristics of adherers and non-adherers differ. The use of persuasive technology in relation to adherence is less investigated. However, using persuasive technology could be important to increase adherence when the appropriate principles are deployed on those critical moments when non-adherence starts (Kelders & van Gemert-Pijnen, 2013). The PSD-model has been used by Kelders et al. (2012) to study whether the use of persuasive technology affects adherence. In this study by adherence is meant the proportion of participants that use and keep using the intervention in the desired way. Kelders et al. (2012) found that the use of principles from Dialogue Support has a positive effect on adherence in web-based interventions. Social Support also related to better adherence, whereas Primary Task Support did not show a significant contribution to adherence.

It is relatively unknown what impact adherence has on the outcomes of web-based interventions, although adherence is considered to be an important factor in psychotherapy outcomes (Donkin et al., 2011). In the systematic review by Donkin et al. (2011) it was found that adherence was positively related to outcomes targeted at physical health when measured by number of logins and activities completed. These measures however, had no effect on outcomes of depression. For this condition the degree of modules completed and website exposure contributed to better outcomes (Donkin et al., 2011). This was also found by Hilvert-Bruce, Rossouw, Wong, Sunderland, and Andrews (2012), who found better outcomes for people who completed all the lessons of an internet cognitive behavioral therapy for anxiety and depressive disorders in comparison to non-completers, although non-completers showed some improvement as well.

Aim of study

Elaborating on the study of Kelders et al. (2012) this study will investigate through a meta-analysis whether there is a relationship between the number of used PSD principles, and effectiveness of web-based interventions in mental health. The ability to examine the relationship between the use of PSD principles in the studies, as characteristics of these studies, and the size of intervention effect, makes the use of a meta-analysis legitimate (Borenstein, Hedges, Higgins, & Rothstein, 2009; Deeks, Higgins, & Altman, 2011).

Since little is known about the association between adherence and outcomes, this study will also analyze if the adherence rate affects effectiveness. Since Dialogue Support and Social Support have a positive effect on adherence of web-based interventions, it will be interesting to see if the focus for using persuasive design needs to be on outcome effects or on increasing adherence rates, or both.

The aim of this study will be to answer the following research questions: (1) Is there a relationship between the number of used PSD principles and effectiveness of web-based interventions in mental health? (2) Does the adherence rate influence the effectiveness of web-based interventions in mental health? Exploring these associations can give direction to further research and improvements in designing eMental Health interventions.

Method

Study selection and data collection

As mentioned before this study elaborates on the systematic review by Kelders et al. (2012) and therefore the articles were derived from that study. An extensive selection procedure, regarding the initial selection, can be found in the article by Kelders et al. (2012), who selected 101 articles, including 83 interventions. Of these 83 interventions, 48 interventions were targeted at mental health and these were selected for the current study.

A further selection was made to include studies for the meta-analysis using the following criteria:

Intention-to-treat. The results of the study had to be based on intention-to-treat (ITT) analysis. If this was not the case, the study was excluded.

Available data. The study had to provide sufficient data to calculate effect sizes. Effect sizes were determined using group means and standard deviations, or other effect size values in the text (Borenstein et al., 2009). When data was not sufficient to calculate an effect size, the study was excluded.

The following characteristics of the included interventions were taken over from Kelders et al. (2012): intervention name, behavior / condition, studies and study design, interaction, modality, persuasive technology in the intervention, adherence.

Added to those characteristics were: gender and age of the target group, sample size treatment group and/or control group, primary outcome(s), group mean(s) and standard deviation(s) at baseline (within-group) and at post-treatment (within-group and between-group), and correlation. These characteristics were abstracted and coded by one researcher (GW).

Meta-analysis

For the purpose of this study a within-group (WG) meta-analysis and a between-group (BG) meta-analysis were performed. The WG meta-analysis was based on the improvement from baseline to post-test in the treatment groups using a web-based intervention. The BG meta-analysis was based on comparisons of a treatment group using a web-based intervention versus a waiting list (WL) control group.

To be included in the WG meta-analysis the treatment group had to use a web-based intervention. Waiting list control groups as well as treatment groups using non-web-based interventions were excluded. When a study compared two or more treatment groups, all treatment groups using web-based interventions were included.

In the BG meta-analysis only the studies that had a treatment group using web-based interventions versus a WL control group were included. When a study compared two or more treatments without a WL control group the study was excluded. In studies with multiple treatment groups combined with only one WL control group, the treatment group using the web-based intervention versus the WL control group was included in the BG meta-analysis.

For each study an effect size was calculated (Hedges' g). Hedges' g is the standardized mean difference that expresses the size of the intervention effect in each study relative to the variability observed in that study (Higgins & Green, 2011). Hedges' g was preferred over Cohen's d because Cohen's d tends to overestimate the absolute value of d in small samples. This bias can be corrected using Hedges' g (Borenstein et al., 2009). In the calculations of the effect sizes the results of the primary outcome(s) were used. When multiple measurement instruments were used, effect sizes were calculated for each of the instruments and then the mean of the effect sizes was computed.

For the WG meta-analysis, the effect size was calculated by subtracting the average post-treatment score from the average pre-treatment score, and dividing the result by the pooled standard deviation. The values from pre-treatment to post-treatment are not independent from each other, so the correlation between the time points is required. When the correlation was not reported in a study it was conservatively estimated as $r = 0.90$.

Effect sizes for comparisons between a treatment and control group for the BG meta-analysis were calculated by subtracting the average score of the treatment group from the average score of the control group, and dividing the result by the pooled standard deviations of the two groups.

For the calculation of the pooled mean effect sizes the computer program Comprehensive Meta-analysis (version 2.2.064) was used. Effect sizes of 0.2 are considered small, while effect sizes of 0.5 are moderate and 0.8 can be assumed to be large (Cohen, 1988).

Since the included studies are diverse, and also because the different characteristics of the participants and the difference in the implementations of interventions, the random effects model was used to compute the mean effect sizes. In the random effects model it is assumed that the true effect size varies from study to study, and the summary effect is the estimate of the mean of the distribution of effect sizes. The random error within studies is taken into account as well as the true variations of effect sizes from one study to the next. This leads to broader 95%-confidence intervals (95% CI) and more conservative results (Borenstein et al., 2009).

As a test of heterogeneity of effect sizes the I^2 statistic was calculated. I^2 is an indicator of heterogeneity in percentages. A value of 0% indicates no observed heterogeneity, and larger values show increasing heterogeneity, with 25% as low, 50% as moderate and 75% as high heterogeneity (Higgins, Thompson, Deeks, & Altman, 2003).

Since the meta-analysis focuses on whether persuasive system design principles have an influence on the effect size, subgroup analyses were performed. For the conduction of the subgroup analyses the subgroups were compared within four categories: total PSD principles, PTS principles, DS principles, and SS principles. Since the maximum number of persuasive system design principles used in one study was 9 out of total 21, the distinguished subgroups for the total PSD principles used in the interventions were: ≤ 3, 4-6, and ≥ 7 principles. For the number of PSD principles in the categories PTS, DS, and SS used in the interventions, the analysis was done for each number of used principle, resulting in 5 subgroups for PTS, 4 subgroups for DS, and 5 subgroups for SS. For each subgroup the pooled mean effect size is calculated and a test is conducted to examine whether the subgroups' effect sizes differ significantly from one another within the four categories. These analyses were conducted according to the mixed effects model, implemented in Comprehensive Meta-analysis (version 2.2.064). In this model, studies within subgroups are pooled with the random effects model, while tests for significant differences between subgroups are conducted with the fixed effects model.

To explore the relationship between adherence and the effect size, a meta-regression analysis was performed, using the random-effect model (method of moments), which is implemented in Comprehensive Meta-analysis (version 2.2.064).

The summary effect in meta-analyses may be biased due to the likelihood that studies with relatively high effect sizes are more often published and included in the meta-analysis, than studies which report lower effect sizes (Borenstein et al., 2009). This issue is known as publication bias and was tested by inspecting the funnel plot on effect sizes and by applying the Trim and Fill procedure (Duval & Tweedie, 2000), as implemented in Comprehensive Meta-analysis (version 2.2.064).

Results

Study selection

The 48 interventions selected by Kelders et al. (2012) were described in 51 articles. These articles were screened for intention-to-treat analysis and available effect size data. There were 10 articles that did not have data available based on intention-to-treat (ITT) analysis (Bingham et al., 2010; Carrard et al., 2011; de Graaf, Huibers, Riper, Gerhards, & Arntz, 2009; Farvolden, Denisoff, Selby, Bagby, & Rudy, 2005; Gerrits, van der Zanden, Visscher, & Conijn, 2007; Linke, Murray, Butler, & Wallace, 2007; March et al., 2009; Meyer et al., 2009; Postel, de Haan, & de Jong, 2010; Schwinn, Schinke, & Di Noia, 2010). These were excluded from the meta-analysis. Sufficient data available for calculating effect sizes were not found in 8 articles (Christensen, Griffiths, Groves, & Korten, 2006; Kiropoulos et al., 2008; Klein, Slaymaker, Dugosh, & McKay, 2011; Klein et al., 2009; Klein, Richards, & Austin, 2006; Linke, Brown, & Wallace, 2004; Nicholas et al., 2010; Richards, Klein, & Austin, 2006). These were also excluded from the meta-analysis. This resulted in 33 articles that were included in the meta-analysis (see Figure 1).

Characteristics of selected studies

Four of the 33 articles were observational studies, 29 articles were RCT's. Sixteen RCT studies compared a treatment group with a WL control group, 6 studies compared two treatment groups, and 7 RCT studies reported multiple comparisons.

A total of 3,078 people participated in the studies of whom 1,834 received a web-based intervention, 401 were given another treatment, and 843 people were part of the WL control group. The number of participants in each study ranged from 17 to 303 (mean = 93, median = 74).

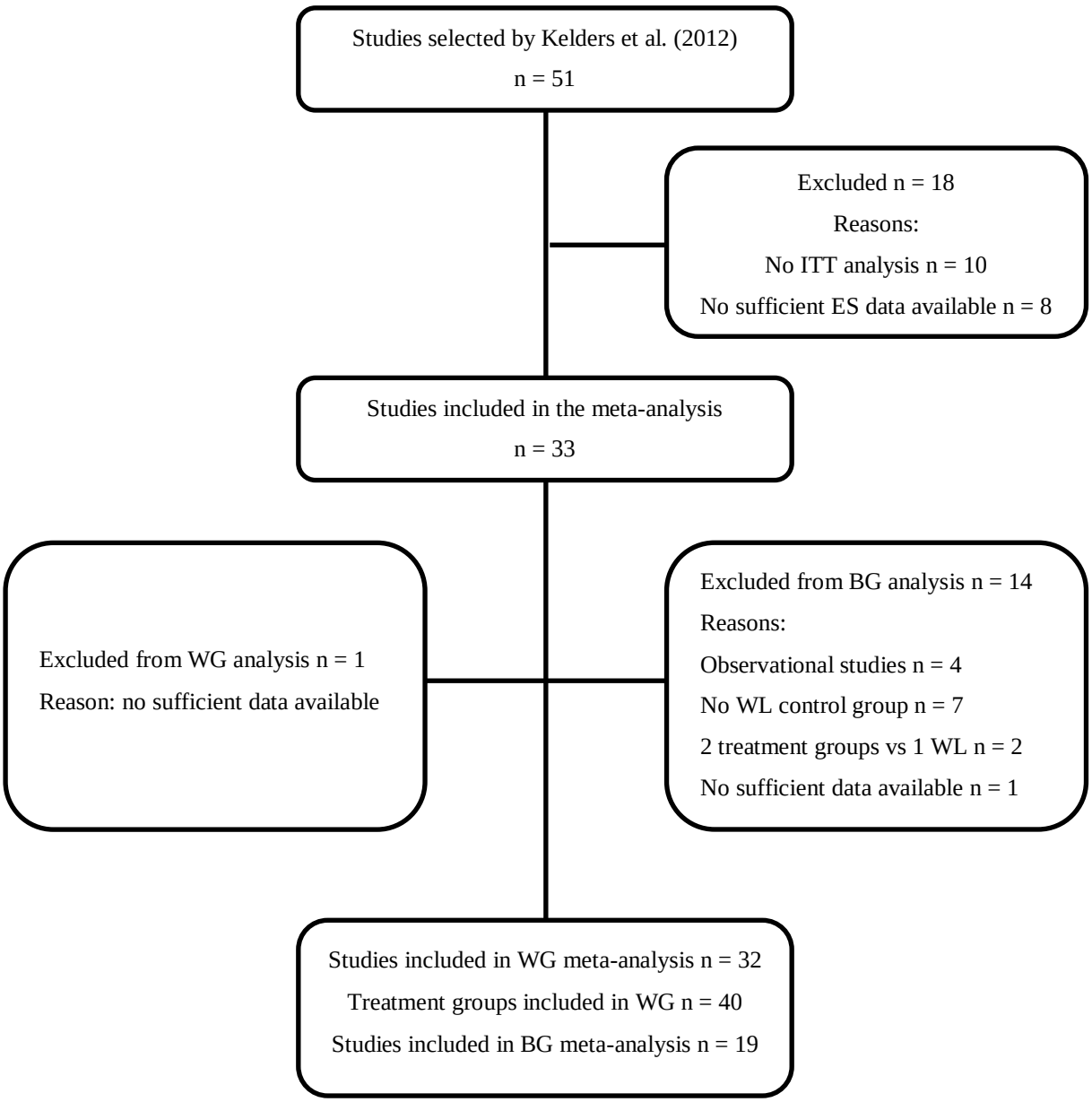

Figure 1. Flow diagram of study selection

Regarding gender and age of the target population, most of the studies were aimed at both male and female adults over 18 years old. There were 4 exceptions of which in one the researchers recruited adolescents (range 12-18 years) (Spence et al., 2011). In another study high school students (range 15-21 years) were recruited (Tillfors et al., 2011). University students (range 19-53 years) were recruited in the study by Tillfors et al. (2008). Finally, one study was targeted at women between 18 and 60 years old (Carrard et al., 2011). The major part of all the participants was female (65.43%).

The conditions that were examined in the studies were social phobia (n = 13), depression (n = 7), anxiety (n = 5), panic disorder (n = 4), post-traumatic stress disorder (PTSD) (n = 2), alcohol (n = 1), and eating disorder (n = 1). The number of measurement instruments for the primary outcomes ranged from 1 to 8 (mean = 3, median = 2) per study.

Adherence to the web-based interventions varied between a minimum of 12% to a maximum of 93%. The average adherence percentage was 57.95%. In the WG the mean adherence rate was lower than in the BG, respectively 58.40% (min 12%, max 93%) and 65.42% (min 34%, max 93%).

A detailed list of the characteristics can be found in Appendix B.

Within-group meta-analysis

In the 33 articles 40 treatment groups met the inclusion criteria for the WG meta-analysis. The article by Postel, de Haan, ter Huurne, Becker, & de Jong (2010) lacked sufficient available data for calculating the WG effect size and was excluded. Titov, Andrews, Choi, Schwencke, and Mahoney (2008) did not report sufficient data for calculating the WG effect size for the clinician-assisted computerized cognitive behavioral treatment (CaCCBT) group. Therefor only the self-guided computerized CBT was included in the WG meta-analysis. See also Appendix B for a complete overview of included and excluded treatment groups. Correlation was not reported in any study; hence the correlation was set at 0.9 for all included studies to calculate the effect sizes. An overview of the data of the primary outcome(s) can be found in Appendix C.

The conditions examined in these studies were social phobia (n = 19), depression (n = 9), anxiety (n = 5), panic disorder (n = 4), post-traumatic stress disorder (PTSD) (n = 2), and eating disorder (n = 1).

The mean pooled effect size (Hedges' g) was 0.94 (95% CI: 0.84 – 1.03), which is considered to be large (Cohen, 1988). The effect size was significant ($p < 0.001$), indicating a large pre- to post-treatment effect. Heterogeneity was high ($I^2 = 92.56\%$). The effect sizes and 95% confidence intervals of all included studies are shown in figure 2.

Subgroup analysis

Table 1 shows the results regarding the subgroup analyses. Twenty-five studies used 4-6 principles out of the total of 21 that could be deployed, 10 studies used 7 or more principles and 5 studies used 3 or less principles. In the PTS category in 31 studies 2 principles out of 7 were deployed, 5 studies used 3 principles, 2 studies used 4 principles, one study used 1 principle, and 1 study used 5 principles. Out of the 7 DS principles 20 studies used 1 principle, 14 studies used 2 principles, 3 studies used 3 principles and 3 studies did not use DS principles at all. In the SS category 17 studies used 2 principles out of 7, 10 studies did not use any DS principles, 8 studies used 3 principles, 4 studies used 1 principle, and 1 study used 4 principles.

For the total number of PSD principles the effect size between the subgroups was significantly different ($p < 0.01$). Also for the number of PTS principles, as well as DS principles, and SS principles used in an intervention the subgroups differed significantly ($p < 0.01$). This is an indication that the effect size is related to the total number of PSD principles as well as the number of principles in each category used in an intervention. For the total number of PSD principles it seemed that more principles led to a higher effect size. Hedges' g varied from 0.99 ($Z = 33.69$; $p < 0.01$) for 7 or more principles, to 0.87 ($Z = 53.60$; $p < 0.01$) for 4-6 principles, and 0.78 ($Z = 26.96$; $p < 0.01$) for 3 or less principles. For the number of PTS principles it seemed that two or more principles lead to higher effect sizes, although the effect sizes did not show a rising trend with the increase of used principles, instead they varied among the number of principles. Four principles yielded the highest effect size (Hedges' $g = 1.08$; $Z = 14.72$; $p < 0.01$), followed by 5 principles (Hedges' $g = 0.95$; $Z = 11.80$; $p < 0.01$), then 2 principles (Hedges' $g = 0.91$; $Z = 60.55$; $p < 0.01$), 3 principles (Hedges' $g = 0.77$; $Z = 27.52$; $p < 0.01$), and finally 1 principle (Hedges' $g = 0.28$; $Z = 3.47$; $p < 0.001$). In the DS category the more PSD principles were used the higher the effect size. Three principles led to an effect size of 1.07 ($Z = 19.39$; $p < 0.01$), 2 principles led to an effect size of 0.93 ($Z = 42.61$; $p < 0.01$), 1 principle led to an effect size of 0.89 ($Z = 46.86$; $p < 0.01$) and using no DS principles led to an effect size of 0.65 ($Z = 19.78$; $p < 0.01$). For the number of SS principles the effect sizes fluctuated: 4 principles led to a higher effect size (Hedges' $g = 1.12$; $Z = 12.11$; $p < 0.01$), followed by 2 principles (Hedges' $g = 0.92$; $Z = 43.21$; $p < 0.01$), then zero principles (Hedges' $g = 0.86$; $Z = 37.13$; $p < 0.01$), and 3 principles (Hedges' $g = 0.85$; $Z = 26.75$; $p < 0.01$), and finally 1 principle (Hedges' $g = 0.79$; $Z = 24.97$; $p < 0.01$).

Adherence

The average adherence rate of the studies included in the WG analysis was 58,40% (min 12%, max 93%). To explore the association between adherence and effect size a meta-regression analysis was performed. Although the figure shows a slight increase of effect size with higher adherence rates, the association was not significant (slope: 0.002; 95% CI: -0.003-0.006; p = 0.45), suggesting that the increase in adherence does not lead to a higher effect size (figure 3).

Table 1. Subgroup analyses Within-Group.

Subgroups	N	g	95% CI	Z	I^2	p[a]
Number of total PSD principles						<0.01
≤ 3 principles	5	0.78	0.73-0.84	26.96*	96.42	
4-6 principles	25	0.87	0.84-0.90	53.60*	91.76	
≥ 7 principles	10	0.99	0.93-1.05	33.69*	90.68	
Number of PTS principles						<0.01
1 principle	1	0.28	0.12-0.44	3.47**	0.00	
2 principles	31	0.91	0.88-0.94	60.55*	90.99	
3 principles	5	0.77	0.72-0.83	27.52*	96.27	
4 principles	2	1.08	0.93-1.22	14.72*	67.73	
5 principles	1	0.95	0.79-1.10	11.8*	0.00	
Number of DS principles						<0.01
0 principles	3	0.65	0.58-0.71	19.78*	67.73	
1 principle	20	0.89	0.85-0.93	46.86*	94.16	
2 principles	14	0.93	0.89-0.97	42.61*	89.09	
3 principles	3	1.07	0.96-1.17	19.39*	59.41	
Number of SS principles						<0.01
0 principles	10	0..86	0.82-0.91	37.13*	94.07	
1 principle	4	0.79	0.72-0.85	24.97*	98.13	
2 principles	17	0.92	0.88-0.97	43.21*	63.16	
3 principles	8	0.85	0.79-0.92	26.75*	95.25	
4 principles	1	1.12	0.94-1.30	12.11*	0.00	

Note. [a] The p-values in this column indicate whether the difference between the effect sizes in the subgroups are significant

*p<0.01

**p=0.001

Meta-Analysis Within-Group

Study name	Outcome	Hedges's g	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
Andersson ICBT+exp	Combined	0,909	0,093	0,009	0,727	1,092	9,751	0,000
Andersson-A	Combined	0,834	0,099	0,010	0,640	1,028	8,425	0,000
Aydos Shyness 5 CaCCBT	Combined	0,599	0,114	0,013	0,376	0,822	5,272	0,000
Carlbring ICBT	Combined	1,026	0,101	0,010	0,829	1,224	10,179	0,000
Carlbring1 IT	Combined	0,793	0,102	0,010	0,593	0,993	7,763	0,000
Carlbring2	Combined	1,098	0,103	0,011	0,896	1,300	10,648	0,000
Carrard	EDI-2 Bulimia	0,988	0,088	0,008	0,814	1,161	11,170	0,000
De Graaf CYL1 CCBT	BDI-II	0,699	0,050	0,002	0,602	0,796	14,093	0,000
De Graaf CYL1 CCBT+TAU	BDI-II	0,563	0,048	0,002	0,469	0,657	11,778	0,000
Furmark IAR	Combined	0,875	0,096	0,009	0,687	1,063	9,131	0,000
Furmark ICBT-1	Combined	0,947	0,084	0,007	0,782	1,112	11,236	0,000
Furmark ICBT-2	Combined	1,142	0,106	0,011	0,933	1,350	10,741	0,000
Hedman	HAI	1,811	0,114	0,013	1,588	2,035	15,880	0,000
Hedman ICBT	LSAS-SR	1,392	0,078	0,006	1,239	1,544	17,852	0,000
Klein PTSD Online	PTSD-CSR	0,646	0,102	0,010	0,447	0,845	6,351	0,000
Mohr MoodManager	Combined	1,264	0,130	0,017	1,010	1,518	9,740	0,000
Perini Sadness	Combined	0,820	0,098	0,010	0,628	1,011	8,395	0,000
Ruwaard Interapy	Combined	0,716	0,095	0,009	0,530	0,902	7,551	0,000
Spence Brave2 NET	Combined	0,946	0,080	0,006	0,789	1,103	11,800	0,000
Spence PTSD Program	PCL-C	0,739	0,102	0,010	0,538	0,940	7,219	0,000
Tilfors ICBT 2008	Combined	0,945	0,120	0,014	0,709	1,180	7,854	0,000
Tilfors ICBT 2011	Combined	0,638	0,152	0,023	0,340	0,936	4,199	0,000
Tilfors ICBT+exp	Combined	0,855	0,120	0,015	0,619	1,091	7,099	0,000
Titov Anxiety Program	GAD-7	0,784	0,080	0,006	0,628	0,940	9,842	0,000
Titov Shyness 1 CaCCBT	Combined	1,039	0,078	0,006	0,886	1,192	13,306	0,000
Titov Shyness 2 CaCCBT	Combined	1,094	0,087	0,008	0,922	1,265	12,520	0,000
Titov Shyness 3 CCBT	Combined	0,281	0,081	0,007	0,122	0,440	3,465	0,001
Titov Shyness 4 CCBT	Combined	0,793	0,056	0,003	0,683	0,904	14,077	0,000
Titov Shyness 4 CCBT+tel	Combined	1,096	0,063	0,004	0,972	1,221	17,301	0,000
Titov Shyness 6 CCBT+forum	Combined	1,433	0,101	0,010	1,235	1,631	14,192	0,000
Titov Shyness 6 CCBT+tel	Combined	1,265	0,091	0,008	1,087	1,443	13,923	0,000
Titov Shyness 7 iCBT	Combined	1,047	0,074	0,006	0,901	1,193	14,064	0,000
Titov Shyness 7 iCBT+MS	Combined	0,830	0,071	0,005	0,692	0,968	11,751	0,000
Titov Wellbeing Program	DASS-21	1,122	0,093	0,009	0,941	1,304	12,112	0,000
Titov Worry Program	Combined	1,217	0,121	0,015	0,980	1,453	10,069	0,000
Van Straten EUC	Combined	0,432	0,045	0,002	0,343	0,522	9,507	0,000
Vernmark Self-help	BDI	1,349	0,113	0,013	1,127	1,571	11,921	0,000
Warmerdam CYL2	CES-D	1,124	0,061	0,004	1,005	1,243	18,555	0,000
Warmerdam EUC2	CES-D	1,013	0,058	0,003	0,899	1,128	17,377	0,000
Wims Panic Program	Combined	0,417	0,086	0,007	0,249	0,585	4,872	0,000
		0,936	0,048	0,002	0,843	1,030	19,701	0,000

Hedges's g and 95% CI

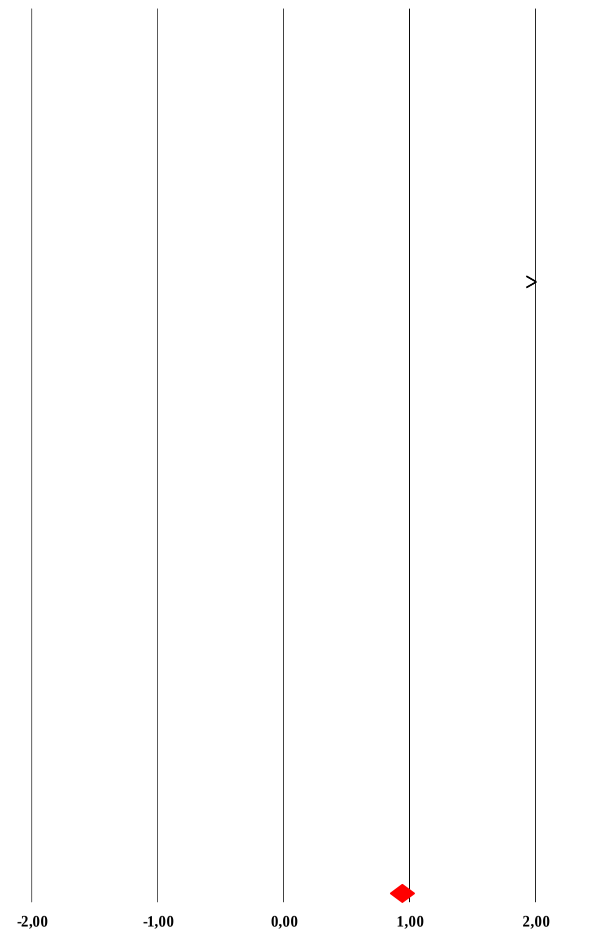

Figure 2. Standardized effect sizes (Hedges' g) pre-to post-treatment change

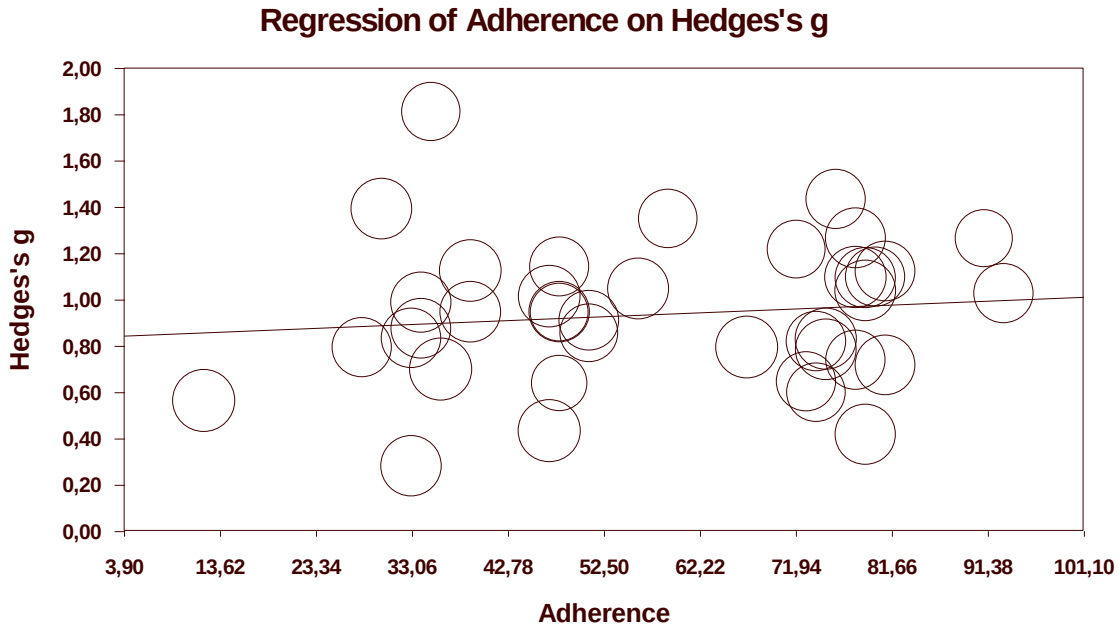

Figure 3. Relation of adherence to the effect size Within-Group.

Publication bias

Publication bias analysis was performed using the funnel plot and applying the Duval and Tweedie's Trim and Fill procedure (Duvall & Tweedie, 2000). When the studies are symmetrically distributed around the mean effect size publication bias is not present. In case of publication bias, non-significant studies and studies with lower effect sizes should be missing in the middle and on the bottom of the left side. Figure 4 shows that the funnel plot for the studies included in the WG analysis was asymmetric, indeed missing studies on the left side, which suggested presence of publication bias. This is confirmed by the Trim and Fill procedure which recalculates the effect size by first removing the most extreme small studies on the positive side of the funnel plot and then adding all the original studies and imputing a mirror image for each study. The adjusted effect size would be 0.77 (95% CI: 0.67-0.87, number of trimmed studies: 13). This is lower than the observed mean effect size (0.94; 95% CI: 0.84-1.03) indicating evidence of publication bias.

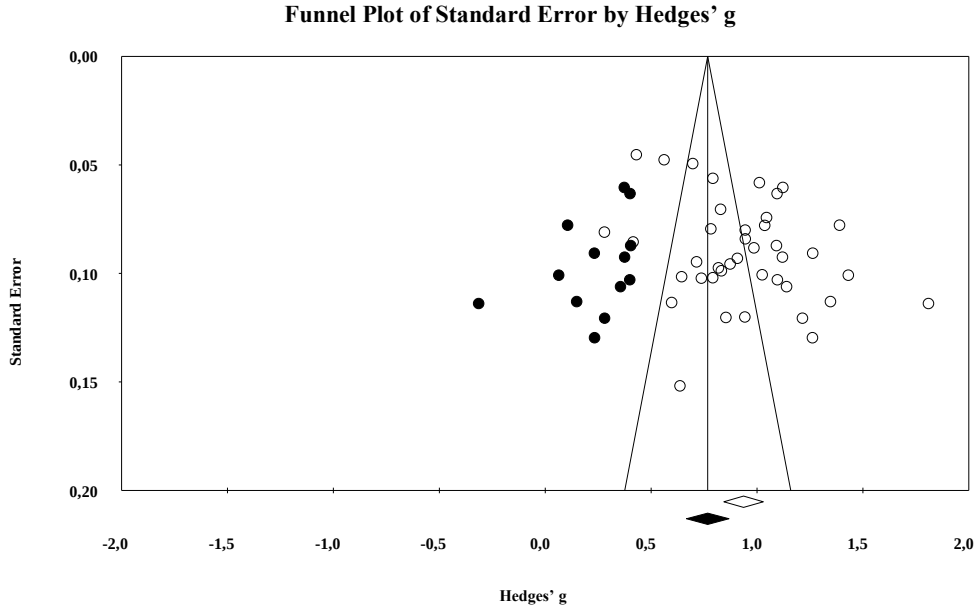

Figure 4. Funnel plot with observed (○) and imputed (●) studies Within-Group.

Between-group meta-analysis

For the BG meta-analysis 19 comparisons met the inclusion criteria. The four observational studies were excluded (Andersson et al., 2011; Aydos, Titov, & Andrews, 2009; Klein et al., 2010; Mohr et al., 2010). Seven studies did not use a WL control group and were therefor excluded (Carlbring et al., 2005; de Graaf, Gerhards, et al., 2009; Hedman, Andersson, Andersson, et al., 2011; Hedman, Andersson, Ljotsson, et al., 2011; Titov, Andrews, Choi, Schwencke, & Johnston, 2009; Titov et al., 2010; Titov, Andrews, Schwencke, et al., 2009). Two studies compared two treatment groups using a web-based intervention versus one WL control group (Titov et al., 2008; Warmerdam, van Straten, Twisk, Riper, & Cuijpers, 2008) and were excluded from the meta-analysis, otherwise the WL control group would lead to a 'double count' in the number of participants, because both intervention groups share the same WL control group. This would cause a unit-of-analysis error due to the unaddressed correlation between the estimated intervention effects from multiple comparisons (Higgins, Deeks, & Altman, 2011). Finally, the study by Tillfors et al., 2008 was excluded because there was no data available for the WL control group to calculate an effect size. See also Appendix B for a complete overview of included and excluded treatment groups.

The examined conditions were social phobia (n = 6), depression (n = 4), anxiety (n = 3), panic disorder (n = 3), post-traumatic stress disorder (PTSD) (n = 1), alcohol (n = 1), and eating disorder (n = 1).

The mean pooled effect size (Hedges' g) at post-test was 0.78 (95% CI: 0.63 – 0.92), which is considered to be moderate to large (Cohen, 1988). The effect sizes and 95% confidence intervals of all included studies are shown in figure 5. The pooled mean effect size was significant ($p < 0.001$), in favor of the treatment groups. Heterogeneity was low to moderate ($I^2 = 42.14\%$). See Appendix C for an overview of the data of the primary outcome(s).

Twelve studies used 4-6 principles out of the total of 21 that could be deployed, 6 studies used 7 or more principles and 1 study used 3 or less principles. In the PTS category in 13 studies 2 principles out of 7 were deployed, 2 studies used 3 principles, 2 studies used 4 principles, one study used 1 principle, and 1 study used 5 principles. Out of the 7 DS principles 11 studies used 1 principle, 6 studies used 2 principles, and 2 studies used 3 principles. In the SS category 8 studies used 2 principles out of 7, 4 studies used 3 principles, 3 studies did not use any DS principles, 3 studies used 1 principle, and 1 study used 4 principles.

Subgroup analysis

Subgroup analyses did not indicate a significant association between the effect size and the number of total PSD principles, number of DS principles, and SS principles used in an intervention (see table 2). Except for the number of PTS principles used in an intervention, the subgroups differed significantly ($p = 0.001$). This is an indication that the effect size is related to the number of PTS principles used in an intervention, but the effect sizes did not show an upward trend along with the increase of the number of principles. Instead the effect sizes varied among the different numbers of principles. In this category the use of 1 principle yielded the highest effect size (Hedges' $g = 1.18$; $Z = 4.95$; $p < 0.01$), followed by 4 principles (Hedges' $g = 1.11$; $Z = 7.27$; $p < 0.01$), then 5 principles (Hedges' $g = 0.86$; $Z = 3.39$; $p < 0.001$), 2 principles (Hedges' $g = 0.75$; $Z = 10.11$; $p < 0.01$) and 3 principles (Hedges' $g = 0.38$; $Z = 3.09$; $p < 0.05$).

Meta Analysis Between-Group

Study name	Outcome	Hedges's g	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
Andersson-S1 ICBT+exp	Combined	0,700	0,255	0,065	0,200	1,200	2,743	0,006
Carlbring2	Combined	0,974	0,274	0,075	0,437	1,511	3,556	0,000
Carlbring-S3 ICBT	Combined	1,123	0,282	0,080	0,570	1,676	3,982	0,000
Carrard	EDI-2 Bulimia	0,849	0,240	0,058	0,378	1,320	3,531	0,000
Furmark-S2 ICBT	Combined	0,666	0,228	0,052	0,220	1,113	2,924	0,003
Perini Sadness	Combined	0,731	0,309	0,095	0,125	1,336	2,365	0,018
Postel Alcohol de Baas	Combined	1,284	0,198	0,039	0,897	1,672	6,502	0,000
Ruwaard Interapy	Combined	0,567	0,266	0,071	0,046	1,087	2,133	0,033
Spence Brave2	Combined	0,855	0,252	0,064	0,361	1,350	3,390	0,001
Spence PTSD Program	PCL-C	0,449	0,308	0,095	-0,155	1,053	1,457	0,145
Tilfors-S2 ICBT	Combined	1,235	0,494	0,244	0,266	2,204	2,498	0,012
Titov Anxiety Program	GAD-7	0,770	0,233	0,054	0,314	1,226	3,310	0,001
Titov Shyness 1	Combined	0,944	0,211	0,044	0,532	1,357	4,485	0,000
Titov Shyness 2	Combined	1,182	0,239	0,057	0,714	1,651	4,947	0,000
Titov Wellbeing program	DASS-21	0,545	0,234	0,055	0,085	1,004	2,324	0,020
Titov Worry Program	Combined	1,076	0,315	0,099	0,458	1,693	3,415	0,001
Van Straten EUC	Combined	0,327	0,138	0,019	0,057	0,596	2,375	0,018
Vernmark Self-help	BDI	0,554	0,264	0,070	0,036	1,072	2,097	0,036
Wims Panic Program	Combined	0,324	0,271	0,074	-0,208	0,856	1,194	0,232
		0,776	0,075	0,006	0,628	0,923	10,317	0,000

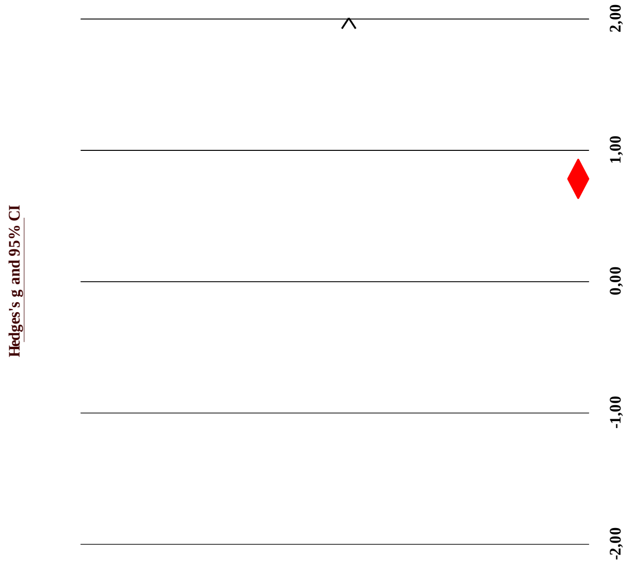

Figure 5. Standardized effect sizes (Hedges' g) Between-Group.

Table 2. Subgroup analyses Between Group.

Subgroups	N	g	95% CI	Z	I^2	p[a]
PSD principles						
Number of total PSD principles						0.698
≤ 3 principles	1	0.55	0.04-1.07	2.10*	0.00	
4-6 principles	12	0.74	0.61-0.88	10.84**	52.20	
≥ 7 principles	6	0.79	0.59-0.99	7.82**	32.23	
Number of PTS principles						0.001***
1 principle	1	1.18	0.71-1.65	4.95**	0.00	
2 principles	13	0.75	0.60-0.89	10.11**	0.00	
3 principles	2	0.38	0.14-0.62	3.09*	0.00	
4 principles	2	1.11	0.81-1.41	7.27**	48.96	
5 principles	1	0.86	0.36-1.35	3.39***	0.00	
Number of DS principles						0.918
1 principle	11	0.76	0.63-0.90	10.95**	59.66	
2 principles	6	0.74	0.53-0.95	6.82**	6.29	
3 principles	2	0.69	0.35-1.03	4.01**	0.00	
Number of SS principles						0.605
0 principles	3	0.67	0.38-0.96	4.53**	0.00	
1 principle	3	0.68	0.47-0.88	6.56**	87.84	
2 principles	8	0.83	0.63-1.02	8.40**	0.00	
3 principles	4	0.84	0.60-1.09	6.75**	50.29	
4 principles	1	0.55	0.09-1.00	2.32*	0.00	

Note. [a] The p-values in this column indicate whether the difference between the effect sizes in the subgroups are significant
*p<0.05
**p<0.01
***p=0.001

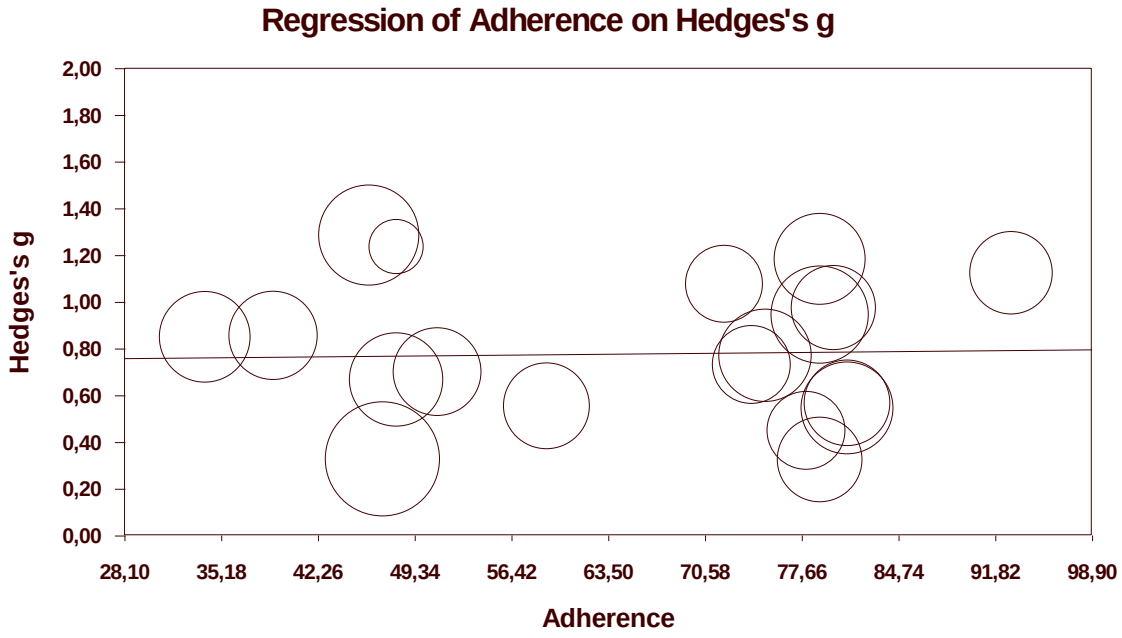

Figure 6. Relation of adherence to the effect size Between-Group.

Adherence

The average adherence rate was 65.42% (min 34%, max 93%). To explore the association between adherence and effect size a meta-regression analysis was performed. The association was not significant (slope: 0.000; 95% CI: -0.008-0.009; p = 0.904), suggesting that the increase of adherence does not lead to a higher effect size (figure 6).

Publication bias

Publication bias analysis was performed using the funnel plot and the Duval and Tweedie's Trim and Fill procedure (Duvall & Tweedie, 2000). Publication bias is not present when the studies are symmetrically distributed around the mean effect size . In case of publication bias, non-significant studies and studies with lower effect sizes should be missing in the middle and on the bottom of the left side. The funnel plot, see figure 7, showed studies missing on the left side, suggesting presence of publication bias. The Trim and Fill procedure resulted in an adjusted effect size of 0.62 (95% CI: 0.46-0.79, number of trimmed studies: 6) This is lower than the observed mean effect size (0.78; 95% CI: 0.63-0.92) indicating evidence of publication bias.

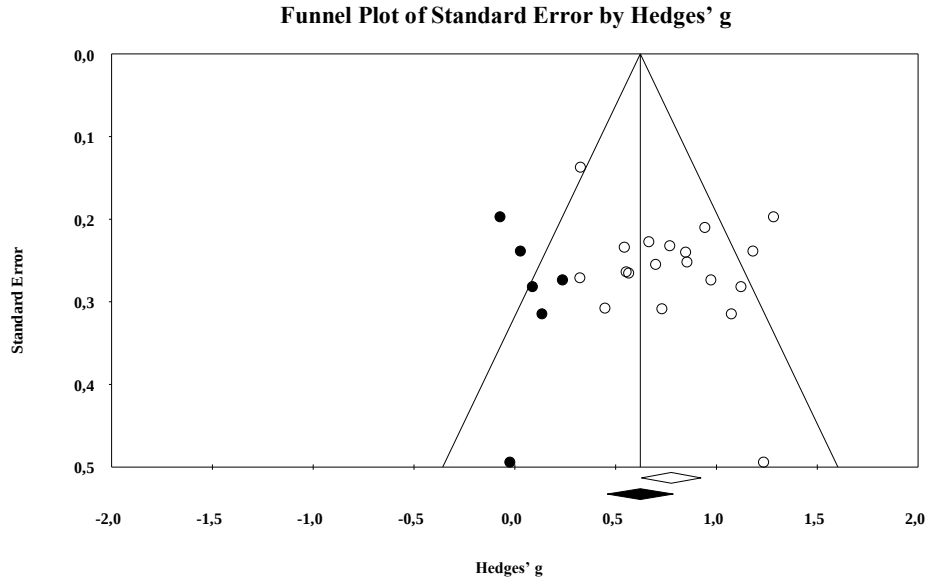

Figure 7. Funnel plot with observed (○) and imputed (●) studies Between-Group.

Discussion

This meta-analysis examined 33 studies with a total of 3,078 participants with regard to study the relationship between the number of persuasive technology principles and effectiveness of web-based interventions in mental health. For this purpose a within-group and between-group meta-analysis were performed and subsequently a subgroup analysis. Also the influence of adherence on the effectiveness of web-based interventions in mental health was examined in this study through a meta-regression analysis. The studies treated a variety of mental health conditions and included 4 observational and 29 RCT studies.

For the WG analysis 40 treatment groups were included with a total of 1,725 participants. The BG analysis included 19 studies with a total of 733 participants in the treatment groups and 694 participants in the WL control groups. The mean pooled effect size in the WG analysis indicated a large pre- to post-treatment effect for the web-based interventions, while for the BG analysis the mean pooled effect size was moderate to large in favor of the web-based interventions. The mean pooled effect size of the WG is higher than other meta-analyses, of which, in most cases, the overall effect sizes were calculated on a BG basis, being the difference between the treatment group and control group at post-treatment. Barak et al. (2008) found an overall effect size which was considered to be moderate. However, that study did not focus on only mental health but included several other conditions such as physiological and weight loss programs. These latter problem areas yielded lower effect sizes in comparison to the effect sizes of the psychological treatments which were moderate and large, except for depression which was small to moderate in the study by Barak et al. (2008). Other meta-analyses that focused on the psychological conditions depression and anxiety only included RCT's in their studies and based their calculations of effect sizes of the differences between the treatment and control group at post-treatment. The effect sizes found in these studies were considered moderate to large (Andrews, Cuijpers, Craske, McEvoy, & Titov, 2010; Richards & Richardson, 2012; Spek et al., 2007). This is comparable to the BG effect size found in the present study.

The difference between the WG and BG mean pooled effect sizes could be caused by the fact that the mean pooled effect size for the WG analysis was based on change scores from pre- to post-treatment which may have yielded larger effect sizes than the BG analysis which were calculated for the differences in average scores at post-treatment between the treatment and WL control groups. In studies where the WL control groups show some improvement from baseline too, the differences at post-treatment will be influenced by that. Also the different

number of included studies, hence the number of participants, as well as the inclusion of observational studies in the WG analysis could have affected this.

With regard to the total number of PSD principles it appeared that, when measured from pre- to post-treatment, the implementation of more principles yielded a larger effect size, which difference was significant in the WG subgroup analysis. This indicates that an increase of persuasive technology principles will lead to an increase in effectiveness. However, in the analysis only a maximum of 9 out of total 21 principles from the 3 categories PTS, DS and SS, were deployed in the included studies, so it cannot be concluded that the use of all 21 principles in a web-based intervention will lead to the largest effect size. Besides, although in the BG subgroup analysis the effect sizes increased when more principles were used, the difference was not significant. Based on these results it seems desirable to implement more PSD principles to improve the outcome results, but more research has to be done to investigate how many principles will yield the best possible outcomes.

Keeping the participant focused on reaching the targeted behavior and not be distracted by side issues is the goal of Primary Task Support. In the PTS category the subgroup analysis showed significant differences in the effect sizes for the number of principles in both the WG as the BG subgroup analysis, although the effect sizes did not show an upward trend with the increase of used principles. Instead the effect sizes fluctuated with the number of used principles. The deployment of 4 principles yielded the largest effect size in both subgroup analyses. The 3 included studies that used 4 principles, of which 2 were included in the WG analysis (Carrard, Crépin, Rouget, Lam, Golay, & van der Linden, 2011; Mohr et al., 2010) and 2 in the BG analysis (Carrard et al., 2011; Postel et al., 2010) all used the same combination of principles: reduction, tunneling, tailoring, and self-monitoring. Implementing these 4 principles is therefore recommended. Because only 3 studies were included, future research should be undertaken to investigate if this is an optimal combination to use in web-based interventions. Most studies used a combination of 2 principles, namely tunneling and tailoring, which also led to a large effect size in the WG analysis and a moderate to high effect size in the BG analysis. This combination should be considered when designing a web-based intervention.

With the increase of DS principles in an intervention an increase in effect size was realized in the WG subgroup analysis and the difference between the effect sizes was significant. On the other hand, the effect sizes decreased with the increase of the number of principles in the BG subgroup analysis, although the difference was not significant. Reminders were used most often, followed by similarity. The majority of the studies in the WG analysis that used the

combination of reminders with similarity examined web-based interventions for treatment of social phobia, for which this combination seems to work well. Motivating participants in an appropriate way, keeps them involved and active in reaching the targeted behavior and therefor implementing more principles to support this is important. More research is needed to investigate what kind of effect the number of DS principles has on the effect sizes, which combination is the best option, and whether the combination is valid for all treatment conditions.

For the number of SS principles used in web-based interventions the effect sizes did not show an upward trend with the implementation of more principles, but fluctuated instead. The subgroup analysis showed a significant difference in the effect sizes in the WG analysis but not in the BG analysis. The combination of the 2 principles social learning and social facilitation was used most often and led to a large effect size in both the WG as the BG subgroup analysis. Remarkable was that not implementing any principles at all out of this category still led to a high effect size in the WG subgroup analysis. This is an interesting detail and the impact of social support principles on effect size of web-based interventions should be further investigated.

Although the subgroup analysis shows that an increase of the total number of persuasive technology principles yields larger effect sizes, this is not consistent with the subgroup analyses in the PTS and SS categories. In the WG subgroup analyses of these categories the effect size did not show an upward trend with the implementation of more principles, but instead fluctuated with the number of used principles. An explanation could be that with the increase of principles the chance increases that some implemented principles do not have an added value to the effect size and may even decrease it because they counteract each other. That the use of all principles is not always necessary was confirmed by Räisänen et al. (2010), who found that some principles work well together and some principles do not work together well at all or show some overlap. They suggest that a coherent set of principles should be selected that will create as much as synergy as possible. Oinas-Kukkonen (2013) indeed argued that the PSD model does not claim that all possible principles should always be implemented. A further investigation of what kind of principles and combination of principles would affect the effect size could shed more light on how to implement persuasive technology in the design of web-based interventions.

Also the influence of adherence on the effectiveness of web-based interventions in mental health was examined. A meta-regression was performed to examine the influence of adherence on the effectiveness of web-based interventions. Contrary to expectations the

results did not show a relationship between adherence and effectiveness of web-based interventions. There is a slight upward trend visible although this is not significant. It could be that even though a participant does not complete the intervention, it still may have had a positive effect on the changing of behavior. Hilvert et al. (2012) found that non-completers of an internet cognitive behavioral therapy for anxiety and depressive disorders did benefit from the intervention. The participants that did not complete all the lessons showed a smaller decrease in psychological distress than completers, but did benefit from the lessons they completed. When more lessons were completed, more profit was gained from the intervention. This is an indication that adherence is important to optimize the outcome. In a study of the use of a web-based application for supporting the self-care of patients with type-2 diabetes a ceiling effect was found, where participants stopped using the intervention because they felt good and found that using the application was no longer needed. However, to avoid that participants overestimate their well-being, it is recommended that they stay motivated in using the intervention. Persuasive technology could keep them involved (Nijland, van Gemert-Pijnen, Kelders, Brandenburg, & Seydel, 2011).

Adherence is said to be a problem (Eysenbach, 2005; Kelders et al., 2012) and also in the present study adherence rates varied from a minimum of 12% to a maximum of 93%. Improving adherence could be realized by implementing persuasive technology (Kelders et al., 2012; Nijland et al., 2011).

Limitations

This meta-analysis has several limitations. The overall effect size in this study was high and this could be a consequence of publication bias as well as the used selection of articles. The articles were derived from the study by Kelders et al. (2012) and this selection may have influenced the results. They could have excluded studies in their selection criteria and also studies that were published thereafter were not included in the present study. Also there was evidence of publication bias. Studies that report low or no effect sizes tend not to become published. Therefor the results should be interpreted with caution.

Heterogeneity was high in the WG analysis as expected and low to moderate in the BG analysis. The studies varied in gender and age of participants, sample sizes, study design, primary outcome(s), used measurement instruments and implementation of interventions. This has an influence on the mean pooled effect size, but does not have to affect the results with regard to the relationship between the number of persuasive technology principles and

effect size, and the relationship between adherence and effect size. Since subgroup analyses are observational, another issue in interpreting the results is the difficulty to detect confounders, which can have a moderated effect, such as participants' characteristics like age and gender, the severity of the condition of participants, and the use of different outcome measures (Barak et al., 2008). The difference in heterogeneity between WG and BG may have been the result of the number of included studies and consequently the related factors as mentioned above. Therefore, high heterogeneity should be taken into account when interpreting the results.

Another issue that should be taken into consideration whilst interpreting the results is the chosen correlation factor in the WG analysis in this study. The correlation was imputed with an estimation of the correlation. A sensitivity analysis with other correlation values to investigate whether the results are robust, was not performed (Deeks et al., 2011). When replicating this study it is recommended to also perform a sensitivity analysis.

The purpose of this study was to investigate the relationship of the number of persuasive technology principles and effectiveness. The quality of the principles and how they were defined and implemented in the interventions was not part of this study. This could have influenced the results and is worth further looking into.

Despite these limitations this study shows that the number of persuasive technology principles seems to affect the effectiveness of web-based interventions and gives direction to future research.

Future research

Based on the findings of this study additional research could focus on investigating which persuasive technology principles work well together, per category as well as between the categories. RCTs with multiple comparison groups, in which different combinations are implemented in an intervention, could be undertaken to investigate if certain principles are a good combination which leads to better outcomes. The four principles of Primary Task Support could be a starting point. Also the quality and the way the principles are implemented could be examined by a systematic review of studies. With regard to adherence, completers of interventions seem to benefit the most of the interventions even though no significant relationship with effectiveness was found in this study. Further research in therefor needed in this area. A clearer understanding of these issues could contribute to the improvement of the design of web-based interventions.

Appendix A. Persuasive design principles per category and their definitions (Oinas-Kukkonen & Harjumaa, 2009)

Principle	Definition
Primary Task Support (PTS)	
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 one's 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 (DS)	
Praise	By offering praise, a system can make users more open to persuasion.
Rewards	Systems that reward target behaviors may have great persuasive powers.
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.
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.
System Credibility Support (SCS)	
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 services 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.
Social Support (SS)	
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.
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.
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.
Cooperation	A system can motivate users to adopt a target attitude or behavior by leveraging human beings' natural drive to co-operate.
Competition	A system can motivate users to adopt a target attitude or behavior 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.

Appendix B. Characteristics of the included studies

Intervention name ***Study design*** **First author** **publication year**	**Behavior / condition**	**Target group** **gender (%) and age** **(Mean, SD)**	**Sample size**[a] **Treatment group**	 **Control group**	**Reason when exlcuded /** **Explanatory notes**
1. BRAVE2 *RCT* Spence 2011	anxiety	adolescents (12-18 years) and their parent(s) all participants in study: gender: M 41%, F 59% age: 13.98 (1.63) data after randomization is not reported	NET 44	CLIN 44 WL 27	comparison of two treatments and WL NET is web-based intervention BG analysis: NET vs. WL WG analysis: NET
2. Worry Program *RCT* Titov 2009	anxiety	> 18 years all participants in study: gender: M 24%, F 76% age: 44 (12.98) data after randomization is not reported	CaCCBT 24	WL 21	
3. Anxiety Program *RCT* Titov 2010	anxiety	> 18 years Treatment group: gender: M 27.5%, F 72.5% age: 38.6 (12.0) Control group: gender: M 36.8%, F 63.2% age: 40.5 (14.1)	iCBT 40	WL 38	
4. Andersson-A *Observational* Andersson 2011	anxiety	>18 years gender: M 85%, F 15% age: 38.3 (10.3)	iCBT 27		
5. Hedman *RCT* Hedman 2011	severe health anxiety	age range 25-69 Treatment group: gender: M 70%, F 30% age: 39.3 (9.8) Control group: gender: M 78%, F 22% age: 38.8 (9.5)	iCBT 40	Onl.Discus. Forum 41	comparison of two treatments excluded from BG analysis included in WG analysis
6. Alcohol de Baas *RCT* Postel 2010	alcohol	> 18 years Treatment group: gender: M 46%, F 54% age: 46.7 (9.7) Control group: gender: M 46%, F 54% age: 43.9 (9.7)	78	WL 78	included in BG analysis excluded from WG analysis: no sufficient data available
7. Everything under control *RCT* Van Straten 2008	depression	no inclusion or exclusion criteria, general population Treatment group: gender: M 28%, F72% age: 45.1 (10.9) Control group: gender: M 29.2%, F 70.8% age: 45.4 (10.4)	107	WL 106	

8. Colour your Life1 *RCT* De Graaf 2009	depression	age range: 18-65 years CCBT gender: M 48%, F 52% age: 44.3 (11.8) TAU gender: M 44.7%, F 55.3% age: 45.1 (12.2) CCBT + TAU gender: M 37%, F 63% age: 45.2 (10.9)	CCBT 100 CCBT + TAU 100	TAU 103	comparison of two treatments and WL excluded from BG analysis included in WG analysis (2 treatment groups): CYL1 CCBT CYL1 CCBT+TAU
9. Colour your Life2 Everything under control2 *RCT* Warmerdam 2008	depression	> 18 years CYL2 gender: M 30.7%, F 69.3% age: 45.7 (n.r.) EUC2 gender: M 35.2%, F 64.8% age: 45.1 (n.r.) WL gender: M 20.7%, F 79.3%) age: 44.1 (n.r.)	CYL2 88 EUC2 88	WL 87	comparison of two treatments and WL excluded from BG analysis included in WG analysis (2 treatment groups): CYL2 EUC2
10. Sadness *RCT* Perini 2009	depression	> 18 years Treatment group: gender: M 14.81%, F 85.19% age 49.28 (9.38) Control group: gender: M 33.33%, F 66.67% age: 49.30 (15.56)	CaCCBT 27	WL 18	
11. MoodManager *Observational* Mohr 2010	depression	> 18 years gender: M 19%, F 81% age: 32.9 (9.97)	21		
12. Vernmark *RCT* Vernmark 2010	depression	> 18 years E-mail group: gender: M 30%, F 70% age: 40.5 (13.9) Self-help group: gender: M 20.7%, F 79.3% age: 37.2 (13.0) Control: gender: M 44.8%, F 55.2% age: 32.7 (10.6)	Self-help 29	WL 29 E-mail 30	comparison of two treatments and WL Self-help treatment = internet based BG: Self-help versus WL WG: Self-help
13. Wellbeing program *RCT* Titov 2011	depression and anxiety	> 18 years Treatment group: gender: M 30%, F 70% age: 44.8 (14.9) Control group: gender: M 24%, F 76% age: 42.9 (14.5)	iCBT 37	WL 37	
14. Carrard *RCT* Carrard 2011	eating disorder	women, age range 18-60 years Treatment group: age: 34.4 (11.0) Control group: age: 37.8 (11.8)	37	WL 37	

15. Carlbring1 *RCT* Carlbring 2005	panic disorder	age range 18-60 years LIVE group: gender: M 25%, F 75% age: 35.8 (9.3) IT group: gender: M 32%, F 68% age: 34.2 (6.0)	IT: 25	LIVE: 24	comparison between two treatments excluded from BG analysis included in WG analysis: IT
16. Carlbring2 *RCT* Carlbring 2006	panic disorder	age range: 18-60 years all participants in study: gender: M 40%, F 60% age: 36.7 (10.0) data after randomization is not reported	30	WL 30	
17. Interapy *RCT* Ruwaard 2010	panic disorder	>18 years Treatment group: gender: M 19%, F 81% age: 38 (11) Control group: gender: M 35%, F 65% age: 39 (10)	iCBT 27	WL 31	
18. Panic program *RCT* Wims 2010	panic disorder	>18 years Treatment group: gender: M 27.58%, F 72.41% age: 39.49 (11.12) Control group: gender: M 20.00%, F 80.00% age: 45.09 (13.21)	29	WL 25	
19. PTSD program *RCT* Spence 2011	posttraumatic stress disorder	> 18 years Treatment group: gender: M 26%, F 74% age: 43.0 (15.2) Control group: gender: M 11%, F 89% age: 42.0 (10.4)	iCBT 23	WL 19	
20. PTSD online *Observational* Klein 2010	posttraumatic stress disorder	> 18 years gender: M 22.7%, F77.3% age: M: 51 (11.02) age: F: 40.6 (11.7)	iCBT 22		
21. Andersson-S1 *RCT* Andersson 2006	social phobia	> 18 years Treatment group: gender: M 43.75%, F 56.25% age: 36.4 (9.4) Control group: gender: M 53.1%, F 46.9% age: 38.2 (11.0)	iCBT + exp 32	WL 32	
22. Andersson-S1 and S2 *RCT* Tillfors 2008	social phobia	university students ICBT + exp gender: M 16.7%, F 83.3% age: 30.4 (6.3) ICBT gender: M 21.1%, F 78.9% age: 32.3 (9.7) WL gender: M 28.6%, F 71.4% age: 32.9 (9.2	iCBT + exp 18 iCBT 19	WL 28	comparison of two treatments no WL data reported in the study excluded from BG analysis included in WG analysis: Andersson-S1 = Tillfors iCBT+exp Andersson-S2 = Tillfors iCBT

23. Andersson-S2 *RCT* Tillfors 2011	social phobia	high school students all participants in study: gender: M 11%, F 89% age: 16.5 (1.6) data after randomization is not reported	iCBT 9	WL 9	
24. Andersson-S2 and IAR *RCT* Furmark 2009	social phobia	> 18 years ICBT-1 gender: M 22%, F 78% age: 35.0 (10.2) Bib-1 gender: M 40%, F 60% age: 37.7 (10.3) WL gender: M 35%, F 65% age: 35.7 (10.9) ICBT-2 gender: M 34%, F 66% age: 34.9 (8.4) Bib-2 gender: M 34%, F 66% age: 32.5 (8.5) BibDG gender: M 36%, F 64% age: 35.0 (10.4) IAR gender: M 24%, F 76% age: 36.4 (9.8)	iCBT-1 40 iCBT-2 29 IAR 29	WL 40 Bib-1 40 Bib-2 29 BibDG 28	Comparison of multiple treatments included in BG analysis: iCBT-1 vs WL included in WG analysis: iCBT-1, iCBT-2 and IAR 2 trials: trial 1: iCBT - Bib – WLC trial 2: iCBT - Bib - BibDG - IAR Furmark iCBT-1 (= Andersson-S2) Furmark iCBT-2 (= Andersson-S2) Furmark IAR
25. Andersson-S3 *RCT* Carlbring 2007	social phobia	> 18 years Treatment group: gender: M 41%, F 59% age: 32.4 (9.1) Control group: gender: M 29%, F 71% age: 32.9 (9.2)	iCBT 29	WL 28	
26. Andersson-S4 *RCT* Hedman 2011	social phobia	age range 18-64 years ICBT gender: M 62.5%, F 37.5% age: 35.2 (11.1) CBGT gender: M 66.1%, F 33.9% age: 35.5 (11.6)	iCBT 64	CBGT 62	comparison of two treatments excluded from BG analysis included in WG analysis: iCBT
27. Shyness1 *RCT* Titov 2008	social phobia	> 18 years CaCCBT: gender: M 44.00%, F 56.00% age: 37.58 (11.89) Control group: gender: M 38.78%, F 61.22% age: 38.69 (12.68)	CaCCBT 50	WL 49	
28. Shyness2 *RCT* Titov 2008	social phobia	> 18 years CaCCBT: gender: M 41.46%, F 58.54% age: 37.80 (10.71) Control group: gender: M 32.50%, F 67.50% age: 35.75 (11.19)	CaCCBT 41	WL 40	PSD and adherence according to Shyness 1

29.Shyness3 *RCT* Titov 2008	social phobia	> 18 years CaCCBT gender: M 45.16%, F 54.84% age: 39.71 (9.50) CCBT gender: M 23.33%, F 76.67% age: 36.86 (10.78) WL gender: M 47.06%, F 52.94% age: 37.32 (13.22)	CaCCBT 31 CCBT 30	WL 34	comparison of two treatments and WL excluded from BG analysis included in WG analysis: only CCBT CaCCBT: SD post-treatment not reported
30. Shyness4 *RCT* Titov 2009	social phobia	> 18 years all participants in study: gender: M 48%, F 52% age: 41.2 (SD n.r.) data after randomization is not reported	CCBT + tel 81	CCBT 82	comparison of two treatments excluded from BG analysis included in WG analysis (both treatments) CCBT: PSD and adherence Shyness 4 CCBT+tel: PSD and adherence Shyness 5 (Kelders)
31. Shyness5 *Observational* Aydos 2009	social phobia	> 18 years gender: M 29%, F 71% age: 42.47 (9.54)	CaCCBT 17		
32. Shyness6 *RCT* Titov 2009	social phobia	> 18 years all participants in study: gender: M 44%, F 56% age 38.88 (12.08) data after randomization is not reported	CCBT + tel 43	CCBT + forum 39	comparison of two treatments excluded from BG analysis included in WG analysis (both treatments) CCBT+tel: PSD and adherence Shyness 5 (Kelders) CCBT+forum: PSD and adherence Shyness 6
33. Shyness7 *RCT* Titov 2010	social phobia	> 18 years all participants in study: gender: M 53%, F 47% age: 43.6 (14.6) data after randomization is not reported	iCBT 55	iCBT + MS 53	comparison of two treatments excluded from BG analysis included in WG analysis (both treatments)

Note. [a] Bib = Bibliotherapy; BibDG = Bibliotherapy with access to an online discussion group; CaCCBT = Clinician-assisted Computerized Cognitive Behavioral Treatment; CBGT = Cognitive Behavioral Group Therapy; CCBT = Computerized Cognitive Behavioral Treatment; CLIN = Clinic Cognitive Behavior Therapy; CYL = Colour Your Life; EUC = Everything Under Control; exp = Exposure Sessions; IAR = Internet-delivered applied relaxation; iCBT = Internet-based Cognitive Behavioral Treatment; IT = Internet-based Therapy; LIVE = Live Therapy; MS = Motivational Enhancement Strategies; NET = Online Cognitive Behavior Therapy; TAU = Treatment As Usual; tel = Telephone; WL = Waiting List.

Appendix C. Data Persuasive technology, Primary Outcome(s) and Adherence

Intervention name ***Study design*** **First author publication year**	**Behavior / condition**	**Persuasive technology[a]** **PTS**	**DS**	**SS**	**total**	**Primary Outcome(s)[b]**	**Mean (SD) Baseline**	**Mean (SD) Post-treatment**	**n (% success)**	**Correlation[c]**	**Adherence (%)**
1. BRAVE2	anxiety	b,c,d,	j,l,m	o	9	CSR					39
RCT		e,f				-NET	5.91 (SE:0.13) (SD: 0.86[d])	3.85 (SE: 0.26) (SD: 1.72 [d])		n.r.	
Spence 2011						-WL		5.50 (SE: 0.34) (SD: 1.77 [d])			
						CGAS					
						-NET	49.86 (SE: 0.89) (SD: 5.90 [d])	61.83 (SE: 1.49) (SD: 9.88 [d])		n.r.	
						-WL		54.04 (SE: 1.95) (SD: 10.13[d])			
2. Worry	anxiety	b,c	j,n	o,r	6	GAD-7					72
Program						-CaCCBT	14.33 (4.50)	6.92 (4.40)		n.r.	
RCT						-WL		12.29 (4.26)			
Titov 2009						PSWQ					
						-CaCCBT	66.13 (8.25)	56.75 (10.78)		n.r.	
						-WL		66.14 (8.70)			
3. Anxiety	anxiety	b,c	j,l	o,r	6	GAD-7					75
Program						-iCBT	11.33 (4.98)	7.43 (4.70)		n.r.	
RCT						-WL		11.42 (5.55)			
Titov 2010											
4. Andersson-A	anxiety	b,c,d	j		4	CORE-OM	1.46 (0.40)	0.95 (0.43)		n.r.	33
Observational						BAI	16.85 (8.04)	10.73 (6.72)		n.r.	
Andersson 2011						MADRS-S	15.96 (6.48)	9.73 (6.65)		n.r.	
						QOLI	0.85 (1.64)	1.65 (1.48)		n.r.	
5. Hedman	severe health	b,c	j	r	4	HAI					35
RCT	anxiety					-iCBT	107.0 (22.0)	60.5 (25.7)		n.r.	
Hedman 2011											
6. Alcohol de	alcohol	a,b,c,e	j	r	6	Weekly alcohol consumption					46
Baas											
RCT						-Treatment		28.8 (21.3)			
Postel 2010						-WL		3.1 (21.2)			
						Drinking with guidelines					
						-Treatment			78 (68%)		
						-WL			78 (15%)		

7. Everything	depression	a,b,c	j	o	5	CES-D				47
under control						-Treatment	29.9 (9.1)	20.9 (10.8)	n.r.	
RCT						-WL		26.2 (10.5)		
Van Straten 2008						MDI				
						-Treatment	25.8 (9.6)	22.9 (6.9)	n.r.	
						-WL		25.1 (6.8)		
						SCL-A				
						-Treatment	24.1 (7.4)	19.7 (6.8)	n.r.	
						-WL		22.7 (7.5)		
						HADS				
						-Treatment	10.1 (3.3)	8.0 (3.4)	n.r.	
						-WL		9.1 (3.3)		
						MBI-EE				
						-Treatment	2.9 (1.3)	2.5 (1.5)	n.r.	
						-WL		2.8 (1.5)		
						MBI-PA				
						-Treatment	3.2 (1.1)	3.5 (1.0)	n.r.	
						-WL		3.2 (1.0)		
						MBI-DP				
						-Treatment	2.4 (1.3)	2.3 (1.4)	n.r.	
						-WL		2.6 (1.5)		
						EQ-5D				
						-Treatment	0.62 (0.23)	0.73 (0.20)	n.r.	
						-WL		0.66 (0.20)		
8. Colour your	depression	b,e			2	BDI-II				CCBT: 36
Life1						-CCBT	28.2 (7.7)	20.6 (10.4)	n.r.	CCBT+TAU: 12
RCT						-CCBT +				
De Graaf 2009						TAU	27.4 (8.2)	21.7 (10.1)	n.r.	
9. Colour your	depression	CYL2:			CYL2:	CES-D				CYL 2: 39
Life2		a,b,c	j		4	-CYL2	31.2 (9.3)	17.9 (11.7)	n.r.	EUC2: 47
Everything		EUC2:			EUC2:	-EUC2	31.9 (9.3)	20.6 (11.2)	n.r.	
under control2		a,b,c	j	o	5					
RCT										
Warmerdam 2008										

10. Sadness	depression	b,c	j,l	o,p,r	7	PHQ-9				74
RCT						-CaCCBT	13.78 (4.53)	9.59 (5.82)	n.r.	
Perini 2009						-WL		14.11 (4.21)		
						BDI-II				
						-CaCCBT	27.30 (7.30)	17.30 (9.86)	n.r.	
						-WL		23.33 (9.29)		
11. Mood-Manager	depression	a,b,c,e	j,k,m		7	HRSD	21.2 (6.42)	12.0 (6.54)	n.r.	91
Observational						PHQ-9	15.0 (3.70)	5.6 (5.74)	n.r.	
Mohr 2010						GAD-7	10.8 (4.59)	3.6 (3.85)	n.r.	
						PANAS-PA	20.6 (5.27)	29.4 (9.14)	n.r.	
12. Vernmark	depression	b,c	j		3	BDI				59
RCT						-Self-help	22.2 (6.3)	12.33 (7.3)	n.r.	
Vernmark 2010						-WL		16.6 (7.9)		
13. Wellbeing Program	depression and anxiety	b,c	j,k,l	o,p,r,u	9	DASS-21				81
RCT						-iCBT	58.48 (21.47)	32.80 (22.90)	n.r.	
Titov 2011						-WL		44.86 (20.87)		
14. Carrard	eating disorder	a,b,c,e	j		5	EDI-2 Bulimia				34
RCT						-Treatment	6.3 (3.4)	2.8 (2.6)	n.r.	
Carrard 2011						-WL		5.9 (4.4)		
15. Carlbring1	panic disorder	b,c		o,r	4	BSQ	48.7 (11.7)	31.8 (11.6)	n.r.	28
RCT						ACQ	34.5 (8.6)	23.8 (9.0)	n.r.	
Carlbring 2005						MI-Alone	2.2 (0.9)	1.7 (0.7)	n.r.	
						MI-Accompanied	1.8 (0.5)	1.4 (0.4)	n.r.	
						BAI	18.7 (10.3)	10.9 (7.1)	n.r.	
						BDI	11.8 (7.8)	6.6 (5.5)	n.r.	
						MADRS	13.4 (5.3)	8.6 (5.7)	n.r.	
						QOLI	1.4 (1.7)	2.0 (1.4)	n.r.	
16. Carlbring2	panic disorder	b,c	j	o,r	5	BSQ				80
RCT						-Treatment	50.5 (11.9)	29.5 (9.5)	n.r.	
Carlbring 2006						-WL		48.8 (10.1)		
						ACQ				
						-Treatment	34.4 (8.6)	21.6 (6.3)	n.r.	
						-WL		33.9 (9.9)		
						MI-alone				
						-Treatment	3.2 (0.9)	2.3 (0.9)	n.r.	
						-WL		2.9 (0.9)		

						MI-Accompanied				
						-Treatment	2.7 (0.8)	1.9 (0.7)	n.r.	
						-WL		2.3 (0.8)		
						BAI				
						-Treatment	20.8 (10.0)	8.5 (5.5)	n.r.	
						-WL		19.6 (9.9)		
						BDI				
						-Treatment	17.7 (8.8)	9.1 (8.4)	n.r.	
						-WL		14.4 (9.0)		
						MADRS				
						-Treatment	16.4 (7.2)	8.4 (7.0)	n.r.	
						-WL		13.9 (6.5)		
						QOLI				
						-Treatment	0.7 (1.5)	1.8 (1.6)	n.r.	
						-WL		1.1 (1.6)		
17. Interapy	panic disorder	b,c,e	k		4	1-week attack				81
RCT						frequency				
Ruwaard 2010						-iCBT	4.7 (3.5)	2.7 (3.1)	n.r.	
						-WL		3.6 (3.4)		
						Symptom count				
						-iCBT	3.2 (1.5)	1.9 (1.7)	n.r.	
						-WL		3.0 (1.9)		
						Attack intensity				
						-iCBT	4.5 (2.2)	2.3 (2.1)	n.r.	
						-WL		4.2 (2.3)		
						PDSS-SR				
						-iCBT	9.0 (5.5)	5.9 (4.4)	n.r.	
						-WL		8.4 (4.6)		
18. Panic	panic disorder	b,c	j,l	o,p,r	7	PDSS				79
Program						-Treatment	17.10 (4.84)	12.14 (5.74)	n.r.	
RCT						-WL		15.56 (5.77)		
Wims 2010						Full Panic				
						Attacks				
						-Treatment	8.03 (12.30)	3.72 (4.93)	n.r.	
						-WL		8.20 (16.74)		
						BSQ				
						-Treatment	53.97 (12.94)	46.21 (15.46)	n.r.	
						-WL		51.40 (15.66)		

						ACQ				
						-Treatment	32.79 (10.29)	26.66 (7.55)	n.r.	
						-WL		30.96 (9.37)		
						MI-alone				
						-Treatment	73.62 (27.53)	67.31 (29.82)	n.r.	
						-WL		71.12 (28.01)		
						MI-Accompanied				
						-Treatment	60.28 (28.85)	55.66 (28.81)	n.r.	
						-WL		56.44 (24.77)		
19. PTSD program *RCT* Spence 2011	PTSD	b,c	j,k	o,r	6	PCL-C				78
						-iCBT	60.78 (10.03)	44.78 (17.29)	n.r.	
						-WL		51.79 (12.51)		
20. PTSD Online *Observational* Klein 2010	PTSD	b,c	k		3	PTSD Clinician Severity Rating	5.73 (1.12)	4.06 (2.01)	n.r.	73
21. Andersson-S1 *RCT* Andersson 2006	social phobia	b,c	j	o,r	5	LSAS-SR				51
						-iCBT + exp	68.5 (22.5)	45.6 (25.1)	n.r.	
						-WL		62.8 (21.7)		
						SPS				
						-iCBT + exp	35.8 (16.7)	20.7 (14.8)	n.r.	
						-WL		31.0 (15.9)		
						SIAS				
						-iCBT + exp	44.4 (16.1)	27.3 (13.4)	n.r.	
						-WL		33.9 (12.6)		
						SPSQ				
						-iCBT + exp	30.4 (8.7)	20.0 (8.5)	n.r.	
						-WL		28.9 (7.9)		
						PRCS				
						-iCBT + exp	25.5 (4.2)	22.7 (5.4)	n.r.	
						-WL		25.5 (4.8)		
22. Andersson-S1 and S2 *RCT* Tillfors 2008	social phobia	b,c	j	o,r	5	LSAS-SR				iCBT+exp: 51 iCBT: 48
						-iCBT + exp	57.4 (25.7)	38.1 (21.6)	n.r.	
						-iCBT	59.8 (19.0)	41.4 (17.3)	n.r.	
						SPS				
						-iCBT + exp	31.9 (15.9)	17.2 (10.6)	n.r.	
						-iCBT	31.7 (12.0)	17.3 (12.6)	n.r.	

						SIAS				
						-iCBT + exp	33.6 (11.8)	25.6 (12.1)	n.r.	
						-iCBT	36.1 (12.2)	27.2 (10.9)	n.r.	
						SPSQ				
						-iCBT + exp	26.1 (8.5)	15.1 (8.2)	n.r.	
						-iCBT	24.9 (7.1)	16.9 (7.9)	n.r.	
23. Andersson-S2 *RCT* Tillfors 2011	social phobia	b,c	j	o,r	5	LSAS-SR Fear				48
						-iCBT	23.8 (11.8)	14.6 (8.2)	n.r.	
						-WL		31.0 (13.4)		
						LSAS-SR Avoidance				
						-iCBT	21.4 (13.6)	15.0 (9.1)	n.r.	
						-WL		30.0 (16.4)		
						SPSQ-C				
						-iCBT	14.8 (2.2)	12.2 (2.7)	n.r.	
						-WL		16.0 (3.2)		
24. Andersson-S2 and IAR *RCT* Furmark 2009	social phobia	b,c	j	o,r	5	SPS				iCBT-1: 48
						-iCBT-1	39.15 (15.35)	25.60 (12.22)	n.r.	iCBT-2: 48
						-WL		35.60 (16.16)		IAR: 34
						-iCBT-2	35.34 (17.04)	22.00 (16.07)	n.r.	
						-IAR	43.72 (18.61)	28.17 (16.51)	n.r.	
						SIAS				
						-iCBT-1	50.98 (14.21)	39.03 (14.03)	n.r.	
						-WL		46.58 (18.45)		
						-iCBT-2	51.93 (14.43)	36.14 (16.06)	n.r.	
						-IAR	52.45 (15.41)	39.90 (15.36)	n.r.	
						SPSQ				
						-iCBT-1	32.18 (7.16)	22.10 (8.47)	n.r.	
						-WL		29.73 (11.83)		
						-iCBT-2	31.41 (7.79)	18.52 (8.51)	n.r.	
						-IAR	33.83 (9.76)	23.24 (11.45)	n.r.	
						LSAS-SR				
						-iCBT-1	71.30 (22.49)	50.98 (21.12)	n.r.	
						-WL		70.25 (27.25)		
						-iCBT-2	74.14 (22.81)	44.41 (21.35)	n.r.	
						-IAR	78.93 (25.36)	53.03 (26.97)	n.r.	

25. Andersson-S3	social phobia	b,c	j	o,r	5	LSAS-SR Fear				93
RCT						-iCBT	36.0 (11.7)	24.2 (12.0)	n.r.	
Carlbring 2007						-WL		36.1 (12.3)		
						LSAS-SR Avoidance				
						-iCBT	35.2 (12.9)	21.6 (12.8)	n.r.	
						-WL		33.3 (11.9)		
						SPS				
						-iCBT	36.2 (15.2)	20.0 (15.0)	n.r.	
						-WL		37.7 (16.4)		
						SIAS				
						-iCBT	41.3 (13.2)	27.1 (11.1)	n.r.	
						-WL		43.6 (14.0)		
						SPSQ				
						-iCBT	29.7 (7.8)	20.3 (9.1)	n.r.	
						-WL		32.3 (8.9)		
26. Andersson-S4	social phobia	b,c	j	-	3	LSAS-SR	68.4 (21.0)	39.4 (19.9)	n.r.	30
RCT										
Hedman 2011										
27. Shyness1	social phobia	b,c	j,l	o,p,r	7	SIAS				79
RCT						-CaCCBT	53.82 (11.29)	39.24 (12.18)	n.r.	
Titov 2008						-WL		50.59 (14.15)		
						SPS				
						-CaCCBT	34.02 (14.42)	20.64 (10.46)	n.r.	
						-WL		33.92 (14.70)		
28. Shyness2	social phobia	b,c	j,l	o,p,r	7	SIAS Treatment				79
RCT						-CaCCBT	57.10 (13.81)	39.90 (14.67)	n.r.	
Titov 2008						-WL		56.80 (11.25)		
						SPS				
						-CaCCBT	34.15 (15.55)	18.12 (12.46)	n.r.	
						-WL		32.78 (14.23)		
29.Shyness3	social phobia	b	l	o,p,r	5	SIAS	52.50 (9.30)	48.03 (13.59)	n.r.	33
RCT						SPS	32.87 (17.02)	28.27 (16.27)	n.r.	
Titov 2008										

30. Shyness4	social phobia	b,c	j,l	o,p	6	SIAS				CCBT+tel: 78
RCT						-CCBT + tel	53.88 (11.58)	37.51 (11.68)	n.r.	CCBT: 67
Titov 2009						-CCBT	54.61 (11.10)	42.52 (13.39)	n.r.	
						SPS				
						-CCBT + tel	34.27 (18.18)	19.62 (14.57)	n.r.	
						-CCBT	33.16 (16.75)	21.87 (14.28)	n.r.	
31. Shyness5	social phobia	b,c	j,l	o,p,r	7	SIAS	60.24 (9.27)	47.47 (14.43)	n.r.	74
Observational						SPS	35.47 (17.86)	27.18 (16.35)	n.r.	
Aydos 2009										
32a. Shyness6	social phobia	b,c	j,l	o,p	6	SIAS	54.26 (12.21)	35.26 (13.57)	n.r.	78
CCBT+tel						SPS	35.70 (13.24)	20.88 (12.61)	n.r.	
RCT										
Titov 2009										
32b. Shyness6	social phobia	b,c	j,l	o,p,r	7	SIAS	54.59 (10.17)	37.56 (11.56)	n.r.	76
CCBT+forum						SPS	35.74 (10.15)	18.82 (12.14)	n.r.	
RCT										
Titov 2009										
33. Shyness7	social phobia	b,c	j,l	o,p	6	SIAS				64
RCT						-iCBT	52.76 (12.06)	38.05 (13.19)	n.r.	
Titov 2010						-iCBT + MS	53.13 (9.53)	40.02 (13.08)	n.r.	
						SPS				
						-iCBT	34.87 (15.85)	19.64 (13.48)	n.r.	
						-iCBT + MS	33.32 (16.24)	21.79 (14.25)	n.r.	

Note. [a] PTS = Primary Task Support; DS = Dialogue Support; SS = Social Support; a = reduction; b = tunneling; c = tailoring; d = personalization; e = self-monitoring; f = simulation; j = reminders; k = suggestion; l = similarity; m = liking; n = social role; o = social learning; p = social comparison; r = social facilitation; u = recognition; [b] ACQ = Agoraphobic Cognitions Questionnaire, BAI = Beck Anxiety Inventory, BDI = Beck Depression Inventory, BDI-II = Beck Depression Inventory II, BSQ = Body Sensations Questionnaire, CES-D = Center for Epidemiological Studies Depression Scale, CGAS = Children's Global Assessment Scale, CORE-OM = Clinical Outcomes in Routine Evaluation - Outcome Measure, CSR = Clinician Severity Rating, DASS-21 = Depression Anxiety Stress Scale - 21 item, EDI-2 = Eating Disorder Inventory – 2, EQ-5D = EuroQol Questionnaire, GAD-7 = Generalized Anxiety Disorder - 7 item, HADS = Hospital Anxiety and Depression Scale, HAI = Health Anxiety Inventory, HRSD = Hamilton Rating Scale for Depression, LSAS-SR = Liebowitz Social Anxiety Scale, MADRS = Montgomery-Åsberg Depression Rating Scale, MADRS-S = Montgomery-Åsberg Depression Rating Scale, MBI-DP = Maslach Burnout Inventory Depersonalization, MBI-EE = Maslach Burnout Inventory Emotional Exhaustion, MBI-PA = Maslach Burnout Inventory Personal Accomplishment, MDI = Major Depression Inventory, MI = Mobility Inventory for Agoraphobia, PANAS-PA = Positive and Negative Affect Scale - Positive Affect Scale, PCL-C = Posttraumatic Stress Disorder Checklist - civilian version, PDSS = Panic Disorder Severity Scale, PDSS-SR = Panic Disorder Severity Scale, PHQ-9 = Patient Health Questionnaire - 9 item, PRCS = Personal Report on Confidence as a Speaker, PSWQ = Penn State Worry Questionnaire, PTSD = Posttraumatic Stress Disorder, QOLI = Quality of Life Inventory, SCL-A = Symptom Checklist, SIAS = Social Interaction Anxiety Scale, SPS = Social Phobia Scale, SPSQ = Social Phobia Screening Questionnaire, SPSQ-C = Social Phobia Screening Questionnaire for Children up to 18 years old; [c] n.r. = not reported; [d] SD derived from SE (SD = SE*√N).

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