Does D-cycloserine facilitate the effects of homework compliance on social anxiety symptom reduction?☆

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ABSTRACT

Background: Prior studies examining the effect of D-cycloserine (DCS) on homework compliance and outcome in cognitive-behavior therapy (CBT) have yielded mixed results. The aim of this study was to investigate whether DCS facilitates the effects of homework compliance on symptom reduction in a large-scale study for social anxiety disorder (SAD).
Methods: 169 participants with generalized SAD received DCS or pill placebo during 12-session exposure-based group CBT. Improvements in social anxiety were assessed by independent raters at each session using the Liebowitz social anxiety scale (LSAS).
Results: Controlling for LSAS at the previous session, and irrespective of treatment condition, greater homework compliance in the week prior related to lower LSAS at the next session. However, DCS did not moderate the effect of homework compliance and LSAS, LSAS on homework compliance, or the overall augmenting effect of DCS on homework compliance. Furthermore, LSAS levels were not predictive of homework compliance in the following week.
Conclusion: The findings support the general benefits of homework compliance on outcome, but not a DCS-augmenting effect. The comparably small number of DCS-enhanced sessions in this study could be one reason for the failure to find a facilitating effect of DCS.

1. Introduction

Social Anxiety Disorder (SAD) is a debilitating disorder and its symptomology causes severe impairment for many adults in how they interact with others in both the workplace, as well as in social situations. With a 7.4% 12-month prevalence rate, and a lifetime prevalence of 10.7%, it is a common anxiety disorder in adults and children (Kessler, Berglund et al., 2005; Kessler, Chiu, Demler, & Walters, 2005; Kessler, Petukhova, Sampson, Zaslavsky, & Wittchen, 2012). The disorder is manifested as a fear of negative evaluation from others in one or more social situations (American Psychiatric Association, 2013). The current best practice for treating SAD in adults is a regimen of Cognitive Behavioral Therapy (CBT) with exposure sessions (Morrison & Heimberg, 2013). Notwithstanding, research has shown that CBT is not

always effective in producing remission, with the estimates for reaching high end-state functioning in group CBT treatment ranging between 25 and 60% (Davidson et al., 2004; Gregory, Peters, Abbott, Gaston, & Rapee, 2015; Otto et al., 2000), and treatment non-response rate reaching as high as 50% with those who have SAD (Davidson et al., 2004; Loerinc et al., 2015). Consequently, an important and relevant area of research in CBT treatments is investigating treatment mechanism to improve efficacy.

A core component of CBT is homework assignments, comprised of daily between-session practices of the techniques taught in session. Studies investigating homework compliance as a predictor of outcome in CBT find that patients who practice CBT techniques between sessions have significantly better treatment outcomes than those who do not. In an analysis of CBT long-term outcome, Glenn et al. (2013) showed

superior outcome at 12 and 18 months follow-up in individuals completing more homework, sessions, and exposures during treatment. In a *meta*-analysis of 27 studies (*N* = 1702), Kazantzis, Deane, and Ronan (2000) found that homework compliance was a significant predictor of outcome, with a small to medium effect size (d = 0.22). However, they did not assess whether homework compliance differed between individual and group treatments. A recent *meta*-analysis (years 2000–2008), based on 23 studies (*N* = 2183), confirmed a significant relationship between homework compliance and treatment outcome; but again with only a small to medium effect size (Mausbach, Moore, Roesch, Cardenas, & Patterson, 2010). This study considered both group and individual therapy; however, they did not examine whether there were differences in terms of homework compliance.

Homework compliance within an exposure-based CBT protocol may be particularly beneficial for those with social anxiety because they can apply in-session techniques directly in real life social situations. However, past research on the efficacy of homework compliance within this population is inconclusive. Woody and Adessky (2002) observed that homework compliance during the course of cognitive behavioral group therapy for socially anxious patients did not affect treatment outcome. By contrast, Leung and Heimberg (1996) found that overall homework compliance predicted decreased social anxiety at post-treatment in the context of cognitive behavioral group therapy. Furthermore, those who were more compliant at the beginning of treatment had lower post-treatment scores on fear of social interactions. However, those who were more compliant mid-treatment had lesser improvements on anxiety about social evaluation and scrutiny at the end of treatment (Leung & Heimberg, 1996). As noted above, homework compliance could also benefit social anxiety patients long-term by helping to reduce anxiety and avoidance months after treatment completion. As demonstrated by Edelman and Chambless (1995), greater adherence to homework instruction did not influence outcome during group CBT treatment (except for fear of negative evaluation), but treatment compliant patients had less anxiety, avoidance, and severity at 6-month follow-up while completing a behavioral activation test. No relationship between baseline symptom severity and homework was found (Edelman & Chambless, 1995). Taken together, these findings lend support to the general benefits of homework compliance on outcome in CBT, and in SAD specifically. Thus, facilitating homework compliance (quantity and quality) should be targeted.

One such avenue could be through the use of pharmacological agents. A biological agent that has been shown to have treatment facilitating qualities in CBT is D-Cycloserine (DCS). Specifically, DCS is thought to facilitate long-term consolidation of extinction learning (Kazantzis et al., 2016; and Hofmann et al., 2006, 2013 for DCS in SAD). In a *meta*-analysis of the effect of DCS (compared to placebo) on the efficacy of exposure based CBT for treatment of anxiety disorders, Mataix-Cols et al. (2017) found that patients receiving DCS-enhanced CBT showed significantly greater improvement in symptoms from pretreatment to post-treatment than those receiving placebo-enhanced CBT. Furthermore, for a subset of four studies in which they had investigated the effects of DCS-enhanced CBT on outcome in SAD, patients receiving DCS showed greater pre-to-post-treatment improvement and greater pre-to-follow-up improvement than patients receiving placebo (see Mataix-Cols et al. (2017) supplemental materials). In relation to enhancing homework compliance, Park et al. (2013) proposed that because DCS may augment fear extinction during in-session treatment exposure, and facilitate long-term consolidation of extinction learning, it could thereby also facilitate homework exposures. Patients would learn more in the sessions and hence believe it is easier to complete homework. However, their own study of 30 youth with obsessive-compulsive disorder (OCD), who were assigned to one of two conditions, individual CBT plus DCS or individual CBT plus placebo, was unable to find an enhancing effect of DCS on homework compliance. Olatunji et al. (2015) proposed a different causal relation between DCS and homework compliance: DCS would enhance CBT

primarily for those actually compliant with between-session exposure homework. Using a similar study population and sample size as Park et al. (2013), they found higher homework compliance related to lower OCD severity in the DCS-enhanced condition, but not in the placebo condition. However, as in Park et al. (2013), they did not find an increase in homework compliance in DCS-enhanced condition. Olatunji et al. (2015) theorized that homework compliance would therefore act as a mechanism by which DCS augments extinction learning due to continued practice.

The aim of the present study was to further examine the effects of homework compliance on symptom reduction in a large-scale DCS-enhanced group-CBT study for adults with SAD (Hofmann et al., 2013). Patients were randomly assigned to group CBT with DCS or group CBT with pill placebo. Based on prior studies, we hypothesized that those patients who are higher in homework compliance at each week of treatment will have lower LSAS scores in the following week's treatment session (hypothesis 1). Further, we expect this relation to be stronger for those in DCS than those in placebo (PBO) (hypothesis 2). Likewise, we also expected that lower LSAS at a session will improve homework compliance in the following week (hypothesis 3).

2. Methods

2.1. Participants

Patients were recruited for a study examining the effects of DCS on cognitive behavioral therapy (Hofmann et al., 2013). They were 169 adult outpatients with a primary diagnosis of generalized social anxiety disorder. Patients were recruited in Dallas and Boston from clinical facilities and programs through referrals. Diagnosis was determined using structured clinical interviews (ADIS; Dinardo, Brown, Barlow, Brown, & Barlown, 1994, SCID-IV; First, Spitzer, Gibbon, & Williams, 1996). Participants were predominantly male (56.80%) and White (72.19%) (African American (9.47%), Asian (11.83%), Hispanic or Latino (10.65%) and other (6.51%)). The mean age was 32.6 years (*SD* = 10.36). The majority was single (61.54%) (living with a partner (8.88%), married (24.26%), separated, widowed or divorced (5.33%)) and employed full time (49.70%) (unemployed (11.83%), employed part time (13.02%), student or dependent on spouse (20.12%), missing (0.59%). 40.8% reported having a college degree (graduate (26.63%), partial college (26.04%), high school or partial high school degree (6.4%)). Inclusion criteria for the study was: 1) a primary diagnosis of Generalized Social Anxiety Disorder according to the DSM-IV; 2) a score on the Liebowitz Social Anxiety Scale of 60 or higher (LSAS; Liebowitz, 1987); 3) between the ages of 18 and 65, 4) willingness to participate in CBT treatment and take pharmacological treatment. Exclusion criteria included: 1) clinically significant abnormalities, medical illness, or cognitive illness; 2) lifetime history of seizures, organic brain syndrome, mental retardation, cognitive dysfunction, head trauma, OCD, Bipolar Disorder, Psychosis, Schizophrenia, or delusional disorders; 3) eating or substance use disorders (except nicotine), PTSD, or significant suicidal ideation in the last 6 months 4) pregnant, lactating or not using medically accepted forms of contraception, or current treatment with isoniazid 5) prior nonresponse to adequately delivered exposure treatment. No concurrent psychotropic medication (e.g., antidepressants, anxiolytics, betablockers) for at least 2 weeks prior to study entry was required and also 3 months for any concurrent psychotherapy that was targeting symptoms of social anxiety disorder except for general supportive therapy.

2.2. Measures

2.2.1. Outcome measure

Liebowitz Social Anxiety Scale (LSAS). LSAS is a 24-item clinician administered questionnaire which measures social anxiety symptoms. The items involve social situations that may provoke SAD symptoms.
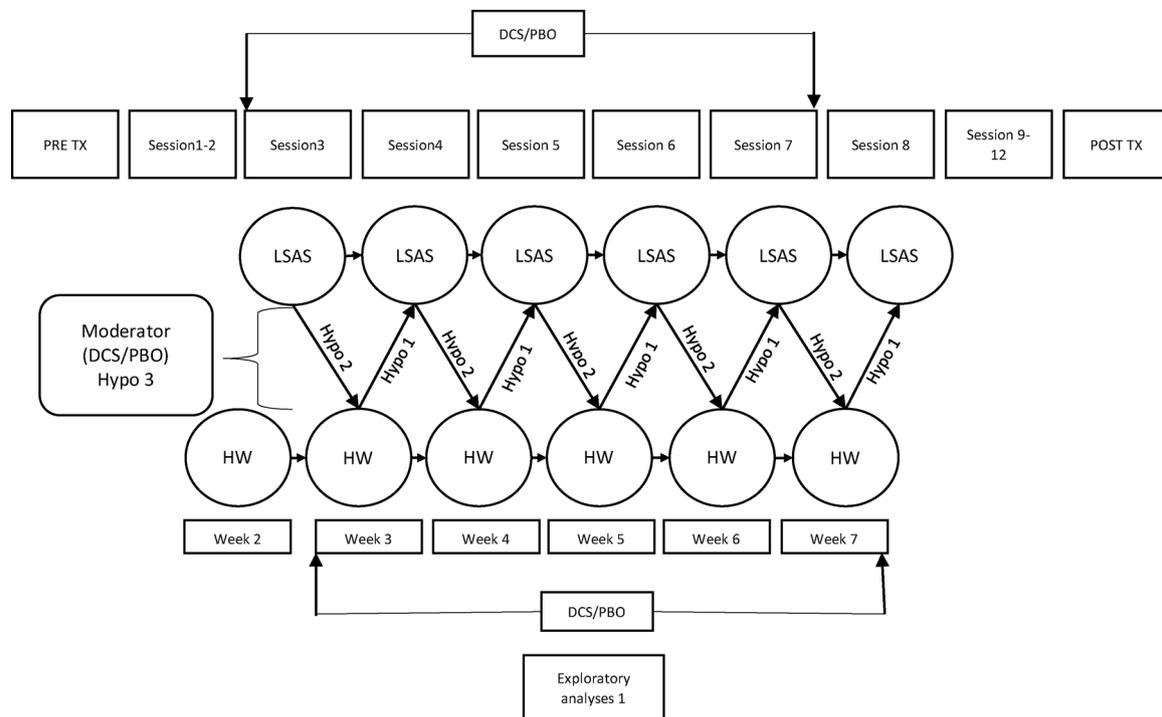
Fig. 1. Timeline of data collection and treatment condition allocation.

On each item, the clinician rates the patient on 1) fear or anxiety [0 (*none*) to 3 (*severe*)], and 2) avoidance of the situation 0 [(*never 0%*) to 3 (*usually 67–100%*)]. Improvement in social anxiety was assessed by independent raters at each session and at post-treatment by raters who were blind to treatment assignment. LSAS has been used extensively and has good psychometric properties including a high internal consistency Cronbach's alpha of 0.96 (Heimberg et al., 1999).

2.2.2. Homework compliance

Homework compliance during the previous week was assessed at treatment sessions 2–8, 10, and 12 by the therapist to minimize self-report bias. Homework compliance was comprised of three measures:

1) *Completion*. Homework completion was a Likert scale with scores that ranged from 1 (*"Patient did not attempt assigned homework"*) through 5 (*"the patient did more of the assigned homework or its equivalent than was requested"*).
2) *Effort*. Homework effort was rated from a 0 (*"patients made no attempt to complete any homework"*) through 4 (*"patient made maximal efforts to compete homework"*).
3) *Relevance*. Homework relevance centered on whether the homework the patient completing during the week was related to their fear hierarchy. The relevance scale was rated from a 0 (*"homework attempted was completely unrelated to particular target problems or homework was not done"*) through 4 (*"homework attempted relevant to particular target problems"*).

The three separate homework items were highly correlated: Completion was correlated r = 0.77 with Effort and r = 0.68 with Relevance. The correlation between Effort and Relevance was r = 0.67. Thus, the three homework compliance items were z-scored and combined into a single scale, with Cronbach's α = 0.88.

2.3. Treatments

The CBT approach used in the current study was modeled after both the Hope, Heimberg, and Turk (2006) and Hofmann and Otto (2008)

approach to group CBT. The CBT protocol consisted of 12 weekly sessions of group therapy lasting 2.5 h each. The therapy sessions were kept small with 4–6 patients in each group led by 2 therapists. In session 1, patients completed psychoeducation about SAD and how it would be treated during the course of therapy. Session 2 introduced and elaborated on cognitive restructuring during treatment. Sessions 3–7 focused on exposure of patients to their fears. Throughout exposure sessions, clients were led in confronting their feared situations for prolonged periods of time repeatedly. Homework assignments during this exposure modules included: public speaking, returning goods to stores, calling strangers and other social evaluative activities. Therapist tailored the exposure homework for each client during the group therapy sessions. The last 5 sessions of the CBT protocol consisted of continued exposure practice; yet at the same time, therapist introduced cognitive restructuring strategies. Study therapists were trained and supervised weekly by senior clinicians.

2.4. Study medication

Participants were randomly assigned to CBT plus 50 mg of DCS study pill (*n* = 87) or CBT plus a pill placebo (PBO) (*n* = 82). Low doses of DCS, as in the 50 mg being used in the current study, have been shown to be effective in the literature (Rodrigues et al., 2014). The placebo pill looked the same as the DCS pill but was filled with polyethylene glycol 3350 powder. Both the DCS pill and placebo were administered to participants an hour before the exposure sessions 3–7 by either a nurse or psychiatrist. The groups did not differ significantly on any demographic information except gender. There were significantly more males 64% in the DCS augmentation group than in the placebo 49%.

3. Data analytic overview

Data were analyzed using multilevel models (MLMs). MLM is intent-to-treat, includes all participants regardless of missing data, and is the recommended approach for analyzing clinical trials (Hamer & Simpson, 2009). As depicted in Fig. 1, controlling for prior-session LSAS scores,
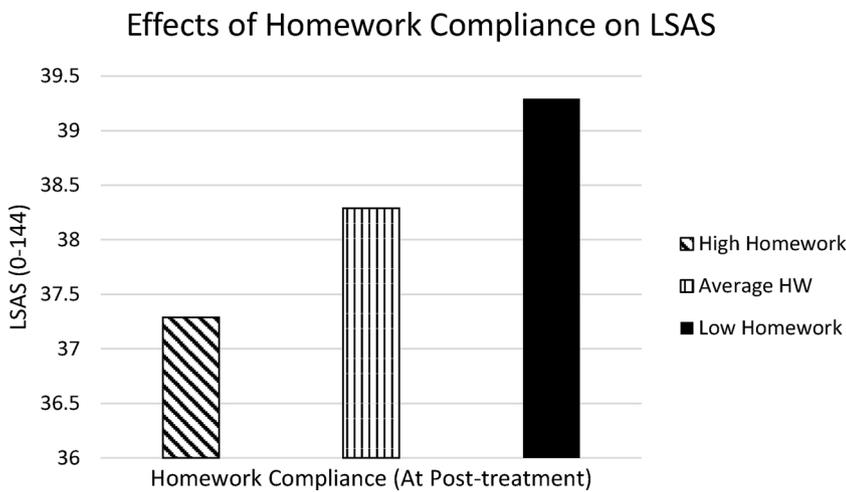
Effects of Homework Compliance on LSAS

hypothesis 1 predicted that greater homework compliance in the week prior to a session would be associated with better (lower) LSAS scores at the start of that session. Conversely, hypothesis 3 predicted that lower LSAS scores the previous session would improve homework compliance in the week following that session, controlling for homework compliance the previous week. To control for any shared variance that might be due merely to both LSAS and homework compliance changing over time, we controlled for Time, treatment condition, and the Treatment x Time interaction. Thus, our MLM model for hypothesis 1 was:

$$LSAS_{ij} = b0_i + b1_i*LSAS_{ij-1} + b2_i*HW_{ij} + b3_i*Time_{ij} + b4_i*DCS_i + b5_i*Time_{ij}*DCS_i + controls + \varepsilon_{ij}$$

$LSAS_{ij}$ is the score for individual i at session j, DCS_i is the treatment condition for individual i (-0.5 for those assigned to DCS, 0.5 for those assigned to PBO), HW_{ij} is homework compliance for individual i during the time between session j-1 and session j, and ε_{ij} is the error. Control variables included gender and ethnicity (as in the original study, Hofmann et al., 2013). For hypothesis 3, LSAS and homework were reversed, except that HW_{ij} was predicted by LSAS at the previous session.

Hypothesis 2 stated that DCS would moderate the effect of prior-week homework compliance on LSAS scores at the end of the next week. Thus, the MLM model included the addition of the DCS x HW interaction for hypothesis 2. Further, since DCS was administered only at sessions 3 through 7, only those assessments were included in the models for hypothesis 2.

We modeled the covariance matrix of the errors of the repeated measures as "unstructured". Power analyses using the MLM power analysis program PinT 3.12 (Snijders & Bosker, 1993) indicated that we had greater than a 0.80 power to detect effect sizes as small as d = 0.33 (between a small, d = 0.20, and a medium, d = 0.50, effect size) for hypothesis 1 and 3, and d = 0.42 for hypotheses 2.

3.1. Exploratory analysis

Exploratory analysis investigated whether DCS would moderate the effect of symptom severity on next week's homework compliance (exploratory analyses 1). We speculated that patients with more severe symptoms are less likely to comply with their assigned homework, but that this relation could be moderated by DCS. Furthermore, while previous studies have not found a general increase in homework compliance in DCS-augmented CBT, it remains unknown whether DCS may enhance homework compliance following sessions in which DCS was administered (exploratory analyses 2).

4. Results

4.1. Homework compliance

The mean number of homework reports per participant was high with 7.85 (SD = 1.73, range: 2–9) out of 9 possible assessments (at weeks 2–8, 10 and 12). Average scores for the individual subscales were a) *Completion* (M = 3.71 out of 5, SD = 0.81), b) *Relevance* (M = 3.67 out of 4, SD = 0.82), and c) *Effort* (M = 3.20 out of 4, SD = 1.02). As stated above, the three homework items were highly correlated. Thus, they were z-scored and combined into a single scale.

4.2. Homework compliance predicting end of week symptom severity (hypothesis 1)

Consistent with hypothesis 1, greater homework during the week leading up to a session (referred to as the homework compliance during the "current week", HW_{ij}) was related to lower LSAS assessed at the beginning of that week's session ($LSAS_{ij}$), b = -1.11, t(588) = -4.40, p < 0.001, controlling for LSAS at the prior session ($LSAS_{ij-1}$). Prior session LSAS was related to LSAS at the current session, b = 0.91, t(152) = 67.77, p < 0.001.

4.3. DCS as a moderator of the effects of homework compliance on LSAS (hypothesis 2)

DCS did not moderate the effect of previous week homework compliance (HW_{ij-1}) on LSAS at the end of the current week ($LSAS_{ij}$), regardless of whether or not previous week's LSAS ($LSAS_{ij-1}$) was controlled (p = 0.980 and p = 0.531, respectively). Further, the main effect for previous week's homework compliance (HW_{ij-1}) on LSAS at the end of the current week ($LSAS_{ij}$) was also not significant (p = 0.461 and p = 0.521, respectively). However, current week homework compliance (HW_{ij}), as opposed to previous week's homework compliance (HW_{ij-1}), *was* related to LSAS at the end of the week ($LSAS_{ij}$) for DCS/placebo-enhanced sessions (i.e. sessions 3–7), b = -0.76, t(377) = -2.43, p = 0.016, controlling for previous week's LSAS. This result is the same as the finding for hypothesis 1, except hypothesis 1 included all treatment sessions, not just the sessions in which a pill was administered.

4.4. Symptom severity predicting next week's homework compliance (hypothesis 3)

Prior-session LSAS ($LSAS_{ij-1}$) was not significantly related to homework compliance the week following that session (HW_{ij}), b = 0.00, t(122) = 0.31, p = 0.757, controlling for prior week

homework compliance (HW_{ij-1}); nor was prior session LSAS ($LSAS_{ij-1}$) related to the following week's homework compliance (HW_{ij}) when not controlling for prior week homework (HW_{ij}; $p = 0.617$). Prior week homework compliance was highly related to the following week's homework compliance, $b = 0.22$, $t(715) = 7.95$, $p < 0.001$.

5. Exploratory analyses

5.1. DCS as a moderator of the effect of symptom severity on next week's homework compliance (exploratory analyses 1)

DCS did not moderate the relation between prior session LSAS ($LSAS_{ij-1}$) and homework compliance in the week following that session (HW_{ij}), whether or not prior week homework compliance (HW_{ij-1}) was controlled ($p = 0.697$ and $p = 0.686$, respectively). Further, the main effect of previous session's LSAS ($LSAS_{ij-1}$) on the following week's homework compliance (HW_{ij}) was also not significant, whether or not prior week homework compliance was controlled ($p = 0.651$ and $p = 0.239$).

5.2. Does DCS augmentation enhance homework compliance (exploratory analyses 2)?

We also investigated whether DCS enhanced homework compliance following sessions in which DCS was administered (regardless of previous session LSAS). We investigated this question in three ways. First, DCS treatment condition was used to predict homework compliance in the week following the treatment session, controlling for previous week homework compliance. Administration of DCS, compared to PBO, was not associated with greater homework compliance in the next week, controlling for homework compliance the previous week ($p = 0.326$). Second, we examined whether the level of homework was higher in DCS than in PBO, both after the pill administration sessions and over the entire course of the study (we examined this effect over the entire course of the study in case the DCS effects on homework were delayed), without controlling for previous levels of homework compliance. It wasn't ($p = 0.872$ and $p = 0.622$ respectively). Finally, we examined the change in homework compliance over time as a function of treatment condition, using treatment condition, Time, and treatment x Time as predictors of homework. We found no evidence that homework increased any faster in DCS than in PBO (i.e., the treatment x Time interaction was not significant) during DCS administration ($p = 0.627$) or during the entire study, ($p = 0.992$). Nor was homework compliance at the last week of the study any higher in DCS than in PBO ($p = 0.789$) (Fig. 2).

6. Discussion

The current study investigated whether DCS facilitates the effects of homework compliance, and whether DCS would moderate outcome in homework-compliant patients with social anxiety disorder. In all, greater homework compliance was related to better improvement on outcomes irrespective of group assignment (DCS or PBO). However, DCS did not moderate the relationship between homework compliance and social anxiety severity, nor did DCS increase homework compliance. Social anxiety severity was unrelated to later homework compliance.

In line with our first hypothesis, regardless of the condition (CBT + DCS or CBT + PBO), higher homework compliance during the preceding week was related to lower LSAS scores at the end of the week, controlling for previous symptom severity. This outcome reflects prior findings, both across diagnoses (Glenn et al., 2013; Kazantzis et al., 2016), and SAD specifically (Edelman & Chambless, 1995; Leung & Heimberg,1996; but not Woody & Adessky, 2002). Homework compliance, irrespective of group assignment (DCS vs PBO), also had a significant effect on treatment outcome in studies by Olatunji et al.

(2015) and Park et al. (2013). Therefore, the findings of the current study continue to provide credence to the importance of homework compliance in patients with SAD.

Counter to our second hypothesis, DCS did not moderate the effect of homework on improvement in LSAS at the next session. This finding differs from those by Olatunji et al. (2015) who found that DCS moderated the relationship between homework compliance and treatment outcome within a sample of youth with OCD. Several reasons may account for divergence in findings, including differences in sample characteristics, treatment, homework compliance, timing of administration, and number of DCS-enhanced sessions. Participants in the current study had a principal diagnosis of SAD, whereas in the study by Olatunji et al. (2015), participants had a principal diagnosis of OCD. Participants were aged 8–18, as compared to adults in the current study. Sample size of the current study ($N = 169$) was close to six times larger than for sample sizes in both the Park et al. (2013) and Olatunji et al. (2015), which had sample sizes of $N = 30$ and $N = 27$ respectively. The use of a much larger sample allows for a more definitive inference of the effects of DCS on homework compliance in a sample of adults with SAD. The degree to which participants were adherent to homework in the different studies is also critical, because having a highly adherent sample would not allow room for improvement (ceiling effect). In Olatunji et al. (2015) the mean number of homework compliance reports was 7.44 ($SD = 3.55$) out of 11, while in the current study the mean was 7.85 ($SD = 1.73$) out of 9 sessions. Participants in the current study may lack a moderating effect of DCS because of the already existing high homework compliance. As in the majority of DCS studies (Mataix-Cols et al., 2017), both the Park et al. (2013) and the present study administered DCS or placebo pills one hour *before* their exposure sessions, whereas DCS/PBO was given right *after* exposure in the Olatunji et al. (2015) study. It is possible that by delivering DCS after the exposure session, when extinction learning was at its highest salience, accounted for greater results, at least in terms of enhancing outcome in CBT homework-compliant patients. In the *meta*-analysis by Norberg, Krystal, and Tolin (2008) on the role of DCS in exposure therapy and extinction learning in animals, the authors suggest that once a conditioned training session occurred, the process of decreasing learned fear response in these animals took place in waves over the two day period. Moreover, they note that DCS reaches its highest concentration in the blood stream about 4–8 h after ingestion (Norberg et al., 2008). This could imply that taking DCS right after an exposure session, which marks the beginning of peak extinction learning, might result in superior memory consolidation. Thus, timing of DCS administration may be essential, at least in the relation of homework compliance and outcome.

While each of these factors may have contributed to the lack of a moderating effect of DCS on the relation of homework compliance and outcome, number of DCS-enhanced treatment sessions may likely be the most salient one. Whereas, the total number of treatment sessions in the current study and Olatunji et al. were comparable 10.8 ($SD = 2.19$) and 12.6 ($SD = 2.3$), respectively, only 5 (41.67%) of the sessions in the current study were augmented by DCS. By contrast, DCS was administered in 10 (71.43%) sessions in the Olatunji et al. study.[1]

Contrary to our third hypothesis, social anxiety severity was not related to homework compliance. That is, whether a person had high or low symptom severity did not influence whether they completed homework. This result was found when looking at the impact of severity on homework compliance, not only in the week immediately following the session, but also examining the effects into the following week (second week). Olatunji et al. (2015), but not Park et al. (2013) who found a relationship with externalizing symptoms, also observed that severity of OCD symptoms was unrelated to homework

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[1] Park et al. (2013) did not examine moderating effects of DCS on the relationship between homework compliance and symptom reduction.

compliance, as did Edelman and Chambless (1995) in sample of patients with SAD. Further, severity at pretreatment did not affect homework compliance in general or at any of the individual assessments (Leung & Heimberg, 1996). Likewise, a moderating effect of DCS on the relationship between LSAS severity and later homework was also not established. This finding matches that of Olatunji et al. (2015). DCS augmentation also did not increase the amount of homework compliance, as was also found by Olatunji et al. (2015) and Park et al. (2013).

One limitation of the current, and prior, studies was the lack of patient ratings of homework compliance. Future studies should provide self-report as well as clinician administered rating of homework compliance to account for desirability effects. Electronic self-monitoring system for assessing homework compliance can provide more fine-grained analysis of the quantity and quality of completed self-exposures. Future studies should further investigate how dosage, and administration timing, of DCS-enhanced exposure sessions relates to outcomes in homework-compliant patients. As noted above, administering DCS only after successful sessions may optimally enhance fear extinction learning. Failed exposure sessions were not accounted for in the current study, but neither in the study by Olatunji et al. (2015). In addition, it is unclear whether there are differences in homework compliance between individual and group cognitive behavioral therapy. Though prior studies have not compared homework compliance between the two treatments, studies have shown that group CBT is as efficacious as individual treatment (Barkowski et al., 2016). Future studies should investigate homework compliance difference in group vs individuals CBT for SAD. Taken together, even though the current study failed to show that DCS can facilitate the effects of CBT in homework-compliant patients with SAD, we replicated the finding that greater homework compliance was a reliable predictor of treatment outcome. Thus, it is important to continue investigating moderators that increase homework compliance throughout treatment, so that a higher rate of treatment response can occur.

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