Online Attention Bias Modification for Obsessive-Compulsive Disorder: A Randomized Controlled Trial

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Abstract

There is evidence that attention bias modification trainings (ABMT) based on the dot-probe task are a promising therapeutic approach for several anxiety disorders. However, little is known about the malleability of attention bias in obsessive-compulsive disorder (OCD) and its impact on OCD symptoms. The present study tested this hypothesis using an online ABMT designed to train attention away from OCD-related stimuli. We hypothesized that ABMT would reduce attention bias and OCD symptoms. Participants were randomized to receive the active ABMT ($n = 58$) or a placebo control training (PCT; $n = 50$) and completed a minimum of 8 training sessions over a period of 4 weeks. As predicted, participants receiving ABMT showed a significant reduction in attention bias. This effect was not present in the placebo condition. ABMT did however not significantly outperform the PCT with regard to symptom reduction. In both conditions self-reported OCD symptoms decreased and the reduction of symptoms remained stable at 1-month follow-up. The present findings suggest that online ABMT can effectively reduce attention bias in OCD, but question its effectiveness in reducing OCD symptoms. More research on the mechanisms of attention training is inevitably needed before online ABMT can be recommended for clinical application.

Keywords: attention bias modification training; obsessive-compulsive disorder; modified dot-probe task; online intervention

Introduction

Obsessive-compulsive disorder (OCD) is a severe disorder associated with high levels of psychosocial impairment (Grabe et al., 2000). It is characterized by recurring intrusive thoughts or impulses (obsessions) causing anxiety and uneasiness as well as by repetitive behaviors (compulsions) carried out in an attempt to reduce the associated anxiety (American Psychiatric Association, 2013). OCD was classified as an anxiety disorder until recently (American Psychiatric Association, 2000), but several authors (e.g. Hollander, Braun, & Simeon, 2008) promote its separation from anxiety disorders due to unique features. *The Diagnostic and Statistical Manual of Mental Disorders* (5th ed.; DSM-5; American Psychiatric Association, 2013) takes this into account by including "Obsessive Compulsive and Related Disorders" in a separate chapter.

With its estimated lifetime prevalence of approximately 2.3% (Ruscio, Stein, Chiu, & Kessler, 2010) OCD is a widespread mental disorder. However, OCD patients are seeking treatment on average not until 7 to 10 years after symptom onset (Rasmussen & Eisen, 1992; Stengler et al., 2013). Cognitive-behavioral therapy including exposure with response prevention has been shown to be by far the most effective psychological treatment for OCD (e.g. Abramowitz, Franklin, & Foa, 2002). However, as only few of those affected by OCD seek treatment (Torres et al., 2007) and even after state-of-the-art treatment only 50-60% recover (Fisher & Wells, 2005), there is still an urgent need for additional interventions.

A promising approach could be to modify attention processes using recently developed attention bias modification programs (ABMT). These short-term interventions arose from research on the processing of threat-related material in anxiety disorder patients. It is assumed that their attentional system may be particularly sensitive to threatening stimuli in the environment. This concept is referred to as *attention bias*. In the following, we will outline the basic research on attention bias and its application for interventions.

Various empirical studies show that anxious individuals automatically attend to threat-related stimuli over neutral stimuli at an early stage of information processing (e.g. generalized anxiety disorder: Bradley, Mogg, White, Groom, & De Bono, 1999; MacLeod, Mathews, & Tata, 1986; social anxiety disorder: Asmundson & Stein, 1994; high self-report anxiety: Bradley, Mogg, & Millar, 2000; Broadbent & Broadbent, 1988). Beck and Clark (1997) argued that this involuntary biased attention allocation triggers a state of arousal, which fosters the development and maintenance of anxieties in an ensuing vicious circle. Accordingly, attention bias towards threat is assumed to causally increase vulnerability to (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van IJzendoorn, 2007; MacLeod, Rutherford, Campbell, Ebsworthy, & Holker, 2002; Mathews & MacLeod, 2002, 2005) and maintenance of anxiety disorders (Mathews, 1990; Mogg & Bradley, 1998; review by Van Bockstaele et al., 2014). Altogether this suggests that modification of attention bias could break the vicious circle at an early stage and thus decrease anxiety symptoms.

In OCD patients a similar attention bias has been empirically demonstrated using different experimental paradigms (dot-probe task: Amir, Najmi, & Morrison, 2009; modified Stroop task: Foa, Ilai, McCarthy, Shoyer, & Murdock, 1993; inhibition of return: Moritz, von Mühlenen, Randjbar, Fricke, & Jelinek, 2009). Although evidence for selective attention processing in OCD patients is mixed (for reviews see Muller & Roberts, 2005; Summerfeldt & Endler, 1998), a recent meta-analysis supports the hypothesis of an attention bias towards OCD-related stimuli in OCD patients (Bar-Haim et al., 2007).

Previous research on attention bias used a variety of measures (dichotic listening task e.g.: Foa & McNally, 1986; modified Stroop task: e.g. Kampman, Keijsers, Verbraak, Näring, & Hoogduin, 2002; visual search e.g.: Morein-Zamir et al., 2013). In their pioneering work, MacLeod, Mathews, and Tata (1986) criticized these measures for their inability to rule out alternative explanations, such as interpretation or response biases. To overcome this

flaw, they developed the dot-probe task, which permits direct measurement of the distribution of visual attention. In this paradigm, a pair of one threat-related and one neutral stimulus is presented on a computer screen for a short period of time, usually for 500 ms. After the stimulus pair disappears, one of two possible probes (e.g. the letters P or R) is shown in one of the former stimulus locations. Participants are instructed to react to the probe by pressing a corresponding button on the keyboard as fast and accurately as possible. It is expected that reactions are faster when the probe appears at the previously attended location. Shorter reaction times for probes appearing in the location of the threat-related stimulus are therefore interpreted as an attention bias towards threat.

Tata, Leibowitz, Prunty, Cameron, and Pickering (1996) were the first to apply the dot-probe paradigm for OCD by integrating contamination-related words in the task. They compared subjects with OCD and subjects high in trait anxiety and found a content-specific attention bias in both groups (i.e. OCD subjects showed attention bias for contamination words and not for social threat words and vice versa for high trait anxious subjects).

Originally introduced as a measurement tool, a modified version of the dot-probe task has been developed to alter attention bias. The modified dot-probe task links the appearance of the probe to the neutral stimulus by establishing a contingency between their locations. Consequently, task performance is facilitated by attending to neutral stimuli and subjects are expected to learn to direct attention towards neutral stimuli and away from threat-related stimuli over the course of several dot-probe sessions. Using this approach, attention bias modification trainings (ABMT) aim at reducing attention bias and associated symptoms.

Recently, ABMTs have been found to effectively modify attention bias in several carefully conducted RCTs (for a review see Bar-Haim, 2010; for a meta-analysis see Hakamata et al., 2010). For instance, a reduction in attention bias and anxiety symptoms was found after only eight training sessions for participants suffering from generalized anxiety

disorder (Amir, Beard, Burns, & Bomyea, 2009) and social anxiety disorder (SAD; Amir, Beard, Taylor, et al., 2009; Schmidt, Anthony, Buckner, & Timpano, 2009). Yet, research regarding the impact of attention bias training in OCD patients is limited. To our knowledge, there is only one study investigating ABMT as a stand-alone intervention for subclinical OCD symptoms so far: Najmi and Amir (2010) reported that after a single session of attention bias modification, participants completed more steps in an exposure task with response prevention compared to a placebo control group in a student sample. Thus, the present study is the first to implement attention training for participants reporting clinical OCD symptoms and evaluate its potential gains in reducing OCD symptoms.

Moreover, an online-adaption of ABMT is desirable considering the various advantages of online therapy such as low cost and convenience of application for both patients and clinical practitioners (see also MacLeod & Mathews, 2012). As ego-dystonia of obsessions is a core symptom of OCD (American Psychiatric Association, 2013) and associated shame (Sørensen, Kirkeby, & Thomsen, 2004) likely increases the threshold to seek face-to-face treatment, OCD patients could particularly benefit from online interventions. High acceptability of online interventions among OCD patients has been demonstrated (Wootton, Titov, Dear, Spence, & Kemp, 2011).

MacLeod, Lih, Elizabeth, and Lynlee (2007) evaluated the efficacy of an ABMT software that participants installed on their own computer and carried out at home. They demonstrated that attention bias modification at home can be effective, implying the transferability of laboratory findings to the home setting (see also See, MacLeod, & Bridle, 2009). Further ABMT programs have been developed using JavaScript, enabling participants to directly attend the training online. However, using this method two recent online replications of the previous laboratory studies on ABMT for SAD by Boettcher, Berger, and Renneberg (2012) and Carlbring et al. (2012) identified no initial bias towards threat and

failed to modify it or reduce symptoms. It seems that ABMT studies conducted outside the laboratory generally yield smaller effect sizes, as reported in a meta-analysis by Mogoşe, David, and Koster (2014).

After Reimers and Stewart (2014) demonstrated that especially relative response times (such as attention bias) can be quite accurately measured online, more recent technical improvements, particularly the implementation of high resolution timing in JavaScript (W3C, 2013), created better conditions for online ABMT research.

To our knowledge, ABMT for OCD has not yet been investigated in an online setting and to date there is no trial testing its efficacy in an adult sample reporting clinically relevant OCD symptoms. To close this gap, we created a dot-probe task with OCD-related picture stimuli and adapted it for online application at the participant's home. We hypothesized that participants with OCD symptoms would show an attention bias towards OCD-related stimuli and that after a minimum of two training sessions per week over a period of 4 weeks the experimental group would show significantly decreased attention bias and self-reported OCD symptoms compared to a placebo control group. Further, we hypothesized that the decrease in self-reported OCD symptoms would remain stable at a 1-month follow-up assessment.

Method

Participants

The study was advertised in online OCD forums and via university-related mailing lists. In addition, we sent information material to multiple medical facilities and OCD self-help groups throughout Germany, Switzerland and Austria. Potential participants were referred to the study homepage, which contained detailed information on OCD, the study goal and procedure. No monetary compensation was offered.

Participants were individuals reporting clinically relevant obsessive-compulsive symptoms based on the Obsessive-Compulsive Inventory-Revised (OCI-R; Foa et al., 2002;

German version by Gönner, Leonhart, & Ecker, 2008), that has been demonstrated to accurately identify OCD patients (Foa et al., 2002). They were included in the study if they (a) were at least 18 years old, (b) reported no suicidal tendency, (c) showed no evidence of current or past psychotic disorder, (d) reported no current substance abuse or dependency, (e) had normal or corrected-to-normal vision, and (f) had an overall OCI-R score ≥ 18 . All inclusion criteria were based on self-report and assessed in an online questionnaire. Finally, we asked if the questionnaire was answered honestly and excluded participants who negated this item from data analyses.

Of the 236 individuals who enrolled for study participation, 187 completed the self-report online questionnaire. In total 66 participants had to be excluded due to being under age ($n = 4$), reporting suicidal tendencies ($n = 3$), past or current psychotic symptoms ($n = 6$), substance abuse or dependency ($n = 13$), or an OCI-R score below cut-off ($n = 39$). Data from one participant who negated the honesty-item was excluded as well. Finally, 121 participants met all inclusion criteria and were randomized to the attention bias modification training (ABMT) or the placebo control training (PCT). The first bias assessment session was completed by 108 participants (ABMT, $n = 58$, PCT, $n = 50$). Eleven of these reaction time datasets were incomplete due to a web server error and hence excluded. In the end 97 datasets were available for reaction time analyses.

Participants dropped out of training continuously leaving a total of 59 participants who completed the whole training period including posttraining bias assessment. The self-report questionnaire was completed by 49 participants at posttraining and by 55 participants at follow-up one month later (see Fig. 1 for participant flow).

Materials and Task

Self-report measures

The Yale-Brown Obsessive Compulsive Scale (Y-BOCS; Goodman, Price, Rasmussen, Mazure, Fleischmann, et al., 1989; German self-report version by Schaible,

Armbrust, & Nutzinger, 2001) is considered the gold standard to assess symptom severity in OCD (e.g. Deacon & Abramowitz, 2005) and was used as the primary symptomatic outcome measure. The Y-BOCS is composed of a 50-item symptom checklist and a 10-item severity scale. The total score contains only the severity scale and is thus independent of content and number of obsessive-compulsive symptoms. Several studies have reported its reliability and validity as well as its sensitivity to change (Farris, McLean, Van Meter, Simpson, & Foa, 2013; Goodman, Price, Rasmussen, Mazure, Delgado, et al., 1989; Jacobsen, Kloss, Fricke, Hand, & Moritz, 2003; Kim, Dysken, & Kuskowski, 1990). The Y-BOCS self-report version has demonstrated moderate to strong convergent validity compared to the original expert rating scale (Federici et al., 2010; Rosenfeld, Dar, Anderson, Kobak, & Greist, 1992; Schaible et al., 2001; Steketee, Frost, & Bogart, 1996). Federici et al. (2010) suggested, that more detailed instructions might enhance the validity of the self-report version. We therefore added definitions of compulsions and obsessions within the instructions to improve participants' understanding of those concepts (see also Moritz, Wess, Treszl, & Jelinek, 2011).

The OCI-R (Foa et al., 2002; German version by Gönner, Leonhart, & Ecker, 2007) is a short self-report measure of obsessive-compulsive symptoms with good psychometric properties (Abramowitz & Deacon, 2006; Gönner et al., 2008). It accurately differentiates OCD patients from other anxiety disorder patients and healthy controls (Foa et al., 2002) and is also sensitive to symptom change (Abramowitz, Tolin, & Diefenbach, 2005). Therefore we used the OCI-R as primary screening instrument and as the secondary outcome measure.

The OCI-R consists of 18 items on 6 subscales (washing, obsessing, hoarding, ordering, checking, neutralizing) describing obsessions and compulsions. The items are rated on a 5-point Likert scale of associated distress from 0 (*not at all*) to 4 (*extreme*). A cut-off score of 18 is recommended to discriminate OCD patients from healthy controls (Gönner,

Hahn, Leonhart, Ecker, & Limbacher, 2009) as well as from anxious and depressive controls (Gönner, Ecker, & Leonhart, 2009).

Participants also completed the Beck Depression Inventory-II (Beck, Steer, Ball, & Ranieri, 1996; German version by Hautzinger, Bailer, Worall, & Keller, 1995), a well-established self-report measure of depression with good psychometric properties (Keller, Hoffmann, & Weithmann, 2002; Kühner, Bürger, Keller, & Hautzinger, 2007) and the Beck Anxiety Inventory (BAI; Beck, Epstein, Brown, & Steer, 1988; German version by Margraf, Beck, & Ehlers, 2007). The BAI is a reliable and valid self-report measure of anxiety (Fydrich, Dowdall, & Chambless, 1992; Steer, Ranieri, Beck, & Clark, 1993). For all self-report measures the applied time frame was the last week at all three assessments in order to capture potential change.

Dot-probe Task

Attention bias was measured with a dot-probe task. Picture stimuli consisted of 40 OCD-related and 40 neutral pictures. We chose contamination and checking-related pictures from the Berlin Obsessive Compulsive Disorder-Picture Set (BOCD-PS; Simon, Kischkel, Spielberg, & Kathmann, 2012) to cover the two most prevalent OCD concerns (checking and washing) (Rasmussen & Eisen, 1988). Neutral pictures were taken from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2005).

Each dot-probe trial began with a fixation cross presented in the center of the screen for 500 ms. Then, a pair of one OCD-related and one neutral picture was presented for 500 ms. Subsequently, a letter (R or P) randomly appeared in one of the previous picture positions. Participants were asked to react as fast and accurately as possible by pressing the corresponding button on their keyboard. The sequence of trial events is depicted in Fig. 2. The size of images, probes and fixation cross as well as the distances between them were relative to the participant's screen.

In the beginning of each session, participants completed six practice trials to

familiarize themselves with the task. In this practice phase, only neutral stimuli were presented and participants received feedback on accuracy and speed of their reactions.

Subsequently, participants completed 160 trials. These were divided into four blocks of 40 trials each. In Block 1 and 3, neutral and OCD pictures were randomly paired and positioned and the probe randomly appeared in one of the two locations. Block 2 and 4 repeated the picture pairs of the preceding blocks. Thereby every picture pair was to be presented twice in reversed positioning.

Procedure

After completing the online questionnaire, participants automatically received e-mail feedback on their study inclusion. The e-mail for excluded participants provided useful links for psychotherapy options and emergency hotline numbers. Eligible participants were randomly assigned to either the ABMT or PCT group. Both participants and investigators were blind to participant condition. Participants received information about their treatment condition after the follow-up assessment and the PCT group was then given access to the active attention training.

ABMT

The attention training was a modified dot-probe task in which the probe appeared in the location of the neutral stimulus in 100% of trials. Thereby the neutral stimulus predicted the probe position. Consequently, directing attention towards the neutral stimulus and away from the OCD-related stimulus facilitated task performance.

PCT

In the placebo training, the dot-probe task was not modified, so that the probe appeared at the two locations with equal frequency. One placebo training session was thus equivalent to the dot-probe procedure used for bias assessment. Apart from that, the placebo training was exactly identical to the attention training including duration, stimulus material and procedure.

Participants received an e-mail reminder containing a link to the training website on two days of the week, which participants could individually choose in the beginning. If a training session was missed a second reminder was sent the next day. Participants were free to do supplementary training in addition to the scheduled sessions. They were asked to attend at least 10 training sessions, with the first and last session being bias assessments, though this was not apparent to participants.

To enhance training motivation, a feedback graph showing the progress of individual mean reaction times across trainings was shown prior to and after each session. On average, training sessions took 5.63 minutes ($SD = 2.12$), after excluding 13 sessions with implausible lengths (> 30 minutes).

Following the posttraining bias assessment, participants were sent an e-mail invitation to the posttraining questionnaire. One month later, they were again invited via e-mail to complete the follow-up questionnaire. The study was implemented using the survey framework *formr* (Version 0.2.0; Arslan, 2013) and study management was automated to a large extent. The study protocol was approved by the Institutional Review Board of the Humboldt-Universität zu Berlin and preregistered (ClinicalTrials.gov identifier: NCT02018848).

Statistical Analyses

All analyses were computed using the statistical software R (Version 3.0.2). Analyses were carried out on an intention-to-treat basis, including all participants who completed the first bias assessment prior to the training period. To deal with missing data and to analyze all available data points we used a general linear mixed-model approach as suggested by Gueorguieva & Krystal (2004). The study had a 2 (Condition: ABMT, PCT) $\times$ 3 (Time: pretraining, posttraining, follow-up) mixed-design. We analyzed change in outcome measures by conducting mixed-effects models (see Pinheiro, Bates, DebRoy, & Sarkar, 2007)

with a random intercept to account for individual differences between subjects and non-independence of repeated measurements within subjects. Statistical significance was set at $p < .05$. The magnitude of symptom change was determined by calculating within-group effect sizes (d ; Cohen, 1988).

Results

Participants

At baseline, participants had an average Y-BOCS-SRS score of 20.94 ($SD = 5.67$) and OCI-R score of 30.36 ($SD = 9.35$). The two scales correlated significantly ($r = .38, p < .001$). The two groups did not significantly differ on demographic characteristics, obsessive-compulsive, depressive and anxiety symptoms (all $ps \geq .35$). There was also no significant group difference on the OCI-R subscales (see Table 1 for sample characteristics at baseline assessment).

Attention Training

On average, participants in the ABMT group completed 7.53 training sessions ($SD = 5.01$, range: 0-21 sessions) and participants in the PCT group completed 8.52 sessions ($SD = 7.69$, range: 0-45 sessions). A t test revealed no significant group difference regarding the amount of completed training sessions ($t(82) = 0.78, p = .44$).

Data Preparation

To prepare reaction time data for analyses we followed the procedure used in previous ABMT studies (see Amir, Beard, Taylor, et al., 2009; Boettcher et al., 2012; Carlbring et al., 2012). First, practice trials (3.6%) and trials with incorrect responses (4.4%) were eliminated from the analysis. There was no significant difference in mean accuracy of responses between participants of both conditions, $t(100) = 0.78, p = .44$ (mean accuracy in ABMT = .95, mean accuracy in PCT = .96). Second, trials with response latencies less than 50 ms or greater than 1200 ms (1.6%) were considered outliers and removed. There was no significant

difference between the mean percentage of removed trials between the ABMT and the PCT group ($t(93) = -0.15, p = .88$).

Further, trials from Block 2 and 4 were excluded from reaction time analyses due to a programming error. In these blocks OCD-related pictures appeared at the bottom position in almost all trials. In concordant trials (probe and OCD-picture in the same location) the probe thereby also appeared mainly at the bottom position. As reaction times were generally faster, when the probe appeared at the top of the screen ($t(24172) = 7.67, p < .001$), this data was not suitable to measure attention bias.

Measure of Attention Bias

To examine baseline attention bias, we computed a mixed-effects model with reaction time (RT) as outcome and probe position and OCD-picture position as predictors. We specified a random intercept and random slopes to account for individual differences between participants. Picture position had a significant main effect on reaction time ($b = 14.6, t(7039) = 3.68, p < .001$), as did probe position ($b = -25.0, t(7039) = -5.08, p < .001$). Most importantly, the Picture Position $\times$ Probe Position interaction was significant ($b = -13.2, t(7039) = -2.36, p = .018$), indicating faster RTs when OCD-picture and probe appeared in the same location and thus an attention bias towards OCD-related pictures.

To simplify further analyses, we computed an attention bias score following the formula described by MacLeod, Mathews, and Tata (1986) by subtracting the average reaction time of concordant trials (probe and OCD-picture in the same location) from the average reaction time of discordant trials (probe and OCD-picture in different locations) and dividing this term by two. A positive bias score indicates an attention bias towards OCD-related pictures, whereas a negative bias score indicates an attention bias away from OCD-related pictures. Consistent with the analysis reported above, there was a positive bias score at pretraining ($M = 2.86, SD = 17.36$, one-tailed t test: $t(96) = 1.62, p = .054$), indicating

biased attention towards OCD-related pictures.

Change in Attention Bias

To test our hypothesis that attention training would alter attention bias, we calculated a mixed-effects model with attention bias score as outcome and treatment condition (ABMT, PCT) and time (pretraining, posttraining) as predictors, specifying random intercepts. There were no significant main effects of condition ($b = 3.51$, 95% CI = -2.86, 9.87, $t(102) = 1.08$, $p = .28$) and time ($b = 0.44$, 95% CI = -6.92, 7.81, $t(50) = 0.12$, $p = .91$) on attention bias score. More importantly, there was a significant Condition $\times$ Time interaction ($b = -12.29$, 95% CI = -22.41, -2.17, $t(50) = -2.41$, $p = .02$) as depicted in Fig. 3. Consistent with our predictions, paired-sample t tests revealed a significant and large reduction of attention bias from pre- to posttraining in the ABMT group ($t(25) = -3.74$, $p < .001$, $d = -0.73$), whereas the PCT group showed no such reduction ($t(25) = -0.004$, $p = .997$, $d = -0.001$).

Change in Obsessive-Compulsive Symptoms

To test our hypothesis regarding the effect of attention training on self-reported symptoms, we calculated mixed-effect models for Y-BOCS severity score and OCI-R score using treatment condition (ABMT, PCT) and time (pretraining, posttraining, follow-up) as predictors, again specifying random intercepts. Means of self-report measures by condition at all assessment times are presented in Table 2.

Y-BOCS

The main effect of time on Y-BOCS score was significant (pre- to posttraining: $b = -1.84$, 95% CI = -3.51, -0.16, $t(100) = -2.14$, $p = .035$; pretraining to follow-up: $b = -3.75$, 95% CI = -5.37, -2.12, $t(100) = -4.51$, $p < .001$), indicating a significant reduction of Y-BOCS score over time that remained stable until one-month follow-up. However, there was no significant main effect of condition ($b = 1.03$, 95% CI = -1.29, 3.35, $t(106) = 0.87$, $p = .39$), nor a significant interaction of Time $\times$ Condition (pre to post: $b = -0.69$, 95% CI = -3.03, 1.65, $t(100) = -0.58$, $p = .57$; pre to follow-up: $b = 0.46$, 95% CI = -1.78, 2.70, $t(100) = 0.40$,

$p = .69$).

Paired sample t tests comparing pretraining and posttraining scores revealed a highly significant reduction in Y-BOCS scores in the ABMT group ($t(24) = -3.91, p < .001, d = -0.78$), whereas the PCT group showed no significant reduction ($t(23) = -1.71, p = .101, d = -0.35$); see Fig. 4.

OCI-R

A similar pattern of results emerged for the OCI-R score. Again, there was a significant main effect of time (pre- to posttraining: $b = -5.42$, 95% CI = -8.60, -2.25, $t(100) = -3.34, p = .001$; pretraining to follow-up: $b = -7.22$, 95% CI = -10.29, -4.14, $t(100) = -4.59, p < .001$), indicating a significant reduction of OCI-R score over time that remained stable until one-month follow-up. However, there was no significant main effect of condition ($b = 1.60$, 95% CI = -2.43, 5.64, $t(106) = 0.78, p = .44$), nor a significant interaction of Time $\times$ Condition (pre to post: $b = -1.73$, 95% CI = -6.16, 2.69, $t(100) = -0.77, p = .45$; pre to follow-up: $b = 0.19$, 95% CI = -4.05, 4.43, $t(100) = 0.09, p = .93$).

Paired sample t tests revealed significant reductions of OCI-R scores from pre- to posttraining in both conditions (ABMT: $t(24) = -4.09, p < .001, d = -0.82$; PCT: $t(23) = -3.2, p = .004, d = -0.65$; see Fig. 5).

Assumed Group Affiliation

We asked participants at posttraining ($n = 49$) whether they thought they had received the active or the placebo training. About half of the participants in both groups believed that they had received the active attention training (46% in the ABMT condition and 60% in the PCT condition; $\chi^2(1) = 0.5, p = .48$).

Discussion

The present study was a randomized controlled trial to investigate an online attention bias modification training for patients suffering from obsessive-compulsive disorder. As hypothesized, we found attention bias towards OCD-related stimuli at baseline in both groups

and a significant bias reduction only for participants receiving the active attention training. At posttreatment, participants in the ABMT condition showed a bias *away* from OCD-related stimuli whereas the bias scores of participants who received the placebo control training did not significantly differ from their pretreatment scores.

The second aim of the study was to examine the effectiveness of online ABMT in reducing OCD symptoms. We found a significant time effect on self-reported OCD symptoms in both groups. That is, both groups improved significantly from pre- to posttreatment and improvement remained stable until 1-month follow-up. As there was no significant difference between treatment conditions, this result is probably best explained by placebo effect, spontaneous remission or nonspecific effects of study participation.

The present findings are in line with a previous study on attention bias modification in a nonclinical sample of individuals with obsessive-compulsive symptoms by Najmi and Amir (2010). Despite having successfully achieved a significant reduction in attention bias from pre- to posttraining in the ABMT group, they also failed to observe a difference between groups at posttraining in self-reported OCD symptoms. Notwithstanding the lack of symptom reduction, attention bias reduction led to improvement in a behavioral task, in which subjects had to approach anxiety-inducing stimuli. The authors concluded that attention bias reduction might decrease avoidance of feared stimuli in OCD subjects. This is essential for exposure with response prevention, one of the main techniques of state-of-the-art psychological treatment for OCD patients (Franklin, Abramowitz, Kozak, Levitt, & Foa, 2000). ABMT might therefore be a beneficial supplement to or useful preparative element for standard psychological treatment and thereby improve symptom severity in the long run. ABMT could, for instance, be implemented to bridge a waitlist period or as additional homework within the framework of cognitive-behavioral therapy (CBT).

Supporting evidence for the efficacy of a combination of CBT with attention training comes from a study by Riemann, Kuckertz, Rozenman, Weersing, and Amir (2013). They compared two groups that received either ABMT or a placebo program in addition to standard treatment (CBT with or without medication). The sample consisted of 42 adolescents in a residential treatment facility specialized in severe anxiety disorders, the vast majority of them being OCD patients. Riemann et al. (2013) found a significantly greater decrease in symptoms in the active group compared to the placebo group suggesting that ABMT could be an effective supplement to standard CBT.

The present study design was highly realistic for the intended application, in that participation was flexible and fitted to the patients' schedule and that enrollment, diagnostics and study procedure were automated as far as possible. Participants could thus stay anonymous to the researchers (the only personal information compiled were e-mail address, gender and date of birth) and potential participants were not deterred through requirements of direct communication. As such, the study design benefitted from three of the key advantages of online therapy, namely that people are addressed who avoid face-to-face therapist contact, that it is low-cost and time-efficient, and that people in areas that lack adequate medical and psychological care can be reached. Weaknesses in comparison to standardized and controllable study settings can at the same time be seen as a strong test of practicability and contribute to the external validity of the findings. This should be considered the ultimate test of computer-based interventions' usefulness. A detour via the laboratory can thereby be saved and results directly translated to practical recommendations.

The current study extends the findings of Najmi and Amir (2010) on the malleability of attention bias in students with subclinical obsessive-compulsive symptoms to individuals reporting clinically relevant OCD symptoms and to an online setting. To our knowledge, the current study is the first to find evidence for online bias manipulation in OCD patients. Thus,

replication of this finding is needed, before firm conclusions can be derived. Previous studies on online ABMT mainly focused on SAD patients (Boettcher et al., 2012; Carlbring et al., 2012; Neubauer et al., 2013) and failed to find evidence for its efficacy. It has been discussed, that a certain level of arousal and stress is needed for successful bias manipulation that might not be evoked in the comfort of the participant's home (see Boettcher et al., 2012; Neubauer et al., 2013). This assumption is reasonable for socially anxious individuals, but does not necessarily apply to OCD patients.

Additionally, a mere technical limitation might contribute to the contradicting findings between online and laboratory studies. Prior to the implementation of high resolution timing in JavaScript (W3C, 2013) it was imperfectly possible to control presentation duration of stimulus material and online time measurement was subject to numerous biases. However, precise measurement is needed to detect attention bias, as the reaction time differences of interest lie in a range of milliseconds. In the current study, a minimum presentation time of 500 ms could be enforced. It is important to note, however, that due to individual monitor refresh rates a minimal fluctuation of presentation time cannot be prevented. By taking advantage of aforementioned technical improvements, the current study successfully measured and modified attention bias in an online setting. Although our results can only speak for OCD patients and need replication, they advise against an early abandonment of online research on attention bias modification.

The present study has certain limitations. First of all, we encountered a large participant dropout of 45% from pre- to posttraining bias assessment, leading to a high percentage of missing data. This can partly be explained by the online setting of the study, as high dropout rates are common in internet-based treatment studies with a weighted average of 35% (Melville, Casey, & Kavanagh, 2010). In addition, dropout rates might have been fostered by the fact that the posttraining bias assessment was not set to a fixed point in time

but depended on two criteria: firstly that participants had trained at least eight times, and secondly that at least 4 weeks had passed since the first bias assessment. These criteria were set to provide a more naturalistic and flexible study setting, in which participants who took longer than 4 weeks to complete the training schedule were approached. Consequently, posttraining data of non-completers was not available. This threatens the validity of our results as completers might have differed from participants who dropped out. Consequences of this flaw are however mitigated, considering that dropout rates did not differ between treatment conditions and data was analyzed using all available information with a mixed-model approach. Still, further studies should rather set a fixed time-point for posttraining and follow-up assessments to collect data from non-completers as well. A second limitation is that a programming error distorted the picture position in Blocks 2 and 4 of each dot-probe session. Only half of the available reaction time data of each participant could therefore be analyzed, which reduced the statistical power for detecting an attention bias. Importantly, this did not have an impact on the contingency between neutral picture and probe position in the attention training group. This study was the first field-test of a new online attention training software that is now freely available and ready-to-use for future research (Version 1.0.1; Arslan, Lennartz, Habedank & Ertle, 2013). Third, we relied on self-report and did not include formal clinical interviews to select participants. This may have lowered the generalizability of our findings to clinical in- and outpatients. However, it has been demonstrated that symptom severity of online OCD samples is comparable to clinical outpatients and national samples (Wootton et al., 2011). Even more importantly, the average symptom severity of our sample as measured with the Y-BOCS-SRS and OCI-R was comparable to clinical OCD samples (e.g. Federici et al., 2010; Gönner et al., 2007). Fourth, we used a dot-probe task with characteristic contamination- and checking-related picture stimuli to cover the two most common concerns in OCD. It can be argued that participants

with other predominant concerns were not ideally addressed. However, 78.7 % of our participants had checking or contamination concerns as their main symptom domain according to the suggested subscale cutoff-scores by Gönner, Ecker, et al. (2009). The utilization of idiographic stimulus material might do better justice to the heterogeneity of the disorder (McKay et al., 2004) and thus be a less conservative test producing stronger results. Finally, further research on ABMT should assess attention bias not only at posttraining but also at longer follow-ups to allow conclusions about long-term changes in attention processes.

Altogether, our study provides preliminary evidence for the existence of attention bias in OCD and its malleability through online ABMT based on the dot-probe task. Nevertheless, online ABMT did not prove to be effective in reducing obsessive-compulsive symptoms. So far, there is hardly any evidence for the efficacy of stand-alone ABMT to reduce OCD symptoms and we are not alone in finding the direct marketing of attention training software to patients premature (Van Bockstaele et al., 2014). ABMT could quite possibly be a useful supplement to standard CBT, though further (online) research is inevitably needed, before practical application can be recommended.

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Tables and Figures

Tables

Table 1

Sample Characteristics by Condition at Baseline Assessment.

	AMBT (<i>n</i> = 58)	PCT (<i>n</i> = 50)	Test Statistic
<i>M</i> (<i>SD</i>) Age in years	33.47 (10.61)	32.26 (9.87)	<i>t</i> (105) = -0.61, <i>p</i> = .54
<i>N</i> (%) Female	43 (74)	33 (66)	χ^2 (1) = 0.51, <i>p</i> = .48
<i>N</i> (%) Diagnosed with OCD	33 (57)	29 (58)	χ^2 (1) = 0.00, <i>p</i> > .99
<i>N</i> (%) In psychosocial treatment	19 (33)	14 (28)	χ^2 (1) = 0.11, <i>p</i> = .74
<i>N</i> (%) On medication	13 (22)	11 (22)	χ^2 (1) = 0.00, <i>p</i> > .99
<i>N</i> (%) Recently adjusted medication	1 (2)	2 (5)	χ^2 (1) = 0.04, <i>p</i> = .84
<i>M</i> (<i>SD</i>) BDI-II	22.02 (12.64)	23.06 (12.01)	<i>t</i> (105) = 0.44, <i>p</i> = .66
<i>M</i> (<i>SD</i>) BAI	17.83 (11.69)	19.94 (11.42)	<i>t</i> (104) = 0.95, <i>p</i> = .35
<i>M</i> (<i>SD</i>) Y-BOCS	21.41 (5.41)	20.38 (5.97)	<i>t</i> (99) = -0.94, <i>p</i> = .35
<i>M</i> (<i>SD</i>) OCI-R	31.1 (9.38)	29.5 (9.34)	<i>t</i> (103) = -0.89, <i>p</i> = .38
<i>M</i> (<i>SD</i>) OCI-R washing	4.97 (3.79)	3.56 (3.9)	<i>t</i> (103) = -1.89, <i>p</i> = .06
<i>M</i> (<i>SD</i>) OCI-R obsessing	7.88 (2.95)	8.16 (3.27)	<i>t</i> (100) = 0.47, <i>p</i> = .64
<i>M</i> (<i>SD</i>) OCI-R hoarding	3.53 (3.63)	3.64 (2.93)	<i>t</i> (106) = 0.17, <i>p</i> = .87
<i>M</i> (<i>SD</i>) OCI-R ordering	4.95 (3.84)	4.42 (3.23)	<i>t</i> (106) = -0.78, <i>p</i> = .44
<i>M</i> (<i>SD</i>) OCI-R checking	6.79 (3.5)	6.86 (3.62)	<i>t</i> (103) = 0.10, <i>p</i> = .92
<i>M</i> (<i>SD</i>) OCI-R neutralizing	2.98 (3.28)	2.86 (3.27)	<i>t</i> (104) = -0.19, <i>p</i> = .85

ABMT = attention bias modification training; PCT = placebo control training; BDI-II = Beck Depression Inventory–II; BAI = Beck Anxiety Inventory; Y-BOCS = Yale-Brown Obsessive Compulsive Scale (self-report version); OCI-R = Obsessive-Compulsive Inventory-Revised. All values represent raw, non-standardized scores.

Table 2
Self-Report Measures at Pretraining, Posttraining and Follow-up by Treatment Condition.

Measure	Pretraining				Posttraining				Follow-up				Results ^a	
	ABMT (<i>n</i> = 58)		PCT (<i>n</i> = 50)		ABMT (<i>n</i> = 25)		PCT (<i>n</i> = 24)		ABMT (<i>n</i> = 29)		PCT (<i>n</i> = 26)		Time × Condition	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>F</i>	<i>p</i>
Y-BOCS	21.41	5.41	20.38	5.97	18.16	6.04	18.42	7.52	17.24	6.58	16.12	7.51	0.4	.66
OCI-R	31.1	9.38	29.5	9.34	20.52	9.16	23.54	13.47	21.21	10.33	22.38	14.97	0.4	.68
BDI-II	22.02	12.64	23.06	12.01	16.28	11.31	20.08	13.61	14.55	11.41	18.96	12.87	1.0	.39
BAI	17.83	11.69	19.94	11.42	15.44	11.43	16.12	12.56	12.41	8.89	14.35	9.46	0.83	.44

ABMT = attention bias modification training; PCT = placebo control training; Y-BOCS = Yale-Brown Obsessive Compulsive Scale (self-report version); OCI-R = Obsessive-Compulsive Inventory-Revised; BDI-II = Beck Depression Inventory-II; BAI = Beck Anxiety Inventory. All values represent raw, non-standardized scores.

^a *dfs* = 2, 100.

Figures

Fig.1. Participant flow. ABMT = attention bias modification training; PCT = placebo control training; OCI-R = Obsessive-Compulsive Inventory-Revised.

Fig.2. Sequence of trial events in the dot-probe task. Sample pictures are taken from the Berlin Obsessive Compulsive Disorder-Picture Set (BOCD-PS; Simon et al., 2012)

Fig.3. Change in attention bias score over time by condition. PCT = placebo control training; ABMT = attention bias modification training; pre = pretraining assessment; post = posttraining assessment. The error bars represent 95% confidence intervals around sample means assuming normality.

Fig.4. Change in Yale-Brown Obsessive Compulsive Scale (Y-BOCS) score over time by condition. PCT = placebo control training; ABMT = attention bias modification training; pre = pretraining assessment; post = posttraining assessment; follow-up = 1-month follow-up assessment. The error bars represent 95% confidence intervals around sample means assuming normality.

Fig.5. Change in Obsessive-Compulsive Inventory-Revised (OCI-R) score over time. PCT = placebo control training; ABMT = attention bias modification training; pre = pretraining assessment; post = posttraining assessment; follow-up = 1-month follow-up assessment. The error bars represent 95% confidence intervals around sample means assuming normality.