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Research paper

Positivity-approach training for depressive symptoms: A randomized controlled trial

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ABSTRACT

Objective: Depression is highly comorbid and depressive symptoms are very common. Symptom severity adversely affects treatment outcome and later health status. Established interventions for depression leave ample room for improvement. Short interventions that target specific vulnerabilities emerge as plausible augmentation strategies. In this study, we tested the efficacy of a computerized general positivity-approach training and its effect on depressive symptoms.
Methods: Patients ($N = 240$) with various diagnoses of mental disorders who received treatment-as-usual in an inpatient setting were randomly assigned to also receive either 4 sessions of a positivity-approach training or 4 sessions of sham training. Depression severity was assessed at baseline and post-treatment. Training data were analyzed for a subset of 111 patients.
Results: Depressive symptoms were reduced more after positivity-approach training than after sham training. Initial depression symptom severity moderated the intervention effects, such that approach tendencies and depression symptoms were only affected positively among patients with higher levels of initial depression symptom severity.
Conclusions: The findings provide preliminary support for positivity-approach training as an add-on treatment option for depressive symptoms.

1. Introduction

Depression is one of the most common psychological disorders with a lifetime prevalence estimated at 20.8%, and an average age of onset of 30 years (Kessler et al., 2005). It is also highly comorbid (Spinhoven et al., 2011), and it predicts poorer treatment outcome in other disorders (Chambless et al., 1997; Compton et al., 2003; Keijsers et al., 1994). A range of different treatment options are available for depression, but a considerable number of patients do not benefit from these treatments or suffer from recurrent depressive episodes (Möller, 2008). The Netherlands Study of Depression and Anxiety (NESDA; Hardeveld et al., 2013) found that in a cohort with MDD at baseline, 63% still had mild to moderate symptoms one year after treatment. Thus, improvements or augmentation interventions are needed.

Computerized training methods have the potential to be such an augmentation intervention. These trainings are referred to as cognitive bias modification (CBM) which target underlying automatic processes that are thought to contribute to the development and maintenance of depression (Koster et al., 2009; Watkins et al., 2009). CBM aims to modify the cognitive biases observed in depression. Due to these biases, patients preferentially attend to and remember more negative information, or interpret ambiguous situations in a more negative way than healthy individuals do (Benas and Gibb, 2009; Reid et al., 2006; Strunk and Adler, 2009). However, depressed patients also lack the positive biases or the preferred processing of positive information that is usually seen in healthy individuals (Mezulis et al., 2004). A growing body of literature suggests that these biases play an important role in the development and maintenance of the disorder (Rude et al., 2010). In addition, research has shown that cognitive biases may persist even after recovery from depression (Joormann and Gotlib, 2007) and may predict relapse (Bouhuys et al., 1999).

Most CBM trainings to date have targeted attention or interpretation processes, with mixed results. Some meta-analyses support the

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hypothesis that CBM has a medium-sized effect on biases of interpretation and attention as well as a small effect on symptom severity and emotional vulnerability (Hallion and Ruscio, 2011), others have found small effects (Cristea et al., 2015). An alternative to the more common attention or interpretation trainings is an approach-avoidance training. In such a training, participants respond to a series of single pictures presented on a computer screen. For each picture, they use a joystick to either pull the picture closer (joystick is pulled and picture size increases) or push the picture away (joystick is pushed and picture shrinks). In the training version of this task, some pictures are almost always pulled closer (approach) while others are almost always pushed away (avoidance).

Approach-avoidance trainings have successfully been applied in addictions and eating behaviors (for a recent review, see Kakoschke et al., 2017). Alcohol-avoidance trainings successfully reduced relapse rates in abstinent alcohol-dependent patients (Eberl et al., 2013; Manning et al., 2016; Rinck et al., 2018; Wiers et al., 2011), however, they did not reduce drinking in undergraduate students (Lindgren et al., 2015). Nicotine-avoidance trainings also showed promising results in the reduction of smoking behavior (Baird et al., 2017; Machulska et al., 2016; Wittekind et al., 2015). In the area of social anxiety, however, the results were mixed (Asnaani et al., 2014; Rinck et al., 2013; Taylor and Amir, 2012).

Depression is related to decreased approach motivation and increased avoidance motivation (Dickson and MacLeod, 2004; Trew, 2011), thus, training approach of positive stimuli may be beneficial. Experimental studies of approach-avoidance tendencies in individuals showing increased levels of depressive symptoms have mostly employed emotional facial expressions to assess mechanisms of social withdrawal (e.g., Radke et al., 2014; Seidel et al., 2010). These studies have often shown a generally diminished approach-avoidance reaction to emotional faces. However, faces may not be the most salient stimuli for depressed individuals. Instead, studies of cognitive biases in depression show overwhelming support for a bias for negative stimuli in general, and for a lack of positive biases (Deldin et al., 2001; Gotlib and Joorman, 2010).

Because of this general bias, Becker et al. designed a general approach-avoidance training with a broad range of positive and negative pictures, in an attempt to reduce emotional vulnerability in a group of students showing elevated levels of depressive symptoms (Becker et al., 2016; Ferrari et al., 2018). Since depression is marked by a general bias toward negative information, a wide range of positive and negative topics may be more powerful in targeting these biases. In the studies by Becker et al., an approach-avoidance task was employed in which participants used a joystick to repeatedly pull pictures of various positive stimuli closer, and to push pictures of various negative stimuli away. The results showed that the general positivity training successfully modified the participants' approach-avoidance tendencies and reduced their stress levels after an anagram stress task. This was the case for dysphoric, but not for non-dysphoric students, suggesting that the general positivity training worked in the intended group of individuals with elevated depressive symptoms who showed an inherent bias towards negative stimuli. Consequently, in a recent study, the positivity-approach training was applied to inpatients diagnosed with major depressive disorder: Vrijsen et al. (2018) compared the positivity-approach training to a positivity-attention training and two sham control versions of the trainings, all given as add-on to treatment-as-usual. They found that clinician-rated depressive symptom severity decreased more in patients who had received an active training version than a control version.

The findings reported so far suggest that a general positivity training aimed at changing approach-avoidance tendencies in response to emotional stimuli can reduce depressive symptomatology in depressed inpatients. It is unclear, however, whether such a training would also reduce depressive symptoms regardless of the presenting disorder. Depressive symptoms are a common occurrence in many psychological disorders (Spinhoven et al., 2011). Depressive symptoms are, for instance, associated with a higher chronic disease burden (Poole and Steptoe, 2018) and a higher mortality risk (Everson-Rose et al., 2004). They also predict worse treatment outcome in other psychological disorders, such as social phobia (Chambless et al., 1997), obsessive-compulsive disorder (Keijsers et al., 1994), or drug dependence (Compton et al., 2003). Thus, reducing depressive symptom severity in clinical settings is an important treatment target.

Therefore, we conducted this study to find out whether the training—when given in a clinical context as an add-on to treatment-as-usual—would facilitate the reduction of depressive symptoms in an unselected group of inpatients. To this end, we compared the effects of approach-avoidance training to a sham training control on positive bias and depressive symptom severity among patients receiving care at the Salus Clinic Lindow in Lindow, Germany. We hypothesized that (1) patients assigned to the experimental condition would evidence greater improvements in (1a) positivity-approach bias and (1b) depressive symptom severity, and that (2) these differential effects would be moderated by initial depressive symptom severity, such that patients with higher initial levels of depressive symptom severity would evidence greater changes on the outcome measures than those with lower levels of initial depressive symptom severity.

2. Methods

2.1. Participants

Because co-morbidity is the rule in a clinical setting, and we designed the intervention for targeting depression symptom severity rather than major depressive disorder, we opted to include all interested inpatients. We only excluded patients with substance use disorders or eating disorders because these were offered studies testing other CBM protocols tailored to those disorders. In total, 256 inpatients of the Salus Clinic Lindow in Lindow, Germany, were offered participation in the study. We strived for this large sample size to achieve sufficient statistical power of 1-ß = 0.89 (determined using G*Power; Faul et al., 2007) to detect the critical 2 × 2 interaction effect (training group by pre-post measure) with $p = .05$, even if the effect is merely small ($f = 0.10$). Of those 256, 16 refused or left the clinic before they could be assigned to one of the two training groups. The remaining 240 patients (123 male; $M_{age} = 46.0$ years [10.7]) who provided informed consent were randomly assigned to the experimental condition ($n = 112$) or the control condition ($n = 128$), yielding power of 1-ß = .87. Fig. 1 shows a CONSORT diagram of the participant flow, and the characteristics of the sample are shown in Table 1. The most common primary ICD diagnosis was an affective disorder ($n = 109$), followed by an anxiety disorder ($n = 64$), gambling disorder ($n = 43$), and somatoform disorder ($n = 9$). A minority ($n = 15$) received a primary diagnosis of a personality disorder. All diagnoses were given by trained psychotherapists during the clinic's regular intake diagnostic procedure. The two groups did not differ in the distribution of these diagnoses, $Chi^2(2) = 1.2$, $p = .55$.

The sample was highly comorbid, with the mean number of current diagnoses being 1.9, and total number of diagnoses ranging from 1 to 6. The two training groups did not differ in the number of diagnoses or in gender distribution (see Table 1). They did differ in marital status (more participants of the control group were married), but not in relationship status (having a partner or not). There was a significant difference in age, because the control group was slightly older than the trained group (see Table 1). Most importantly, the two groups did not differ in depression level at intake; both groups showed moderate levels of depression. Moreover, the groups did not differ either in the amount of psychopathology as measured with the SCL-90 global score at intake, and they did not differ in the percentage of drop-outs at discharge, which was low in both groups (see Table 1). The study was approved by the German Pension Fund, and the patients provided informed consent.

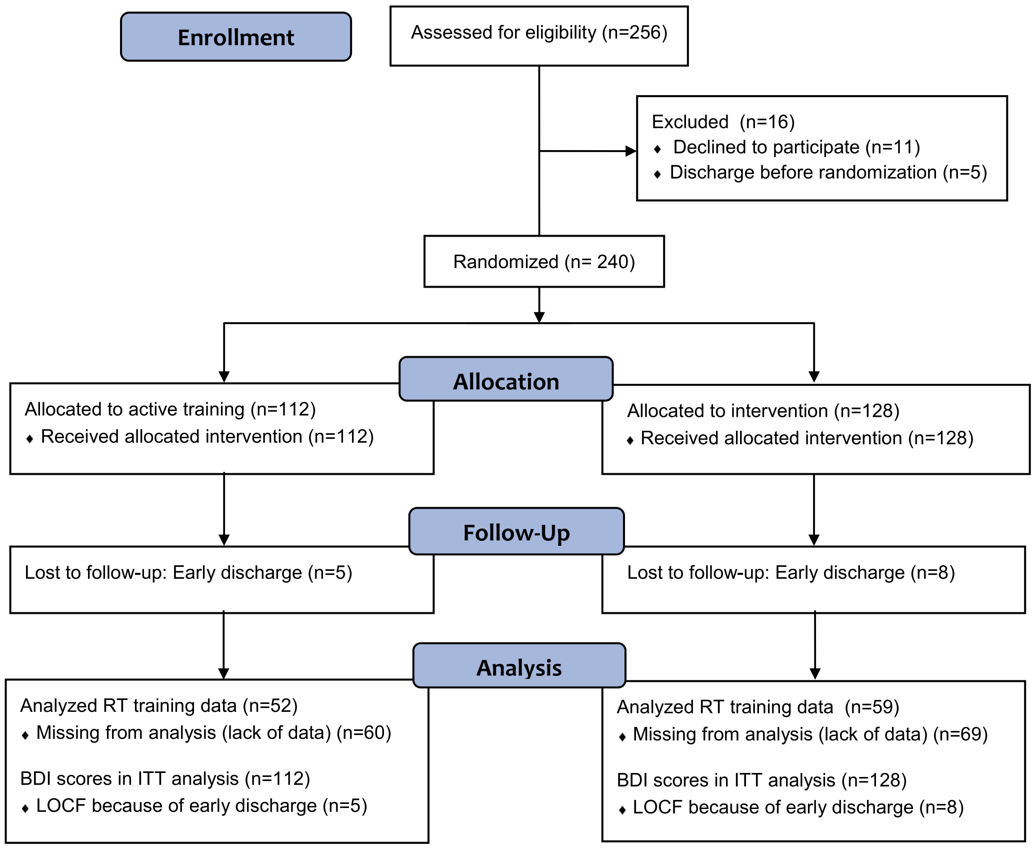

Fig. 1. CONSORT diagram of participant flow.

They did not receive any payment for their participation, and their decision to participate or not did not have any consequences for their treatment. The study was not pre-registered as a clinical trial.

2.2. General procedure

All participants received treatment as usual, an intensive treatment program consisting of individual and group CBT, physical exercise and relaxation training, and various occupational trainings with 5–6 sessions a day on average, for an average of 5 weeks. In addition, participants received 4 sessions of training on 4 consecutive days during their stay, starting approx. 2 weeks after the intake. The time between intake and training varied between patients (1–3 weeks), as did the time between training and discharge (1–3 weeks). During each training session, the participants assigned to the active positivity training/experimental condition were trained to pull all positive pictures closer and to push away all neutral pictures. The participants assigned to the sham training control condition had to pull and push all positive and all neutral pictures equally often. The training took place in a computer room with space for up to 8 participants working simultaneously. Participants were blinded to the difference between active vs. sham training by receiving plausible training rationales for both versions, and by being led to believe that they received a training tailored to their individual needs. This was done to ensure comparable expectancy effects in both groups. For ethical reasons, we used neutral rather than negative pictures because pilot tests had shown that some patients

Table 1
Main sample characteristics (percentages, means and standard deviations) for all 240 patients, and for the sub-sample of 111 patients with AAT data [in brackets].

	Active training	Sham training	Significance test
N	112 [52]	128 [59]	
Gender (% male)	50% [52%]	52% [48%]	$Chi^2(1) = 0.13$, $p = .72$ [$Chi^2(1) = 0.22$, $p = .64$]
Marital status (% married)	43% [47%]	60% [65%]	$Chi^2(1) = 6.54$, $p = .01$ [$Chi^2(1) = 3.77$, $p = .052$]
Relationship status (% with partner)	74% [75%]	81% [81%]	$Chi^2(1) = 1.79$, $p = .18$ [$Chi^2(1) = 0.67$, $p = .41$]
Age (years)	44.1 (11.2) [44.5 (11.4)]	48.0 (9.9) [47.4 (9.9)]	$t(238) = 2.90$, $p = .004$ [$t(109) = 1.47$, $p = .14$]
Number of diagnoses	1.9 (1.0) [1.7 (1.0)]	1.9 (1.0) [1.6 (0.9)]	$t(238) = 0.17$, $p = .87$ [$t(109) = 0.48$, $p = .63$]
Depression at intake: BDI score	18.7 (9.5) [17.6 (9.1)]	18.4 (10.0) [18.2 (9.8)]	$t(238) = 0.24$, $p = .81$ [$t(109) = 0.35$, $p = .73$]
Psychopathology: SCL-90 score	64.0 (9.7) [62.0 (10.1)]	64.5 (10.7) [64.7 (11.1)]	$t(230) = 0.39$ $p = .69$ [$t(107) = 1.34$, $p = .18$]
Percent drop-outs	5%	6%	$Chi^2(1) = 0.37$, $p = .54$

might object to being exposed to negative pictures. This creates a deviation from previous studies (Becker et al., 2016; Ferrari et al., 2018), but still allows for the main purpose of the current training, namely to train approach of positive stimuli. The BDI (Hautzinger et al., 1994) was administered as part of the general diagnostics at the start and end of treatment, respectively.

3. Measures

3.1. Approach-Avoidance Task (AAT): assessment and training

Single pictures were presented to participants on a computer screen. The stimuli consisted of a set of 100 positive pictures and 100 neutral pictures, representing a broad range of different categories (e.g., animals, human beings, objects) that were selected from the International Affective Picture System (IAPS; Lang et al., 2008). The pictures were selected to cover a wide range of topics, but with restrictions on valence (either positive or neutral) and arousal (low arousal for all pictures, e.g., no sexual contents). The participants' task was to respond as quickly as possible to each picture by pulling or pushing a joystick. The correct response did not depend on the contents of the pictures, but on the direction in which they were tilted (slightly to the left or slightly to the right). Participants initiated each trial by holding the joystick in the central position and pressing the fire button of the joystick, upon which a medium-sized picture appeared in the middle of the screen. Pulling and pushing the picture was accompanied by a dynamic zoom effect in order to create the visual impression that the picture itself is being pulled closer or pushed away. To this end, pushing the joystick resulted in a decrease in picture size whereas pulling the joystick led to an increase in picture size. Back-and-forth movements of the joystick created concurrent decreases and increases of the picture size. The picture disappeared and the trial ended as soon as the joystick was moved completely in the correct direction. Depending on the combination of response direction (pulling vs. pushing) and stimulus valence (positive vs. neutral), each trial was either compatible (pull positive or push neutral) or incompatible (pull neutral or push positive). Shorter reaction times on compatible trials than on incompatible ones reflected a bias towards positive pictures and away from neutral ones.

Unbeknown to the participants, each training session was divided into separate parts (without change in instructions): 8 practice trials (with 2 pictures not used afterwards), a block of 40 pre-test trials (with 20 positive and 20 neutral pictures), a block of 200 training trials (with all 100 positive and 100 neutral pictures), and 40 post-test trials (with 20 positive and 20 neutral pictures not used in the pretest). During the pre-test and post-test blocks, both picture types were approached and avoided by all participants (10× pull positive, 10× push positive, 10× pull neutral, 10× push neutral). In contrast, the training block of the sessions differed for the two groups. For the active training group, there was a contingency of tilt and contents such that all positive pictures had to be pulled closer and all neutral pictures had to be pushed away. For the sham training control group, there was no such contingency; they had to pull and push both positive and neutral pictures equally often. In total, each session of the joystick task consisted of 288 trials lasting about 10 minutes. Participants could take a break halfway through the session. Reaction times and movements of the joystick were measured continuously during the whole task.

3.2. Depression severity

In order to assess clinically relevant depressive symptoms, the German version of the Beck Depression Inventory (BDI; Beck et al., 1961; Hautzinger et al., 1994) was administered twice during the patients' stay at the clinic, at intake and before leaving the clinic. The total score ranges from 0 to 63, with higher scores indicating more severe depressive symptoms. A score above 20 is often used as an indication of clinically significant depression, therefore we also used it as a cut-off score here. The BDI is a reliable and valid instrument (Hautzinger, 1991). The therapists who administered the BDI (and the SCL-90 described below) during the routine diagnostic sessions were blind to the training conditions: they did not know whether the patient participated in the active condition, the sham condition, or no training at all.

3.3. Psychological distress

In order to assess psychological distress before the treatment, the global severity index of the Symptom-Checklist SCL-90 (Derogatis, 1977) was used. Employed in this way, the German version of the SCL-90 is known to be a reliable instrument to measure the global intensity of psychological distress (Hessel et al., 2001).

4. Results

4.1. Approach-avoidance biases

To explore whether approach-avoidance biases changed over the course of the training, we compared the participants' approach-avoidance tendencies before training to their tendencies after training. To that end, we computed a so-called compatibility score for the pre-test of session 1 (the very first test) and for the post-test of session 4 (the very last test). To arrive at the compatibility scores, we first excluded the 1% fastest and the 1% slowest reaction times (RTs) from all RTs, then computed, separately for each participant and test, a median reaction time (RT) for each of the 4 combinations of picture valence (positive, neutral) and movement direction (pull, push). From these 4 median RTs, the compatibility score was computed according to the following formula:

(RT-push-positive + RT-pull-neutral) – (RT-pull-positive + RT-push-neutral).

Positive values of these scores indicate a pattern of reaction times, and therefore approach-avoidance tendencies, that are compatible with the intention of the training: Relatively faster approach of positive stimuli and/or relatively faster avoidance of neutral pictures. We expected the participants to show a negative or close-to-zero score on the pre-test, and the actively trained participants to show positive scores on the post-test. The reliability of the compatibility scores was low, with Cronbach's alpha = 0.20 for the pre-test scores and alpha = 0.41 for the post-test scores.

Unfortunately, complete training data existed only for 52 actively trained participants and 59 participants in the sham training group. The loss of data for the other 129 participants was due to a technical error by research staff (i.e., failing to save data prior to daily deletion of data from computers as per clinic's procedures). The demographic data of the 111 patients with available training data are shown in Table 1 in brackets. They closely resembled those of the complete sample.

To test the study hypotheses, we subjected the scores of this sample of 111 patients to a mixed-factors ANOVA with time (pre- vs. post-training) as within-subjects factor, and training group (active vs. sham) and depression level (low vs. high pre-treatment BDI) as between-subjects factors. To create the low vs. high pre-treatment BDI groups, we used the cut-off score of 20. Table 2 reports the means and standard deviations of the scores. The analysis revealed that the compatibility

Table 2
Mean compatibility scores in ms (with standard deviations).

	Low depression Active training (*N* = 28)	Sham training (*N* = 30)	High depression Active training (*N* = 24)	Sham training (*N* = 29)
Pre-test	+57 (264)	−12 (274)	−195 (406)	−59 (301)
Post-test	+72 (148)	−22 (184)	+101 (320)	+9 (221)

scores increased from pre- to post-training, $F(1,107) = 5.32$, $p = .023$, partial eta^2 = 0.047. The participants started out with a negative score (−47 ms on average) which turned into a positive score (+36 ms on average) after training. Thus, initial negativity was modified into positivity. As predicted, this improvement was substantial (145 ms) and statistically significant for the active training group, $t(51) = 2.15$, $p = .037$, partial eta^2 = 0.083, while being small (28 ms) and non-significant for the group receiving sham training, $t(58) = 0.59$, $p = .56$, partial eta^2 = 0.006. However, the critical interaction of training group and time was not significant, $F(1,107) = 2.52$, $p = .116$, partial eta^2 = 0.023, and neither was the 3-way interaction of training group, depression level, and time, $F(1,107) = 1.60$, $p = .208$, partial eta^2 = 0.015.

Because of the significant interaction of depression level and time in this analysis, $F(1,107) = 5.04$, $p = .027$, partial eta^2 = 0.045, we also analyzed the two depression level groups separately. Interestingly, we found that for the low-depression group, there were no significant effects. The change in compatibility scores was significant neither in the active training group, $t(27) = 0.223$, $p = .83$, partial eta^2 = 0.002, nor in the sham training group, $t(29) = 0.16$, $p = .87$, partial eta^2 = 0.001. In contrast, for the high-depression group, the increase in compatibility scores was significant in the active training group, $t(23) = 2.53$, $p = .019$, partial eta^2 = 0.218, but not in the sham training group, $t(28) = 0.95$, $p = .35$, partial eta^2 = 0.031 (see Table 2). As a result, another ANOVA revealed that in the high-depression group, the interaction of training group and time approached significance, $F(1,51) = 2.99$, $p = .09$, partial eta^2 = 0.055.

In summary, despite the reduced sample size, these results tentatively suggest that the training worked as expected, but only for participants with higher levels of depression. They started out with a clearly negative compatibility score (−121 ms), leaving much room for improvement by the active training. In contrast, the low-depression group started out with a slightly positive compatibility score (+21 ms), leaving little room or need for modification.

4.2. Effects of training on depression

For these analyses, data of all 240 participants were used. As a first confirmatory analysis, a mixed-factors ANOVA with the between-subjects factor training group (active vs. sham training) and the within-subjects factor time (pre- vs. post-treatment) was conducted on the BDI scores. In case of missing BDI post-treatment scores (5.4% of the data), missing values were replaced using the last-observation-carried-forward method. The ANOVA revealed a significant main effect of time, $F(1,238) = 149.06$, $p < .001$, partial eta^2 = 0.385, indicating that overall, BDI scores decreased from pre- to post-treatment. Most importantly, the predicted training group × time interaction was significant, $F(1,238) = 4.82$, $p = .029$, partial eta^2 = 0.02, because BDI scores decreased more after active training than after sham training (see Table 3).

As mentioned above, the two training groups differed in age and marital status, and gender might act as a moderator of the training effect. Therefore, the analysis was repeated as an exploratory ANCOVA with the additional between-subjects factors marital status and gender, and the covariate age. However, none of these variables had a significant main effect on BDI scores (all $p > .27$), nor did they interact with time (all $p > .12$) or show any higher-order interaction (all $p > .19$). In contrast, the critical 2 × 2 interaction of training group and time was significant again, $F(1,229) = 4.55$, $p = .034$, partial eta^2 = 0.019.

To test whether in this unselected sample of inpatients, the beneficial effect of the training on depression would increase gradually with increasing levels of depression, the group-wise ANOVA reported above was complemented by an exploratory regression analysis. Here, we regressed post-treatment BDI scores on pre-treatment BDI scores, training group, and their interaction. A significant interaction term in this model would be consistent with the hypothesis. As predicted, the interaction term was significant ($b = 0.25$, $p = .009$) in the final model, suggesting that post-treatment BDI scores varied significantly between treatment conditions, but depending on pre-treatment BDI levels. Fig. 2 shows the nature of this interaction: the higher the level of pre-treatment depression, the larger the predicted difference in post-treatment depression between active and sham training. Thus, the best-fitting model predicts that the more depressed participants will profit more from the training. Consistent with recommendations by Aiken and West (1991), we probed this interaction by examining between-group differences at low and high levels of pre-treatment depression. We selected BDI = 9 as a score reflecting minimal levels of depression symptoms and BDI = 25 as a score reflecting clinically significant levels of depression (Olin et al., 1992; Roelofs et al., 2013). As expected, predicted post-treatment BDI scores were significantly lower for the active than the sham training group among participants presenting with clinically meaningful levels of depression ($b = 3.71$, $p = .001$, partial eta^2 = 0.053). In contrast, the between-group difference was not significant among participants presenting with mild levels of depression ($b = -0.37$, $p = .778$).

4.3. Bias change as predictor of depression change

To explore the mediating role of bias change in the reduction of depressive symptoms, we related the size of the training effect across the whole training (compatibility effect in first pre-test vs. last post-test) to the change in BDI scores from pre-treatment to post-treatment. Again, the analysis was compromised by the incompleteness of the training data (see above). Moreover, the correlation between change in compatibility effect and change in BDI scores was weak and not significant, neither for the complete group, $r = 0.09$, $p = .33$, nor for the actively trained group, $r = 0.07$, $p = .61$, or the sham training group separately, $r = 0.24$, $p = .07$. Moreover, the pre-training compatibility effect did not predict the change in BDI scores either, $r = -0.09$, $p = .34$, although it was weakly related to the pre-training BDI scores, $r = -0.15$, $p = .09$.

5. Discussion

The current study showed that a new CBM approach, namely a general positivity-approach training, was effective in reducing depressive symptoms in a clinical setting, in an inpatient sample with varying levels of depressive symptoms. Here the training was used as an add-on intervention on top of an intensive inpatient treatment of several weeks, consisting mostly of cognitive behavior therapy. The success of the training was closely linked to the patients' level of depression, such that more depressed patients profited more from the training, independently of their primary diagnosis. In the highly depressed group, the training

Table 3
Mean BDI scores before and after active or sham training (with standard deviations).

	Low depression Active training (N = 61)	Sham training (N = 70)	High depression Active training (N = 51)	Sham training (N = 58)
Pre-training	11.5 (5.1)	10.7 (5.1)	27.3 (5.4)	27.7 (5.8)
Post-training	7.0 (5.4)	5.7 (6.1)	17.5 (10.5)	23.0 (11.3)

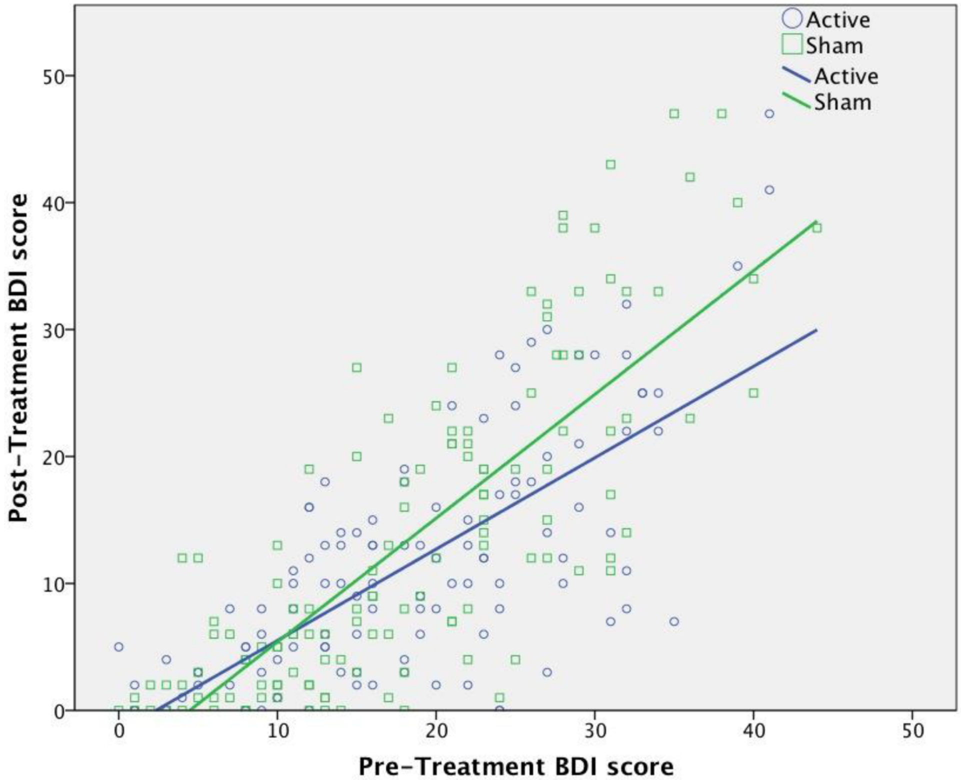

Fig. 2. Post-treatment difference in BDI scores between active and sham training group depending on pre-treatment BDI scores.

had a medium-sized effect on depressive symptoms. This is quite fortunate because particularly the more depressed patients are the ones who are in need of more effective treatments.

Why would the general positivity-approach training employed here be helpful for more depressed patients? One of the major underlying traits of depression is anhedonia, the inability to experience pleasure from activities usually found enjoyable. This goes hand in hand with a lack of motivation to actively engage in those activities. For instance, hobbies are not pursued anymore, social encounters do not take place, and sports are given up. In short, the approach motivation is lacking. The CBM training employed here targets exactly these emotion-driven action tendencies directly, and thus might facilitate behavior activation in the depressed. Furthermore, the situations that depressed individuals do not approach anymore are rather varied, thus the general nature of the positive stimuli presented during the training fits well. By showing many different positive objects, situations, and activities, we can hope to achieve a sufficient level of generalization.

As in Becker et al. (2016), the results suggest that the effects of this CBM training are not restricted to content-specific information. Instead, they seem to extend to the modified processing of emotionally valenced information in general. Interestingly, and in contrast to Becker et al. (2016) and Ferrari et al. (2018), neither the positivity training employed in this study nor the one used by Vrijsen et al. (2018) trained avoidance of negative stimuli. Ferrari et al. differentiated between the effects of approaching positive stimuli and of avoiding negative stimuli. They found that the original training version which contained both approach of positive stimuli and avoidance of negative stimuli had the strongest effects, followed by the version in which participants only had to avoid negative stimuli. However, they also found that the presentation of the negative pictures led to increased negative mood in the participants. Therefore, they were replaced by neutral pictures in this study, due to ethical considerations. Nevertheless, in this clinical sample, the training was effective even without the avoid-negative component: training to approach positive stimuli and avoid neutral ones was sufficient for reducing depressive symptoms, just as it was in the study by Vrijsen et al. (2018). In line with Taylor and Amir (2012), this study provides encouraging support for the notion that enhancing a positive behavioral bias associated with a healthier processing of emotional information can be beneficial.

The current study was also designed to identify the target population of this new positivity-approach training. Is it helpful for any patient, for patients with increased depressive symptoms, or only for patients with a primary diagnosis of depression? The results suggest that although the training itself is general, its target population is fairly specific: patients with more depressive symptoms, that is higher BDI scores, profited most from it, independently of their main diagnosis. In contrast, patients with fewer depressive symptoms did not profit from the training. A floor effect may be a simple explanation of this finding: If patients start out with low BDI scores, it is almost impossible to reduce them even further. However, this is not the complete explanation: The results of the pre-assessment of approach-avoidance tendencies showed that these patients also lacked the to-be-modified incompatibility effect. For these patients, anhedonia and avoidance of positive stimuli are possibly not among their major problems, and the training might be superfluous. Future studies should try to assess whether these non-depressed patients profit from the training in other ways, or whether it is indeed not suitable for them.

Although we could show that it is possible to induce a positivity bias in more depressed inpatients and that these patients profit from the training, the current study did not yield clear-cut information about the working mechanisms of the training. Obviously, the training did not work via being exposed to positive and neutral pictures, or via making joystick movements, or via participating in a mildly demanding computer task. All these features were controlled for by means of the sham training control group. Instead, there was some evidence for our hypothesis that in the more depressed patients, the change of a negativity bias into a positivity bias may be responsible for the decrease in depressive symptoms. This assumption was confirmed at the group level:

high-depressed patients receiving active training showed the expected increase in positivity bias and the expected reduction of depressive symptoms, whereas patients in the control group did not show either change. At the individual level, however, there were no correlations between the size of the bias change and the size of the depression change, casting doubts on the hypothesis that bias change is the active mechanism in symptom change.

However, it has to be kept in mind that these null findings might also be due to a lack of statistical power, caused by two factors: First, the sample size of these analyses was considerably reduced due to loss of AAT data. Second, indirect measures like the AAT which are based on reaction times are notorious for their low reliability. The AAT, although powerful as a training task, also suffers from low reliability when used as an assessment task (Reinecke et al., 2010), and the current pre-test and post-test measures were no exception. Furthermore, the AAT was conducted in a group setting, and distractions might have reduced the reliability of the reaction time measurement even further. It should also be kept in mind that, unfortunately, the two training groups differed in their approach bias before the training. Limitations also apply to the analyses of the BDI scores, where about 6% of post-test values were missing and replaced by the corresponding pre-test values. This very conservative form of the last-observation-carried-forward method may have underestimated changes in depressive symptom levels.

A few more limitations have to be mentioned as well. First, the patients received training at varying time points; it was not possible to keep the time between intake, training, and discharge constant across patients. This may have introduced additional error variance into our measures. Moreover, patients also received treatment-as-usual, therefore we cannot say which effects the training would have as a stand-alone treatment. We do not consider this a serious problem because the training was explicitly designed to augment, rather than replace, behavior therapy of depression. A more relevant aspect of this limitation is the optimal order of positivity training and behavior therapy: Future research should determine whether patients profit more when the training is given before, after, or simultaneously with standard treatment. A second limitation relates to the critical training component: is the approach of positive pictures, or the avoidance of neutral pictures, or both effective ingredients when it comes to modifying approach-avoidance tendencies and subsequently decreasing depressive symptoms? This relates to the problem mentioned above: it remains to be shown that a change in approach-avoidance tendencies is indeed the working mechanism in this training. Furthermore, nothing can be said about the longevity of the induced effects, since follow-up data could not be collected.

Despite its limitations, one has to keep in mind that this was an early proof-of-concept study. In this ecologically valid situation, the training caused beneficial changes in a highly comorbid group of inpatients. Besides being effective in reducing depression symptoms, this study also shows that it is feasible to conduct such a training in a clinical setting, similar to the study by Vrijsen et al. (2018). Therefore, it may become a viable treatment option to augment existing treatment approaches when added to treatment-as-usual. Computerized trainings like the one employed here are relatively cheap, they can be applied by trained staff that do not have to be therapists, and they can reach many patients. Finally, the fact that the training was most helpful for those patients who are most in need for improved treatments, namely the more depressed patients, makes this general positivity-approach training particularly promising. Therefore, as a next step, the effects of the training should be evaluated in a pre-registered, randomized controlled trial involving more severely depressed patients, multiple measures of depressive symptoms, and follow-up measurements.

Authors' contributions

Eni Becker (EB) conceived the positivity-approach training. Anja Barth (AB), EB, Sylvia Beisel (SB), Johannes Lindenmeyer (JL) and Mike Rinck (MR) designed the study. AB collected data under the supervision of SB and JL. SB supervised the clinic's interns who collected additional data. AB, EB, MR, and Jasper Smits (JS) analyzed the data and wrote various versions of the manuscript. JS provided additional statistical support. All authors provided critical revisions and approved the final version for submission.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.jad.2018.11.042.

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