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Preliminary Evidence for the Enhancement of Self-Conducted Exposures for OCD using Cognitive Bias Modification

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Abstract

Exposure and Response Prevention (ERP) is the most effective treatment for OCD but it is not accessible to most patients. Attempts to increase the accessibility of ERP via self-directed ERP (sERP) programs such as computerized delivery and bibliotherapy have met with noncompliance, presumably because patients find the exposure exercises unacceptable. Previous research suggests that Cognitive Bias Modification (CBM) interventions may help individuals approach feared situations. The goal of the current study was to test the efficacy of a treatment program for OCD that integrates sERP with CBM. Twenty-two individuals meeting diagnostic criteria for OCD enrolled in our 7-week treatment program. Results suggest that sERP with CBM led to significant reduction of OCD symptoms and functional impairment. Indeed, the magnitude of the effect of this novel treatment, that requires only an initial session with a clinician trained in ERP for OCD, was comparable to that of the gold standard clinician-administered ERP. Moreover, preliminary evidence suggests that CBM interventions targeting interpretation bias may be most effective, whereas those targeting attention and working memory bias may not be so.

Keywords

obsessive-compulsive disorder; cognitive bias modification; exposure; attentional bias; interpretation bias

Obsessive Compulsive Disorder (OCD) is a severe mental disorder of significant public health concern. According to the World Health Organization, OCD is the 10th leading cause of disability and is the fourth most common psychiatric disorder in the USA (Pigott, 1998; Fisher & Wells, 2008), with a lifetime prevalence of 2.5% (Karno & Golding, 1991). It is a

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2. Consent Statements: All procedures followed were in accordance with the ethical standards of the APA and the Institutional Review Board. Informed consent was obtained at the beginning of the study from all individual subjects participating in the study.
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chronic disorder that can decrease social functioning and quality of life significantly (Tenney et al., 2003), on par with functional impairment caused by schizophrenia (Bystritsky et al., 2001; Hollander, 2005). The disorder is under-diagnosed and 50% of those with OCD do not receive any treatment (Kohn et al., 2004). Of those patients who do receive pharmacological and behavioral treatments, 40% do not respond (Hollander et al., 2006). Thus, OCD is a common and often debilitating disorder that is costly to the individual, the family, and to society.

Cognitive-behavioral therapy (CBT) with Exposure and Response Prevention (ERP) is the psychosocial treatment of choice for OCD. The gold standard ERP treatment for OCD is delivered in about 15 sessions, each 1.5–2 hours in duration (Franklin & Foa, 1998; Kozak & Foa, 1997). ERP comprises confronting anxiety-provoking situations while resisting rituals aimed at alleviating anxiety. Foa and Kozak (1996) reviewed 13 studies that used ERP, comprising 330 patients, and found that 40–97% of patients improved, depending on the study. Abramowitz, Franklin, and Foa (2002) reviewed 17 controlled studies of ERP and reported a 43% reduction on the Yale-Brown Obsessive-Compulsive Scale (Y-BOCS; Goodman et al., 1989), with a controlled effect size of $d = 1.50$. Thus, an Expert Consensus Guideline identified CBT with ERP as the preferred treatment for OCD (March et al., 1997). More recently, cognitive therapy (CT) has also established efficacy (e.g., McLean et al., 2001; Whittal et al., 2005; Wilhelm et al., 2005; 2009). Abramowitz et al. (2002) reported a controlled effect size of $d = 1.19$ for CBT/CT studies compared with wait-list controls.

Despite the demonstrated efficacy of CBT/CT, these treatments are not widely available to most OCD patients seeking treatment in the community (Denys et al., 2002; Mancebo et al., 2006). For example, Mancebo et al. (2006) reported that among OCD patients seeking treatment in the previous 5 years, only 24% received the recommended trial of CBT, suggesting that CBT is underutilized by the majority of treatment-seeking patients with OCD and that those who do undergo CBT receive suboptimal doses.

The finding that CBT is not widely used by mental health practitioners who treat OCD in the community likely reflects a dearth of clinicians trained in CBT (Goisman et al., 1993). One reason for this under-utilization of ERP may be that most graduate programs do not provide specialized training in CBT for OCD (Crits-Cristoph et al., 1995; Davidson, 1998; Gunter & Whittal, 2010), and other resources for training in CBT for OCD (e.g., workshops) are limited and costly. Thus, practical limitations such as a lack of trained therapists or difficulty implementing more intensive CBT with ERP in routine outpatient practices are barriers to accessing treatment (Franklin, 2005; Greist et al., 2002). Furthermore, even when CBT with trained clinicians is available, the cost of CBT for OCD is likely to be prohibitive for many patients (Marques et al., 2010; Leonard et al., 1993) and unattractive to insurance companies. For instance, a 1995 survey showed an average cost of \$4,370 (Turner et al., 1995).

Thus, there is a clear need to develop highly efficient and cost-effective psychological treatments for OCD. In response to this need, researchers have examined alternative forms of CBT for OCD. For example, BT STEPS™ is a computer program designed to assist OCD patients in carrying out self-assessment and self-help ERP therapy (Baer, Greist, & Marks,

2007). Bachofen et al. (1999) and similarly Greist et al. (2002) demonstrated that this treatment is effective for those who complete it, but the dropout rate is greater than 50%. Bibliotherapy for OCD, a second approach, is a treatment method that is both self-directed (i.e., patients generate their own exposure hierarchy) and self-conducted (i.e., patients engage in exposure exercises without the assistance of the therapist). A randomized controlled trial (RCT) comparing therapist-conducted ERP to self-conducted ERP with bibliotherapy reported response rates of 65% and 25%, respectively (Tolin et al., 2007).

In summary, ERP is the most effective treatment for OCD but it is not accessible to most patients with OCD. Attempts to increase the accessibility of ERP via computerized delivery and bibliotherapy have met with noncompliance, presumably because patients find the exposure exercises unacceptable. Therefore, attempts to increase acceptability of exposures will likely increase the efficacy of self-conducted ERP.

To address this, we turned to models of anxiety generally, and OCD more specifically, for clues to enhance the behavioral approach required for exposures. Cognitive models of OCD have emphasized a role of dysfunctional beliefs (Rachman, 1997; Salkovskis, 1985, 1989) in the etiology and maintenance of the disorder. These beliefs are thought to be the result of critical life events or learning and memory processes over time. Salkovskis's model of OCD posits that (1) obsessional thinking has its origins in unwanted intrusive thoughts, images, and impulses, which reflect the individual's current concerns, and that (2) the difference between a normal intrusive thought and an obsession lies in the manner in which the thought is interpreted. According to Salkovskis, individuals with OCD tend to interpret these thoughts as implying high personal responsibility. This inflated responsibility results in an increase in anxiety, which, in turn shifts the focus of attention to the intrusion and anything in the environment that might trigger it. According to Rachman (2003), cognitive biases such as inflated responsibility and thought-action fusion (i.e., the belief that thinking about something makes it more likely to happen) serve to inflate the significance of obsessions. Consistent with these models, other investigators (e.g., Tallis, 1997) have proposed that the characteristic repetitive obsessions and compulsions in OCD may be the result of biased processing of threat-relevant information. Thus, one target for increasing behavioral approach in exposure-based therapy for OCD may be the cognitive deficits underlying OCD symptoms.

Exposure exercises are often unacceptable to patients because, by definition, they require the patient to face anxiety-invoking situations. In several previous studies, researchers have shown that Cognitive Bias Modification (CBM) interventions can help individuals approach feared obsessive-compulsive stimuli (Amir, Kuckertz, & Najmi, 2013; Najmi & Amir, 2010) and other anxiety-invoking situations (Amir, Weber, Beard, Bomyea, & Taylor, 2008). These researchers have drawn on basic experimental psychopathology research to develop CBM techniques designed to improve behavioral approach by modifying basic cognitive vulnerabilities (e.g., impairment in attention, working memory, or interpretation) involved in the maintenance of anxiety disorders. For example, in one study, Najmi and Amir (2010) examined the effects of an Attention Bias Modification Program (ABM) on behavioral responses to contamination-related stimuli in a sample of undiagnosed individuals with obsessive-compulsive concerns. They found that participants in the ABM group completed

significantly more steps approaching feared contaminants in a graded behavioral approach test (Cougles, Wolitzky-Taylor, Lee, & Telch, 2007; Najmi, Tobin, & Amir, 2012) compared to a control group.

ABM may also be effective at modifying anxiety-related behavior in clinically diagnosed individuals. Heeren, Reese, McNally, and Philippot (2012) found that after four consecutive daily sessions of ABM, individuals with generalized social phobia experienced significant decreases in observable anxiety from pre- to post-treatment during a speech task judged by blind raters, whereas this was not found for two controls groups. In another study of clinically-diagnosed youths, youths completing ABM in combination with CBT experienced significantly greater reductions in obsessive-compulsive symptoms compared to youths receiving CBT with a sham attention training program (Riemann, Kuckertz, Rozenman, Weersing, & Amir, 2013). While exposure compliance was not assessed in that study, it is possible that differential group changes in response to CBT resulted from increased quantity and/or quality of exposures for participants receiving ABM.

We note, however, that not all research examining the effect of ABM as an adjunctive intervention has yielded significant differences between ABM and control conditions (Britton et al., 2013; Rapee et al., 2013). Nevertheless, given the positive findings that altering attention mechanisms may improve behavioral performance related to obsessive-compulsive stimuli, as well as the effect of such training in modifying other anxiety-related behavior for clinical levels of anxiety, these studies suggest the possibility that ABM may have utility in facilitating the behavioral approach that is required for exposure therapy.

While extant research in cognitive bias modification has focused largely on attention training programs for anxiety (for reviews see Hakamata et al., 2010; Hallion & Ruscio, 2011; Beard, Sawyer, & Hofmann, 2012; Mogoa e, David, & Koster, 2014), other forms of CBM are beginning to show efficacy in reducing anxiety and facilitating positive behavioral change. Individuals with clinical and subclinical levels of OCD demonstrate biased interpretation of obsessions (OCCWG; Obsessive Compulsive Cognitions Working Group, 2001; 2003) and ambiguous information (Jelinek et al., 2009; Jhung et al., 2010; Kuckertz, Tobin, Najmi, & Amir, 2013). This is consistent with cognitive models of OCD that propose that the maladaptive interpretation of intrusive thoughts causes anxiety and compulsions, thereby transforming them into clinical obsessions. To address this form of cognitive bias, Clerkin and Teachman (2011) examined the effects of a single session interpretation modification program for individuals high in obsessive-compulsive symptoms. These authors found that the interpretation modification program was successful not only in affecting interpretations, but also in reducing negative affect associated with a stressor task tied to obsessive-compulsive beliefs, compared to a control group. Using the same paradigm, Williams and Grisham (2013) and Beadel et al. (2014) found similar results for changes in interpretations associated with the obsessive belief domains of intolerance of uncertainty, overestimation of threat, control of thoughts, over-importance of thoughts, inflated responsibility and perfectionism (OCCWG, 2001; 2003) in individuals high in obsessive-compulsive symptoms. However, they did not find behavioral effects of the CBM task, nor did Grisham et al. (2014) in a follow-up study targeting responsibility beliefs more specifically. Clerkin, Magee, and Parsons (2014) found that the effect of training

interpretation related to the control of thoughts on a stressor task was mediated by a reduction in beliefs about the control of thoughts. Whereas these interpretation training studies examined the effects of single-session programs, others have demonstrated the efficacy of multi-session programs in decreasing symptoms in individuals with generalized social phobia (Amir & Taylor, 2012).

Finally, preliminary research on working memory training suggests that such programs may be beneficial in reducing intrusive thoughts (Bomyea & Amir, 2011). Given the theoretical role of intrusive thoughts in OCD, such training may prove useful in alleviating obsessions.

The goal of our current multiple baseline feasibility trial was to test the efficacy of a self directed treatment program for OCD that integrates sERP with CBM. Our secondary goal was to compare the relative efficacy of each active CBM condition to a control condition. The 7-week treatment program for OCD was therapist-directed (i.e., patient generates exposure hierarchy with the assistance of the therapist) and self-conducted (i.e., patient engages in exposure exercises without the assistance of the therapist). Feasibility and effectiveness of the program was assessed through treatment completion rates, and clinician-administered and self-rated symptoms of OCD, depression and functional impairment.

Method

Participants

The sample comprised 22 treatment-seeking individuals meeting diagnostic criteria for OCD (14 men, 8 women), based on a clinician interview using the Structured Clinical Interview for the DSM-IV (SCID; First, Spitzer, Gibbon & Williams, 1994). The average age of participants was 31.50 ($SD = 11.92$; range: 17 – 62) with an average of 14.57 years of education ($SD = 2.07$; range: 12 – 19). Fifteen participants identified as Caucasian, five as Hispanic, one as Native American/White, and one as Other.

Participants were recruited through posted announcements in community settings and local web-based media (e.g., search engine, Craigslist). Potential participants completed a brief telephone screening that assessed primary complaint and severity of OCD. Individuals whose primary reported problem was OCD and who did not meet the study exclusion criteria (listed below) were invited to participate in a clinical interview held at our research clinic.

Participants were included in the study if they: (a) had a primary DSM-IV (American Psychiatric Association, 2000) Axis I diagnosis of OCD, (b) did not have primary hoarding symptoms (c) showed no evidence of current suicidal intent, (d) showed no evidence of substance abuse in the past 3 months, (e) showed no evidence of current or past schizophrenia, bipolar disorder, or organic mental disorder, and (f) were not currently participating in any other psychotherapy (e.g., CBT). Of the 22 participants enrolled in the study, 5 participants met criteria for a concurrent Axis I disorder. Current comorbid diagnoses included: generalized anxiety disorder ($n = 2$), agoraphobia ($n = 1$), generalized social phobia ($n = 1$), and specific phobia ($n = 1$). Participant primary OCD subtypes were as follows: washing ($n = 8$), obsessing ($n = 7$), neutralizing ($n = 2$), checking ($n = 1$), checking/

neutralizing co-primary ($n = 2$), ordering/neutralizing co-primary ($n = 1$), and ordering/washing co-primary ($n = 1$).

Procedure

Participants read and signed the consent form, completed a diagnostic intake (SCID; First et al., 1994), and battery of interviewer and self-report measures. Clinical interviews were conducted by doctoral level clinicians with extensive experience assessing and treating OCD. Those who were eligible and agreed to participate in the study completed a homework packet in which they were directed to generate idiographic stimuli for each of the CBM information-processing trainings and create an exposure hierarchy. Participants returned to the research clinic for a second session with a clinician, in which the clinician reviewed the idiographic stimuli and exposure hierarchy and adjusted or generated additional stimuli as needed in collaboration with the participant. The clinician assisted with this process by helping the participant generate words and sentences based on content discussed during the YBOCS and clinical interview. Idiographic pictures were gathered using web-based image searches; in addition, some participants opted to take their own digital pictures of OCD-relevant stimuli (e.g., one participant with harming obsessions took a picture of her mother with a knife placed on her chest). Because of the idiographic nature of the stimuli collection, stimuli were not normed. Participants also completed a practice exposure with the clinician, following which participants were sent home with 14 psychoeducation video modules that they were instructed to complete over a six-day period prior to the first week of training. During each of the five treatment (i.e., training) weeks, participants completed self-report measures of OCD symptoms, three training sessions (two in clinic, one at home) paired with three self-conducted exposures and two sessions of an approach practice task (completed in clinic sessions only). Participants were encouraged to further practice by completing additional training sessions and self-conducted exposures beyond the one homework session, but they were not required to do so. During each clinic session, participants received brief contact with the Research Assistant (RA). Participants were informed that following the initial meeting, contact with clinicians would be limited to cases of emergency. The RA conducting the sessions used standardized written instructions for the administration of the training tasks. After the five treatment weeks, participants completed another diagnostic interview and battery of interviewer and self-report measures (see Table 1).

Measures

We administered a battery of clinician-rated and self-report instruments pre- and post-treatment (i.e., before and after the five treatment weeks) that included measures of OCD, anxiety, depression and functional impairment. Additionally, we administered weekly assessments corresponding to each of the five CBM trainings. These included information processing assessments as well as self-report measures of obsessive-compulsive symptoms, and details of completed self-conducted exposure exercises.

Obsessive-compulsive symptoms—Our primary clinician-rated outcome measure was the Yale-Brown Obsessive Compulsive Scale (Y-BOCS; Goodman et al., 1989), a clinician-administered scale designed to assess the presence and severity of specific obsessions and compulsions. The total severity score is the sum of 10 items (range of 0 – 40) with a 5-point

Likert scale ranging from 0 (*none*) to 4 (*extreme*). This scale is one of the most widely used measures of severity of OCD and has become the standard instrument for assessing OCD severity in both drug trials and studies of behavioral treatments (Amir, Freshman & Foa, 2000; Steketee, 1993).

Our primary self-rated outcome measure was the Obsessive Compulsive Inventory-Revised (OCI-R; Foa et al., 2002), an 18-item measure comprising statements about everyday experiences that are relevant to general obsessive compulsive symptoms (Foa et al., 2002). Using a 5-point scale ranging from 0 (*not at all*) to 4 (*extremely*), participants rate how distressed they would feel by the experience described in each statement. The scale has been shown to have good psychometric properties (Foa et al., 2002).

Functional impairment—The Sheehan Disability Scale (SDS; Leon et al., 1997); is a commonly used item measure of the degree to which clinical symptoms interfere with work, social/leisure activities, and family/home responsibilities.

Anxiety—The Hamilton Anxiety Rating Scale for Anxiety (HARS; Hamilton, 1959) is a 14-item clinician-administered scale designed to quantify the severity of anxiety symptoms across numerous domains (e.g., anxious mood, tension, insomnia, intellectual impairment, cardiovascular symptoms, respiratory symptoms, gastrointestinal symptoms). Each item is scored from 0 (*not present*) to 4. This scale demonstrates good reliability and validity (Maier, Buller, Philipp, & Heuser, 1988) and is widely used in treatment outcome studies (e.g., Rickels, Rynn, Iyengar, & Duff, 2006).

The State Trait Anxiety Inventory, trait version (STAI-T; Spielberger et al., 1983) is a 20-item questionnaire that measures the severity of anxiety. It has been shown to have adequate psychometric properties (Ramanaiah, Franzen, & Schill, 1983).

Depression—The Hamilton Rating Scale for Depression (HAM-D; Hamilton, 1960) is a 17-item clinician-administered scale designed to quantify the severity of depression symptoms. Each item is scored from 0 to 4. The scale has sound psychometric properties (Hedlund & Vieweg, 1979; Rabkin & Klein, 1987).

The Beck Depression Inventory II (BDI-II; Beck, Steer, & Brown, 1996) is a 21-item self-report scale that assesses the severity of affective, cognitive, motivational, vegetative, and psychomotor components of depression. The BDI has sound reliability and validity and is widely used in clinical research (Beck, Steer, & Garbin, 1988).

Subjective Units of Distress (SUDS)—To assist participants in recording the details of their self-conducted exposure exercise completed both in clinic and at home (i.e., exposure situation and SUDS ratings during the exposure), we provided participants with an exposure tracking form. Participants were given the following prompt: “During the exercise, rate your discomfort (0 = no distress; 100 = highest possible distress)” and asked to write their SUDS in incremental intervals during the exposure exercise. The clinician reviewed this form with participants and explained the definition of SUDS during the practice exposure. Participants completed one exposure tracking form for each of their self-conducted exposure exercises.

Information-processing measures—Performance-based reaction-time tasks (details of tasks below) were used to assess attention bias to threat, attention control, working memory capacity, and interpretation bias pre- and post- the respective CBM intervention. All stimuli were generated ideographically by each participant and reviewed with the clinician during the setup session to capture each participant's OCD-related threat concerns.

Attention bias assessment: This computerized task is based on previous studies that have reported that individuals with subclinical or clinical OCD show an attention bias for OCD-relevant material (Najmi & Amir, 2010; Amir, Najmi, & Morrison, 2009; Tata, Liebowitz, Prunty, Cameron, & Pickering, 1996). The task consists of 48 trials (similar to task used by Najmi & Amir, 2010) of various combinations of probe type (E or F), probe position (top or bottom), and word type (Neutral or threat). The probe replaces threat (e.g., germs, accident, strangle) and neutral (e.g., flounder, curtain, barrel) words with equal frequency. Thus, neither threat nor neutral words have signal value with regard to the position of the probe. Participants are instructed to respond with a right or left mouse click indicating the probe type ("E" or "F"). The participant's attention bias is calculated by subtracting response latencies for trials in which the probe replaces threat stimuli from response latencies for trials in which the probe replaces neutral stimuli.

Attention control assessment: This computerized task is adapted from the modified Posner cueing task (see Posner, 1980; Amir, Elias, Klumpp, & Przeworski, 2003). It consists of 360 trials. During each trial a fixation sign (either +, -, or 0) appears for 500ms, followed by a cue (negative, neutral, or positive word) that appears in either the left or right side of the screen for 500ms. Following the cue, an arrow appears in either the same or opposite location as the word for 16–500ms. Participants are instructed to respond with a right or left mouse click indicating the direction of the arrow (pointing up or down). Participants are not provided with information regarding their accuracy or location of the arrow. The arrow replaces negative, neutral and positive word cues with equal frequency. Because the attention bias assessment task (see above) is a measure of attention for valenced information (in particular, threatening information), for this task we were specifically interested in assessing attention for neutral information. Thus, we calculated participants' attention control score by subtracting response latencies for valid neutral trials (trials in which the arrow appears in the same location as the neutral word cue) from response latencies for invalid neutral trials (trials in which the arrow appears in the location opposite to that of the neutral word cue).

Interpretation bias assessment: This task is based on the Words Sentence Association Paradigm (Beard & Amir, 2009) that has been used previously to assess interpretation bias in social anxiety. This computerized task consists of 80 trials (the original study used 110 trials). During each trial, a word/phrase representing either a threat interpretation (e.g., "dog-poop") or a benign interpretation (e.g., "twig") appears in the center of the computer screen for 500ms. Next, an ambiguous sentence (e.g., "I stepped on something brown") appears and remains on the screen until participants press the space bar indicating that they have finished reading the sentence. Finally, the computer prompts participants ("Was the word related to the sentence?") to press a key if they thought the word and sentence were related ("agree") or

to press another key if they thought the word and sentence were not related (“disagree”). During this assessment, participants do not receive feedback regarding their accuracy. Each response is coded as ‘1’ if participants believe the word and sentence are related, and as a ‘0’ if they believe the word and sentence are unrelated. Interpretation bias is calculated by subtracting the participant’s average relatedness ratings for threat words and ambiguous scenarios (i.e., range 0 to 1) from their average relatedness ratings for benign stimuli and ambiguous scenarios (i.e., range 0 to 1). Thus, interpretation bias scores range from -1.0 to $+1.0$, with increasingly negative scores associated with a bias towards threat interpretations, and increasingly positive scores associated with a bias towards benign interpretations.

Working memory assessment: This assessment is based on the OSPAN task (Unsworth, Heitz, Schrock, & Engle, 2005). The computerized task consists of 15 sets of 2–6 trials. Each trial begins with a fixation cross in the center of the screen for 500ms. Then, a letter (e.g., L) is presented on the screen for 500ms, followed by a simple math equation. Participants are instructed to respond with a right or left mouse click indicating the accuracy of the equation (correct or incorrect). Half of the equations are correct and half are incorrect. At the end of each set of trials, participants are shown a recall screen listing 12 letters. Using the mouse, participants select the letters they had seen in the order of presentation. Once the recall for the set is completed, the next set of trials begins in the same manner. A working memory index is calculated by adding all correct trials.

Treatment Components

The treatment program comprised 4 components: (1) psychoeducation delivered to participants via videos, (2) CBM interventions designed to modify attention bias, attention control, interpretation bias, or working memory, (3) a computer-based approach practice task, and (4) self-conducted exposure and response prevention exercises. The program consisted of 15 sessions completed over 5 weeks. In each of 15 sessions, participants completed an sERP session based on an item from the exposure hierarchy that was preceded by one of five computerized interventions, four of which targeted impairment in a particular cognitive process potentially implicated in OCD [ABM: Attention Bias Modification Program; ACTP: Attention Control Training Program; WMT: Working Memory Training; IMP: Interpretation Modification Program] and one was a CBM control condition [CC: Control Condition]. The order of CBM conditions was counterbalanced so that each condition was presented at each week with equal frequency in a Cyclic Latin Square design (see Table 2). Thus, we used a multiple baseline design to examine the relative efficacy of four CBM interventions delivered over four different weeks when compared to a control condition. Because participants received instructions to conduct exposures during each week, and because exposures are considered effective in reducing OCD symptoms, we examined the relative augmentation effect of each CBM condition for exposure exercises when compared to a control condition.

Psychoeducation videos and approach practice task—We developed a series of 14 CBT modules that were designed to educate participants about the core concepts of CBT and specific information about ERP for OCD. These modules were recorded by an actor and presented to the participants via brief video clips. These modules included (a) General

psychoeducation about anxiety disorders (3 modules); (b) Cognitive restructuring (2 modules); (c) Exposure (2 modules); (d) Breathing and relaxation (1 module); (e) Activity scheduling (1 module); (f) Relapse prevention (2 modules); (g) Normalizing intrusions in OCD (1 module); (h) ERP for OCD (1 module); (i) Using the Computerized Tasks and sERP (1 module). Each of the video modules was between 2 and 10 minutes in length. Participants were encouraged to complete the modules in a predetermined order over the course of six days following the initial intake session prior to beginning the training sessions.

The computerized approach task was adapted from the Approach Avoidance Task (AAT; Rinck & Becker, 2007). Prior research has found a similar task successful in facilitating behavioral approach towards feared obsessive-compulsive stimuli (Amir et al., 2013). Hence, we included this approach practice task as a computerized proxy for exposure practice. The AAT coordinates arm movements with the size of an image on a computer screen. Pulling a joystick by arm flexion increases the size of the picture on the computer screen, simulating approach, and pushing a joystick by arm extension decreases the size of the picture on the screen, simulating avoidance (Rinck & Becker, 2007). Participants were instructed to pull the joystick when ideographically-selected OCD threat images appeared on the screen, which resulted in simulating approach towards the feared object. Participants completed 192 trials in each session (8 pictures X 2 picture type [threatening, neutral] X 12 repetition). Trials were presented in a new random order each time. The computerized approach task took approximately 6 minutes for participants to complete. Participants completed this task before starting the self-conducted exposure exercises in clinic. For idiographic stimuli generation during the initial session, the clinician instructed participants to provide 8 pictures that represented their target OCD concerns (e.g., picture of a dirty toilet) and 8 neutral pictures (e.g., picture of an empty chair) using their camera or images from the internet.

CBM components—Similar to the information-processing assessment tasks, stimuli for the CBM training tasks were selected ideographically for each participant during the initial session with the clinician to capture the participant's OCD-related threat concerns.

Attention bias modification (ABM): ABM is a computer delivered attention modification program designed to enhance attention disengagement from threatening stimuli. The ABM protocol is identical to the attention bias assessment task with the following exceptions: (1) It consists of 288 trials and (2) the probe always appears in the location previously occupied by the neutral word. Thus, although there was no specific instruction to direct attention away from threat word, the position of the threat word indicated the position of the probe (i.e., in the location opposite the threat word). Each of the 288 trials included one neutral word and one OCD-related threat word: 2 (probe type) X 2 (probe position) X 2 (threat location) X 3 (repetitions) X 12 (word pairs). The ABM task took approximately 20 minutes for participants to complete.

For idiographic stimuli generation during the initial session, the clinician instructed participants to provide 24 words that represented their OCD concerns (e.g., "HIV") and 24 neutral words (e.g., "chair") that were then used for attention bias assessment (6 threat-

neutral word pairs for pre-assessment and 6 for post-assessment) and ABM (12 threat-neutral word pairs).

Attention control training program (ACTP): ACTP is a computer delivered attention training program designed to enhance attention control. This training task is similar to the attention control assessment task with the following exceptions: (1) the color of a fixation sign (green or red) signals whether the arrow will be in the same or opposite location as the word cue. The arrow appears in the same and opposite location from the negative word cues with equal frequency. Thus, unlike AMP, which is based on contingency of the probe and threat word location, this task trains attention according to explicit instructions about where to direction attention. (2) Participants are provided with feedback about the accuracy of their responses, and as their accuracy improves, they accrue points and move to more difficult levels in which the arrows are presented for shorter time durations. (3) The fixation sign informs participants of the reward contingency for that particular trial—for any given trial participants may gain or lose points based on their accuracy. The ACTP task took approximately 20 minutes for participants to complete.

For idiographic stimuli generation during the initial session, the clinician instructed participants to provide a list of 10 threat-related words (e.g., “dirty”), 10 neutral words (e.g., “table”), and 10 positive words (e.g., “ocean”) that was then split to use for attention control assessment (5 threat, 5 neutral, 5 positive words that were used for both pre- and post-assessment) and the ACTP (5 threat, 5 neutral, 5 positive words).

Interpretation bias modification program (IMP): IMP is a computer delivered interpretation modification program designed to increase benign interpretations and decrease threat interpretations of ambiguous stimuli. This training task is similar to the interpretation assessment task with the following exception: After each of the 80 trials participants receive feedback based on their endorsement of word and sentence relatedness. They receive positive feedback when they endorse benign interpretations or reject threat interpretations of the ambiguous sentences, and receive negative feedback when they endorse threat interpretations or reject benign interpretations. This feedback contingency is intended to reinforce a benign interpretation bias and extinguish the threat interpretation bias. The IMP task took approximately 7 minutes for participants to complete.

For idiographic stimuli generation during the initial session, the clinician instructed participants to provide 20 ambiguous sentences (e.g., “I stepped on something brown”), with one word that would skew the sentence towards a threat-related interpretation (e.g., “dog poop”) and one word that would skew it towards a benign interpretation (e.g., “twig”) that were then used for interpretation assessment and the IMP.

Working memory training program (WMT): WMT is a computer delivered working memory training program designed to improve working memory capacity. This training task is similar to the working memory assessment task with the following exceptions: (1) Participants were instructed to determine syntactical accuracy of sentences (e.g., “I in stepped dog-poop,” correct answer: no) instead of solving math equations, and (2) it

includes 30 trial sets instead of 15. The WMT task took approximately 15 minutes for participants to complete.

For idiographic stimuli generation during the initial session, the clinician instructed participants to provide 20 sentences related to their OCD concern (e.g., “I stepped in dog poop”) that were then used for the WMT task.

CBM control task (Control Condition; CC): The CC task was identical to the ABM except that during the presentation of the trials, the probe appeared with equal frequency in the position of threat and neutral words. Thus, neither threat nor neutral words have signal value with regard to the position of the probe. We used this task as an experimental control condition for the active CBM conditions. The CC task took approximately 20 minutes for participants to complete.

Note that information-processing assessments were administered immediately pre- and post- the respective CBM intervention week, rather than pre- and post- the entire treatment program (i.e., attention bias assessment pre- and post- the ABM and CC weeks, attention control assessment pre- and post- the ACTP week, interpretation bias assessment pre- and post- the IMP week, and working memory assessment pre- and post- the WMT week).

Self-conducted Exposure and Response Prevention (sERP)—Each sERP was selected from an exposure hierarchy generated collaboratively with the clinician prior to treatment initiation. Participants completed a minimum of two exposures per week (in the laboratory following each CBM) and one exposure at home. Additionally, participants were encouraged to complete as many additional self-conducted exposures as possible between treatment sessions (at home). Participants gradually moved up the exposure hierarchy, starting with an exposure situation rated as a 40 on a 0–100 anxiety scale in week 1, and moving to situations rated at 100 by week 5. Before each sERP, participants watched the psychoeducational video that provided them with information about how to complete the self-conducted exposure. Participants were given a stopwatch and tracking sheet and were instructed to stay engaged in the exposure exercise until their initial SUDS level dropped by half, or when 40 minutes were completed, whichever occurred first. Furthermore, participants were asked to record their SUDS level at 5–10 minute intervals throughout the exposure.

Statistical Analyses

Participants were classified as completers if they (a) completed at least four of the five CBM conditions, and (b) provided post-treatment assessment data. We compared completers and non-completers on demographic and clinical characteristics at pre-treatment using *t* tests and chi-squared analyses.

We examined symptom outcome and functional impairment measures separately for completer and intent-to-treat (ITT) samples. Analyses for the ITT sample were conducted using the last observation carried forward method. Because we had multiple measures for OCD, anxiety, and depression symptoms, we submitted pre- and post-treatment scores to a multivariate analysis of variance (MANOVA) for each symptom domain. Significant effects

of time for each MANOVA (OCD, anxiety, depression) were followed up with repeated measures ANOVAs for each measure. For OCD symptoms, we submitted pre- and post-treatment OCI-R subscale scores to a MANOVA to determine whether particular subscales appeared to drive effects. To examine treatment effects on functional impairment, we submitted pre- and post-treatment SDS scores to a repeated measures ANOVA.

We calculated responder status as the percentage of participants who no longer met diagnostic criteria for OCD at post-treatment. To examine clinical significance of the intervention as a whole we assessed reliable clinical change for Y-BOCS score, as suggested by Jacobson and Truax (1991, criterion C). This is defined as (a) having a post-treatment mean closer to that of the normal population than that of the non-functional population ($M = 15.95$ or below, normative data obtained from Steketee, Frost & Bogart, 1996) and (b) a reliable clinical change index (RCI) greater than 1.96 (Jacobson & Truax, 1991)¹.

To examine whether each of the CBM conditions resulted in reductions in OCD symptoms, we compared pre- and post- OCI-R scores corresponding to the beginning and end of each specific CBM condition in the intent-to-treat sample. To explore the efficacy of each of the CBM conditions, we used the intent-to-treat sample to examine (1) pre- to post-change in OCI-R for each of the four active CBM weeks (ABM, ACP, WMT, IMP) compared to the control condition (CC), (2) number of exposures during the four active CBM weeks compared to the control condition week, and (3) pre- to post-change in information-processing index specific to each CBM week. All change variables were calculated by subtracting post-week scores from pre-week score. Thus, higher scores for symptom change variables represent greater improvements. Effect sizes (Cohen, 1988) for t tests were calculated as follows: $d = (\text{pre-treatment mean} - \text{post-treatment mean})/\text{pooled standard deviation}$. Confidence intervals (95%) for Cohen's d were calculated using *Exploratory Software for Confidence Intervals* [ESCI; Cumming, 2012] (<http://www.latrobe.edu.au/psy/research/projects/esci>). We report η_p^2 for all ANOVA effects. Confidence intervals for η_p^2 were calculated using a 90% confidence interval to account for this effect size statistic always being a positive value (i.e., as are F tests); hence, one-sided tests are appropriate (Smithson, 2003).

Results

Treatment Completion and Utilization

Of the 22 participants who initiated treatment, 16 were classified as completers (73% completion rate). Non-completion was due to personal issues for the patient ($n = 2$), loss of contact with our clinic without providing a reason ($n = 2$), desire to discontinue participation for alternative treatment ($n = 1$), and alleviation of symptoms prior to completion of four treatment weeks ($n = 1$). Completers did not differ from non-completers on age, education,

¹We calculated Reliable clinical change (RCI) as follows (Jacobson & Truax, 1991):

$RCI = \frac{x_1 - x_2}{S_{diff}}$, $S_{diff} = \sqrt{2(S_E)^2}$, $S_E = s_1 \sqrt{1 - r_{xx}}$, x_1 = pre-assessment Y-BOCS mean, x_2 = post-assessment Y-BOCS mean, s_1 = standard deviation of current sample at pre-treatment, r_{xx} = test-retest reliability of the Y-BOCS. Test-retest reliability of .79 was obtained from Steketee, Frost, and Bogart (1996).

gender ethnicity, marital status or initial level of depression severity. However, OCD severity (Y-BOCS) was higher in non-completers compared to completers [$t(20) = -2.50$; $p = .021$; $d = 1.20$, 95% CI [0.18, 2.19]]. OCI-R scores at pre-treatment ranged from 12–57 in the completer sample ($M = 31.94$, $SD = 12.49$) and from 13–41 in the non-completer sample ($M = 33.33$, $SD = 10.52$) and were not significantly different.

Participants in the full sample completed an average of 4.09 of the five CBM conditions ($SD = 1.38$ range: 1 – 5) and an average of 4.88 CBM conditions in the completer sample ($SD = 0.34$, range: 4 – 5). On average, participants in the full sample completed 17 exposures during the treatment program ($SD = 10.60$, range: 1 – 55). This average was higher in the treatment completer sample ($M = 21.00$, $SD = 9.53$, range: 15 – 55).

Treatment Completer Sample

The MANOVA examining scores on Y-BOCS and OCI-R revealed a main effect of Time, $F(1, 15) = 33.39$, $p < .001$, $\eta_p^2 = .69$, 90% CI for η_p^2 [.40, .79]. Follow up ANOVAs for each measure were significant [Y-BOCS: $F(1, 15) = 55.06$, $p < .001$, $\eta_p^2 = .79$, 90% CI for η_p^2 [.55, .86]; OCI-R: $F(1, 15) = 12.70$, $p = .003$, $\eta_p^2 = .46$, 90% CI for η_p^2 [.12, .64]], indicating that scores on all OCD symptom measures were reduced from pre- to post-treatment (see Table 3 for means). In addition, a MANOVA examining OCI-R subscale scores indicated no Time X Subscale interaction, $F(5, 12) = 0.31$, $p = .813$, $\eta_p^2 = .12$, 90% CI for η_p^2 [.00, .13]. Follow up analyses suggested that all OCI-R subscales decreased significantly from pre- to post-treatment ($ps < .05$). The MANOVA conducted on the anxiety measures (STAI-T, HARS) revealed a main effect of time, $F(1, 15) = 24.43$, $p < .001$, $\eta_p^2 = .62$, 90% CI for η_p^2 [.30, .75]. Follow up ANOVAs indicated that participants experienced significant changes in anxiety symptoms for self-report symptoms [STAI-T: $F(1, 15) = 30.27$, $p < .001$, $\eta_p^2 = .67$, 90% CI for η_p^2 [.36, .78]], and for clinician ratings [HARS: $F(1, 15) = 5.67$, $p = .03$, $\eta_p^2 = .27$, 90% CI for η_p^2 [.02, .50]] (see Table 3 for means).

The MANOVA conducted for depression symptoms (BDI-II, HAMD) revealed a main effect of time, $F(1, 15) = 16.14$, $p = .001$, $\eta_p^2 = .52$, 90% CI for η_p^2 [.18, .68]. Participants experienced significant reductions in scores on both the BDI-II, $F(1, 15) = 11.73$, $p = .004$, $\eta_p^2 = .44$, 90% CI for η_p^2 [.11, .62], and HAMD, $F(1, 15) = 14.66$, $p = .002$, $\eta_p^2 = .49$, 90% CI for η_p^2 [.16, .66] (see Table 3 for means).

Participants experienced a significant reduction in functional impairment from pre- to post-treatment, as measured by the SDS, $F(1, 15) = 25.62$, $p < .001$, $\eta_p^2 = .63$, 90% CI for η_p^2 [.31, .75].

ITT Sample

Outcomes for symptom measures were similar for completer and ITT samples. For the ITT sample, the MANOVA examining scores on Y-BOCS and OCI-R revealed a main effect of Time, $F(1, 21) = 33.38$, $p < .001$, $\eta_p^2 = .61$, 90% CI for η_p^2 [.35, .73]. Follow up ANOVAs for each measure were significant [Y-BOCS: $F(1, 21) = 28.83$, $p < .001$, $\eta_p^2 = .58$, 90% CI for η_p^2 [.31, .71]; OCI-R: $F(1, 21) = 16.16$, $p = .001$, $\eta_p^2 = .44$, 90% CI for η_p^2 [.15, .60]],

indicating that scores on all OCD symptom measures were reduced from pre- to post-treatment. In addition, a MANOVA examining OCI-R subscale scores indicated no Time X Subscale interaction, $F(1, 17) = 0.18, p = .967, \eta_p^2 = .05$, 90% CI for η_p^2 [.00, .17]. Follow up analyses suggested that all OCI-R subscales decreased significantly from pre- to post-treatment ($ps < .04$).

The MANOVA conducted on anxiety measures (STAI-T, HARS) revealed a main effect of time, $F(1, 21) = 19.15, p < .001, \eta_p^2 = .48$, 90% CI for η_p^2 [.19, .63]. Follow up ANOVAs indicated that participants experienced significant changes in anxiety symptoms for self-report symptoms [STAI-T: $F(1, 21) = 23.62, p < .001, \eta_p^2 = .53$, 90% CI for η_p^2 [.25, .67]] and clinician ratings [HARS: $F(1, 21) = 4.76, p = .04, \eta_p^2 = .19$, 90% CI for η_p^2 [.004, .40]].

The MANOVA conducted for depression symptoms (BDI-II, HAM-D) revealed a main effect of time, $F(1, 21) = 14.67, p = .001, \eta_p^2 = .41$, 90% CI for η_p^2 [.13, .59]. Participants experienced significant reductions in scores on both the BDI-II, $F(1, 21) = 10.40, p = .004, \eta_p^2 = .33$, 90% CI for η_p^2 [.07, .52], and HAM-D, $F(1, 21) = 14.21, p = .001, \eta_p^2 = .40$, 90% CI for η_p^2 [.13, .58].

The ANOVA of SDS scores from pre- to post-treatment indicated that participants experienced a significant reduction in functional impairment from pre- to post-treatment, $F(1, 21) = 20.99, p < .001, \eta_p^2 = .50$, 90% CI for η_p^2 [.22, .65].

Clinical Significance

At post-treatment, 7 of 16 treatment completers (44%) no longer met diagnostic criteria for OCD. Based on criteria outlined by Jacobson & Truax (1991), 9 of 16 (56%) patients experienced reliable clinical change for OCD symptoms at post-treatment.

Maintenance of Treatment Gains

Follow-up data were obtained from 9 of 16 treatment completers. Follow-up data were provided, on average, 4 months, 9 days following treatment completion. The MANOVA examining scores on Y-BOCS and OCI-R, revealed a main effect of time, $F(2, 7) = 13.25, p = .004, \eta_p^2 = .79$, 90% CI for η_p^2 [.28, .86]. ANOVAs conducted separately for each measure indicated that for YBOCS scores, participants experienced a decrease from pre-treatment to follow-up [$F(1, 8) = 21.32, p = .002, \eta_p^2 = .73$, 90% CI for η_p^2 [.28, .83]] as well as from post-treatment to follow-up [$F(1, 8) = 5.86, p = .042, \eta_p^2 = .42$, 90% CI for η_p^2 [.01, .65]]. For the OCI-R, participants experienced a decrease in scores from pre-treatment to follow-up [$F(1, 8) = 19.14, p = .002, \eta_p^2 = .71$, 90% CI for η_p^2 [.26, .82]], but scores did not significantly differ from post-treatment to follow-up [$F(1, 8) = 2.55, p = .149, \eta_p^2 = .24$, 90% CI for η_p^2 [.00, .52]]. These results indicate that treatment gains were maintained between post-assessment and follow-up assessment.

The MANOVA conducted on the anxiety measures (STAI-T, HARS) revealed a main effect of time, $F(2, 7) = 14.53, p = .003, \eta_p^2 = .81$, 90% CI for η_p^2 [.19, .88] as well as Time X Measure interaction, $F(2, 7) = 15.14, p = .003, \eta_p^2 = .81$, 90% CI for η_p^2 [.33, .87]. ANOVAs conducted separately for each measure indicated that for self-rated anxiety (STAI-T), participants experienced a decrease from pre-treatment to follow-up [$F(1, 8) = 15.66, p$

$= .004$, $\eta_p^2 = .66$, 90% CI for η_p^2 [.20, .79]] but experienced no change from post-treatment to follow-up [$F(1, 8) = 0.003$, $p = .96$, $\eta_p^2 < .001$, 90% CI for η_p^2 [.00, .01]]. For clinician rating of anxiety (HARS), participants did not experience a decrease in scores from pre-treatment to follow-up [$F(1, 8) = 2.36$, $p = .163$, $\eta_p^2 = .23$, 90% CI for η_p^2 [.00, .51]] nor from post-treatment to follow-up [$F(1, 8) = 0.23$, $p = .648$, $\eta_p^2 = .03$, 90% CI for η_p^2 [.00, .29]].

The MANOVA conducted for depression symptoms (BDI-II, HAM-D) revealed a main effect of time, $F(2, 7) = 5.93$, $p = .031$, $\eta_p^2 = .63$, 90% CI for η_p^2 [.04, .75], as well as a Time X Measure interaction, $F(2, 7) = 7.19$, $p = .020$, $\eta_p^2 = .67$, 90% CI for η_p^2 [.09, .78]. ANOVAs conducted separately for each measure indicated that for self-rated depression (BDI-II), participants experienced a decrease from pre-treatment to follow-up [$F(1, 8) = 14.53$, $p = .005$, $\eta_p^2 = .65$, 90% CI for η_p^2 [.18, .76]] but experienced no change from post-treatment to follow-up [$F(1, 8) = 0.46$, $p = .52$, $\eta_p^2 = .05$, 90% CI for η_p^2 [.00, .33]]. For clinician rating of depression (HAM-D), participants experienced a marginally significant decrease in scores from pre-treatment to follow-up [$F(1, 8) = 4.27$, $p = .073$, $\eta_p^2 = .35$, 90% CI for η_p^2 [.00, .60]] and experienced no change from post-treatment to follow-up [$F(1, 8) < 0.001$, $p > .999$, $\eta_p^2 < .001$, 90% CI for η_p^2 [.00, .004]].

Participants experienced significantly reduced functional impairment from pre-treatment to follow-up, as measured by the SDS, $F(1, 8) = 10.55$, $p = .012$, $\eta_p^2 = .57$, 90% CI for η_p^2 [.10, .74], suggesting treatment gains were maintained. Significant reductions were not found between post-treatment and follow-up $F(1, 8) = 1.72$, $p = .226$, $\eta_p^2 = .18$, 90% CI for η_p^2 [.00, .47].

Changes Occurring Following Psychoeducation Videos

Participants experienced, on average, a 3.33 points reduction in OCI-R scores between their initial intake session and the start of their first CBM Condition, corresponding to the time during which they viewed the assigned psychoeducation videos but prior to the onset of CBM. This decrease in OCD symptoms was statistically significant, $t(17) = 2.33$, $p = .033$, $d = 0.30$, 95% CI [0.02, 0.56].²

Changes by CBM Condition

The results presented above provide evidence for the efficacy of our treatment program as a whole for the completer sample and for the intent-to-treat sample. The following results for the intent-to-treat sample present evidence for the relative efficacy of the active CBM conditions administered per week:

ABM—Results of a one-sample t -test of OCI-R change scores for the CBM weeks revealed a non-significant decrease in OCI-R after the ABM week, $t(15) = 1.05$, $p = .312$, $d = 0.14$, 95% CI [-0.13, 0.40] (see Figure 1). Change in OCI-R for the ABM week was not significantly different from change in OCI-R for the CC week, $t(14) = 0.59$, $p = .565$, $d =$

²Change scores for the time corresponding to the psychoeducational video week were unavailable for four participants who failed to complete the OCI-R at the end of that week.

0.25, 95% CI for d [-0.47, 0.97]. The number of exposures completed during the ABM week was not significantly different from the number of exposures completed during the CC week, $t(14) = -0.58$, $p = .573$, $d = -0.12$, 95% CI for d [-0.54, 0.30]. Results of a paired sample t -tests to examine pre- to post-change in the information-processing index specific to each CBM condition revealed that the attention bias index did not change significantly pre- to post ABM week, $t(14) = 1.05$, $p = 0.31$, $d = 0.48$, 95% CI [-0.44, 1.39].

ACTP—Results of a one-sample t -test of OCI-R change scores for the CBM weeks revealed a significant decrease in OCI-R after the ACTP week, $t(18) = 2.22$, $p = .04$, $d = 0.31$, 95% CI [0.01, 0.59] (see Figure 1). Change in OCI-R for the ACTP week was not significantly different from change in OCI-R for the CC week, $t(18) = 1.47$, $p = .159$, $d = 0.56$, 95% CI for d [-0.09, 1.21]. The number of exposures completed during the ACTP week was not significantly different from the number of exposures completed during the CC week, $t(17) = 0.53$, $p = .601$, $d = 0.10$, 95% CI for d [-0.27, 0.46]. Results of a paired sample t -tests to examine pre- to post-change in the information-processing index specific to each CBM condition revealed that the attention control index increased significantly pre- to post ACTP week [$t(13) = -2.13$, $p = .05$, $d = 0.56$, 95% CI [-0.01, 1.10]] such that response latencies were smaller pre- to post ACTP week for both invalid neutral trials [$t(13) = 3.34$, $p = .005$, $d = 0.55$, 95% CI [0.16, 0.93]] and valid neutral trials [$t(13) = 6.12$, $p < .001$, $d = 0.91$, 95% CI [0.45, 1.36]]. Whereas participants did not demonstrate a difference in responding to valid and invalid neutral trials at the pre-ACTP assessment [$t(13) = 1.60$, $p = .133$, $d = 0.22$, 95% CI [-0.06, 0.49], they were significantly faster to respond to valid neutral cues relative to invalid neutral trials at the post-ACTP assessment [$t(13) = 5.14$, $p < .001$, $d = 0.56$, 95% CI [0.25, 0.85]].

IMP—Results of a one-sample t -test of OCI-R change scores for the CBM weeks revealed a significant decrease in OCI-R after the IMP week, $t(16) = 2.35$, $p = .032$, $d = 0.39$, 95% CI [0.03, 0.74] (see Figure 1). Change in OCI-R in for the IMP week was larger than change in OCI-R for the CC week, $t(15) = 2.12$, $p = .05$, $d = 0.48$, 95% CI for d [-0.23, 1.18]. The number of exposures completed during the IMP week was not significantly different from the number of exposures completed during the CC week, $t(16) = -1.02$, $p = .324$, $d = -0.23$, 95% CI for d [-0.69, 0.23]. Results of a paired sample t -tests to examine pre- to post-change in the information-processing index specific to each CBM condition revealed that the interpretation bias index increased significantly pre- to post IMP week [$t(12) = 4.79$, $p < .001$, $d = 1.89$, 95% CI [0.79, 2.94]].

WMT—Results of a one-sample t -test of OCI-R change scores for the CBM weeks revealed a non-significant decrease in OCI-R after the WMT week, $t(18) = 1.63$, $p = .262$, $d = 0.13$, 95% CI [-0.10, 0.36] (see Figure 1). Change in OCI-R for the WMT week was not significantly different from change in OCI-R for the CC week, $t(16) = -0.47$, $p = .644$, $d = -0.17$, 95% CI for d [-0.85, 0.50]. The number of exposures completed during the WMT week was not significantly different from the number of exposures completed during the CC week, $t(16) = -0.92$, $p = .370$, $d = -0.21$, 95% CI for d [-0.67, 0.25]. Results of a paired sample t -tests to examine pre- to post-change in the information-processing index specific to

each CBM condition revealed that the working memory index did not change significantly pre- to post WMT week [$t(16) = 0.27, p = 0.79, d = 0.08, 95\% \text{ CI} [-0.47, 0.62]$].

CC—Results of a one-sample t -test of OCI-R change scores for the CBM weeks revealed no change in OCI-R after the CC week, $t(18) = -0.04, p = .97, d = 0.004, 95\% \text{ CI} [-0.21, 0.20]$ (see Figure 1). Results of a paired sample t -tests to examine pre- to post-change in the information-processing index specific to each CBM condition revealed that the attention bias index did not change significantly pre- to post CC week [$t(16) = -0.14, p = 0.89, d = 0.05, 95\% \text{ CI} [-0.66, 0.76]$].

Discussion

In this multiple baseline Latin Square design we examined the feasibility of a treatment program for OCD that integrates self-conducted ERP with Cognitive Bias Modification. Results of this study suggest that participants may be able to complete this program with minimal therapist guidance. Moreover, our results provide preliminary support that pairing CBM techniques with sERP may lead to a significant reduction of obsessive-compulsive symptoms, anxiety symptoms, depression symptoms and functional impairment. Symptom reduction was evident across self-report and clinician-administered measures and was maintained at follow-up. Moreover, 7 of the 16 completers no longer met diagnostic criteria for OCD upon completion of treatment. These outcomes, although preliminary, are remarkable in that they are comparable to that of the gold standard clinician-administered ERP (Foa et al., 2005), which comprises at least 15 sessions with a clinician trained in treatment of OCD, as opposed to the initial sessions with a clinician in the current study.

Examination of OCD symptom change pre- to post- CBM week revealed significant symptom reduction for the IMP and ACTP conditions, and significantly larger symptom reduction in the IMP week relative to the week of the control condition. Moreover, examination of pre- to post-change in the information-processing index specific to each CBM condition revealed significant improvements in interpretation bias after the IMP week and attention control after the ACTP week. These weekly data suggest that, whereas the control condition does not affect information-processing bias or OCD symptoms, the active CBM interventions – IMP and ACTP in particular – are effective in reducing the relevant information-processing biases and improving symptoms of OCD. We note that in order to minimize patient burden with generation of idiographic sentences, we used the same sentence set for assessment and modification in the IMP week. This increases the possibility of response bias; therefore, an important task in future research will be to validate changes in interpretation bias with a novel stimuli set for assessment. More notably, however, the fact that symptom reduction in the IMP week was significantly larger than in the experimental control week provides preliminary evidence for the use of this CBM intervention as a way to augment the effect of self-conducted exposures for OCD. Although the quantity of exposures did not differ amongst the CBM weeks, it may be the case that the quality of exposures did. To the extent that exposure compliance refers to both quantity and quality of exposures, our results are consistent with the possibility that IMP resulted in improved exposure compliance. We note however, that the current data do not address

directly the issue of exposure quality; therefore future research is needed to test this hypothesis.

Although these results are promising, our study has additional limitations that render our findings tentative until replicated. The first limitation concerns our study design. In our multiple baseline Cyclic Latin Square design, we included an inactive CBM condition that allowed us to make inferences regarding the effects of the active CBM conditions; however, the lack of a no-treatment control group tempers our conclusions regarding pre-to-post study outcomes because we did not control for randomization of participants or the effects of history, maturation and treatment expectancies. It is notable however, that the current sample presented with moderate to severe symptoms of OCD and a chronic course of illness. Given the negligible placebo response in OCD and the fact that OCD rarely remits spontaneously (Foa et al., 2005; Mavissakalian, Jones, & Olson, 1990) it seems unlikely that non-specific treatment or maturation effects alone would produce the observed treatment gains. A second limitation of our study is the small sample size, which precluded the possibility of testing for mediation of CBM effects due to being underpowered. This poses limitations on our ability to make clear claims about the mechanisms of change in our study and highlights the preliminary nature of our findings. While previous CBM studies have included behavioral approach tasks as outcome measures (e.g., ABM for contamination fears; Najmi & Amir, 2010; ABM for social anxiety disorder; Heeren et al., 2012), we did not do so in the current study. One reason for this was due to the heterogeneous nature of OCD concerns in our sample, thus rendering standardization of a single behavioral approach task challenging. Nonetheless, future research should focus on methodology for examining behavioral outcomes for clinical OCD similar to the behavioral avoidance test used by Steketee and colleagues (Steketee, Chambless, Tran, Worden & Gillis, 1996). Another limitation of our sample is that it has a lower rate of Axis I comorbidity (23%) than is typical for OCD (e.g., 62% reported by Torres et al., 2006). Our analyses suggested that treatment non-completers had significantly higher YBOCS scores at pre-treatment ($M = 33.67$) than did the completer sample ($M = 29.07$). Although this was not true of baseline OCI-R scores, differences in YBOCS suggest the possibility that our self-conducted program may be too demanding for individuals with extreme OCD. Nonetheless, the mean baseline YBOCS for completers was in the severe range, suggesting that the program may be feasible for most OCD patients. Although the study included a 3-month follow-up assessment, another limitation of the study is the absence of longer-term follow-up assessments, which precludes the possibility of establishing longevity of treatment effects. Another limitation of our study is that we do not know the extent to which our approach practice task using the AAT might have contributed to outcomes. In future studies we need to dismantle the varying effects of our treatment program: psychoeducational videos, approach practice, self-conducted ERP, and each of the CBM interventions. Furthermore, across the CBM interventions we have the potential of differences in engagement; for example, the ACTP is more like a video game in that it incorporates reinforcement contingencies whereas the other tasks do not. In future studies we need to dismantle the effects of the differing parameters within each CBM intervention. Our study is also limited by the lack of standardization of clinician contact. Although the total contact time with the RA averaged approximately 5–10 minutes per session, the amount of time spent with a

clinician after the initial session varied by participant, and ranged from 15–20 minutes ($n = 13$) to two hours ($n = 2$) over the five CBM treatment weeks. Although study interviewers were doctoral level clinicians with extensive training in assessment and treatment of OCD, our study is limited by lack of formal inter-rater reliability data. Another point to note is that, although OCI scores for the CBM interventions were not affected by the sequence of interventions (all $ps > .37$), we acknowledge that our sample is underpowered for this analysis. The counterbalancing in our study was based on a Cyclic Latin Square design such that the temporal sequence of interventions was counterbalanced but the order within each sequence was not. However, the size of our sample precluded the possibility of examining the interaction amongst the CBM interventions. It is a sound hypothesis that cognitive biases do not operate in isolation but rather may influence one another and interact differentially to produce symptom change (e.g., Hirsch, Clark, & Mathews, 2006). Thus, it is a limitation of our study that we were not able to examine this hypothesis. Finally, we note that the change in OCI-R scores during each CBM week -- although statistically significant for the IMP and ACTP weeks -- was small, which suggests the possibility that a different measure of OCD symptoms might be better suited for addressing our study aims.

A follow-up randomized controlled trial with a larger sample size is the next step required to establish the validity of these findings. Due to limitations discussed above, our results for the efficacy of our program should be considered tentative; however, they do suggest that it is feasible for participants to complete self-conducted ERP and CBM with minimal therapist guidance. Thus, findings from this small study, although preliminary, are provocative, especially in light of the negligible placebo response for OCD. These results suggest that this novel treatment, which requires only an initial session with a clinician trained in ERP for OCD, has the potential to increase both the accessibility and acceptability of self-conducted ERP for patients with OCD.

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Figure 1.
Change in OCI-R from start to end of each CBM week

Table 1

Procedure Overview

Session	Tasks
Intake	Self-report questionnaires, clinical interview, idiographic stimuli collection.
Videos	Psychoeducation videos to be completed over a six day period
Weekly CBM Session-1 (in clinic)	Self-report questionnaires, post information-processing assessment from previous week's CBM training (weeks 2–5), pre information- processing assessment for current week's CBM training, Session-1 training, Approach Practice task, exposure video & sERP.
Weekly CBM Session-2 (at home)	Session-2 training, exposure video & sERP
Weekly CBM Session-3 (in clinic)	Session-3 training, Approach Practice task, exposure video & sERP.
Post	Self-report questionnaires, clinical interview

Note. sERP: Self-Conducted Exposure

Table 2

Example of counterbalancing between participants

	Week 1	Week 2	Week 3	Week 4	Week 5
Participant A	ABM	CC	ACTP	WMT	IMP
Participant B	CC	ACTP	WMT	IMP	ABM
Participant C	ACTP	WMT	IMP	ABM	CC
Participant D	WMT	IMP	ABM	CC	ACTP
Participant E	IMP	ABM	CC	ACTP	WMT

Note. ABM: Attention Bias Modification Program, CC: CBM control condition; ACTP: Attention Control Training paradigm; WMT: Working Memory Training; IMP: Interpretation Modification Program

Table 3

Pre/Post Study Means

	ITT Sample	Completers		
Measure	Pre (N=22)	Pre (N=16)	Post (N=16)	FU (N=8)
Y-BOCS	30.32 (4.30)	29.06 (4.37)	16.50 (7.23)	15 (10.61)
OCI-R	32.32 (11.76)	31.94 (12.49)	19.31 (10.77)	13.25 (6.48)
STAI-T	63.18 (7.05)	62.81 (7.75)	47.12 (13.43)	44.75 (14.46)
HARS	15.23 (9.10)	13.94 (5.81)	10.75 (6.94)	9.63 (12.28)
BDI -II	27.18 (11.28)	28.25 (11.52)	15.75 (10.57)	12.75 (14.56)
HAMD	13.18 (7.29)	13.44 (6.76)	8.00 (5.59)	7.88 (8.81)
SDS	23.23 (3.75)	22.88 (4.16)	12.94 (8.18)	11.00(8.78)