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# Psychosocial Factors Associated with Treatment Outcomes in Women with Obesity and Major Depressive Disorder who Received Behavioral Activation for Depression

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## Abstract

Behavioral activation is an empirically supported treatment for depression, but much is unknown about factors associated with treatment response. The present study aimed to determine whether baseline levels and subsequent changes in psychosocial factors were associated with improvement in depression in women with comorbid obesity who received behavioral activation treatment for depression and a lifestyle intervention. Multilevel modeling was used to estimate the associations between psychosocial factors and change in depression scores during the first 10 weeks of treatment and associations between changes in psychosocial factors from baseline to 6-month follow-up and change in depression over the same time period. No baseline psychosocial factors were associated with depression improvement during treatment ($p$= 0.110–0.613). However, greater improvement in hedonic capacity ($p$=0.001), environmental reward ($p$=0.004), and social impairment ($p$=0.012) were associated with greater reductions in depression over 6 months.

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Compliance with Ethical Standards

**Ethical Approval:** All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

**Informed Consent:** Informed consent was obtained from all individual participants included in the study.

**Conflict of Interest:** The authors declare that they have no conflict of interest.

Findings highlight the differential relationship specific psychosocial factors have with depression treatment outcomes.

**Keywords**

Behavioral Therapy; Comorbidity; Treatment Response; Hedonic Capacity; Environmental Reward; Social Engagement

Major depressive disorder is one of the most prevalent psychological disorders affecting approximately 6.7% of adults in the U.S., with women (8.5%) having a higher prevalence than men (4.8%; Substance Abuse and Mental Health Services Administration, 2017). The prevalence of depression among overweight and obese individuals ranges from 12–23% (Carey et al., 2014). A longitudinal, bidirectional association between depression and obesity has been observed in epidemiological studies particularly among middle-aged women (Pan et al., 2012; Vogelzangs et al., 2010; Sachs-Ericsson et al., 2007; Roberts, Deleger, Strawbridge, & Kaplan, 2003). Adults with obesity have a 55% increased risk for developing depression, and adults with depression have a 58% increased risk for developing obesity overtime (Luppino et al., 2010). Obesity and depression may have similar mechanistic pathways, which could have implications for treatment, thus intervention studies have begun to target this comorbidity (Pagoto, 2011). Behavioral activation for depression (BAD) has been tested as a treatment for depression when comorbid with obesity (Pagoto et al., 2013), substance abuse disorder (Ross et al., 2016), age-related macular degeneration (Rovner et al., 2014), and cancer (Hopko et al., 2008). BAD can be defined as a structured psychotherapy designed to increase engagement in adaptive activities and decrease engagement in activities that maintain depression, thereby increasing a patient's access to reward (Dimidjian et al., 2011). Given the broad applicability, further research is needed to understand psychosocial factors associated with BAD treatment outcomes. The purpose of the present study was to investigate baseline psychosocial factors associated with response to BAD, and to examine concurrent changes in these factors and depressive symptoms in women with obesity and major depressive disorder.

BAD is a brief, uncomplicated, reinforcement-based depression treatment rooted in basic behavioral theory. Individualized target behaviors and contextual factors are identified to address low response-contingent positive reinforcement characterized by depression. Healthy behaviors designed to promote positive and productive experiences are boosted via activity scheduling and self-monitoring within an idiographic, values-driven framework. Theorized predictors of change in BAD include hedonic capacity (ability to experience pleasure; Fawcett et al., 1983), environmental reward (increased behavior and positive affect as a result of rewarding environmental experiences; Armento & Hopko, 2007), work/school impairment (consequences of inactivity and passivity on work and school responsibilities; Kanter et al., 2006), avoidance/rumination (avoidance of negative aversive states and engaging in rumination rather than active problem solving; Kanter et al., 2008), social impairment (consequences of social isolation; Manos et al., 2009), and goal-directed behavior (focused completion of scheduled activities; Busch et al., 2008). Over the course of BAD, theorized predictors of change are targeted by increasing the frequency and

reinforcement of healthy behavior. Engagement in daily activity goals is directly tied to major life areas and values (e.g., relationships, education, employment, hobbies and recreational activities, spirituality, and anxiety-eliciting situations), and is intended to be manageable and enjoyable (Hayes, Strosahl, & Wilson, 1999). Because activities scheduled stem from the client's values, certain theorized predictors of change may be targeted earlier in treatment and more frequently. As the patient progresses through treatment, engagement in scheduled activities may result in change in other functional behaviors without having to be directly targeted. For example, an individual with a goal to increase social support may consider planning an activity with a friend or joining a volunteer organization to garner social support. These activities could not only improve social impairment, but could also improve other areas like avoidance/rumination and environmental reward.

Research on mechanisms of behavior change in the context of mental and physical health comorbidities could provide information on how to improve treatment. To date, no research has examined mechanisms of change in BAD in women with obesity and major depressive disorder. An initial step in identifying mechanisms of change is to show concurrent changes in potential mechanisms and depressive symptoms (Kazdin, 2007). Identification of psychosocial factors associated with reductions in depressive symptoms can offer important considerations for future research regarding mechanisms of behavior change in BAD.

The Be Active trial was one of the largest clinical trials to date for BAD. In this study, women with obesity and major depressive disorder were randomized to BAD followed by a lifestyle intervention or to a lifestyle intervention only plus attention control condition (Schneider et al., 2008; Pagoto et al., 2013). Participants in the BAD condition experienced significantly greater improvement in depression at 6- and 12-month follow-up compared to participants in the lifestyle intervention only condition (Pagoto et al., 2013). Using data from this trial, our first aim was to identify baseline psychosocial factors (hedonic capacity, environmental reward, work/school impairment, avoidance/rumination, social impairment, and goal-directed behavior) that impact depressive symptom improvement during the first ten weeks of BAD. We hypothesized that higher baseline hedonic capacity, environmental reward, and goal-directed behavior, and lower baseline work/school impairment, avoidance/rumination, and social impairment would be associated with greater reductions in depressive symptoms during the first ten weeks of BAD. Identifying whether participants high or low in certain psychosocial factors benefit more from treatment could assist with improving treatment tailoring and ultimately lead to better treatment outcomes. The second aim was to examine whether change in these psychosocial factors was associated with improvement in depressive symptoms during the first six months of BAD and group-based lifestyle intervention. We hypothesized that greater improvement in hedonic capacity, environmental reward, work/school impairment, avoidance/rumination, social impairment, and goal-directed behavior during the combined BAD and lifestyle intervention would be associated with greater reductions in depressive symptoms over 6-months. Findings will offer important considerations for future research on mechanisms of behavior change among women with obesity and major depressive disorder undergoing BAD.

## Methods

We conducted a secondary data analysis from the Be Active Trial (NCT00572520), which has been described in detail elsewhere (Schneider et al., 2008; Pagoto et al., 2013). Women with obesity and major depressive disorder were enrolled into a randomized controlled trial to examine whether administering BAD prior to a group-based lifestyle intervention produced greater weight loss than a standard weight loss intervention with health education as an attention control. Participants were recruited from July 2007 to March 2010 from the community and primary care clinics at the University of Massachusetts Medical School. A computerized Patient Health Care Information System used in the University of Massachusetts Memorial primary care clinics identified participants who were potentially eligible using age, gender, and body mass index. Free seminars about women's health were also conducted at local businesses, community organizations, and churches to facilitate recruitment. Participants were eligible for the study if they were women between 18–65 years old, had primary care physician approval to participate in all aspects of the study, had a BMI greater than or equal to 30 $kg/m^2$, met criteria for major depressive disorder via a Structured Clinical Interview for DSM-IV (SCID-IV), and had a score greater than or equal to ten on the Hamilton Depression Rating Scale (HDRS) and the Beck Depression Inventory-II (BDI-II). Exclusion criteria included: bipolar disorder, severe depression (BDI score >29), active suicidal ideation, psychosis, post-traumatic stress disorder, bulimia, diabetes, current smoking, plans to have bariatric surgery, inability to walk unaided for ¼ of a mile without stopping, lack of clearance from a primary care physician, having a medical condition that was likely to limit lifespan or precludes dietary changes, initiated anti-depressant medication within 3 months of the intervention, currently in psychotherapy or a weight loss treatment program, and non-English speaking. Participants responding to study advertisements were initially screened via a brief phone interview. A 2-hr screening visit followed where informed consent was obtained, height and weight was assessed, the SCID-IV was administered, and questionnaires were completed. The Institutional Review Board of the University of Massachusetts Medical School approved all procedures.

Participants were randomized to one of two conditions, each consisting of two treatment components. The Be Active condition included individually delivered BAD followed by a group-based lifestyle intervention. The Standard condition included the same group-based lifestyle intervention with individually delivered attention control visits focused on health education (e.g., menopause, skin health, and breast self-exams) interspersed throughout the first 6 months of the condition. In the Be Active condition, BAD involved ten sixty-minute individual sessions in the first ten weeks of the program. Six monthly twenty-minute counseling phone calls subsequently occurred that focused on depression treatment. During week nine of BAD, participants began the lifestyle intervention, which involved twenty-two, ninety-minute group behavioral weight loss visits over one year conducted by a registered dietitian or exercise physiologist, depending on whether topics focused on nutrition or physical activity. The Diabetes Prevention Program Lifestyle Intervention Protocol was the weight loss intervention. Participants received calorie goals designed to produce a weight loss of 0.5–1 kg per week, and set goals to engage in 30 minutes of moderate physical activity 5 days per week (DPP Research Group, 2002). Consistent with the treatment manual

by Lejuez and colleagues (2001), BAD was administered by a master- or doctoral-level counselor, under the direct supervision of a licensed clinical psychologist. BAD included activity monitoring and scheduling within an idiographic, values-driven framework to systematically engender increases in positive and productive experiences. Participants identified key values from different life areas, and translated them into activities (e.g., planning a date with a significant other, reading a book, socializing with friends). Only participants randomized to the Be Active condition (n = 78) were included in the primary analyses for the current study. The Standard condition was not included in the analytic sample due to insufficient power to formally test mediation.

## Measures

### Depression Screening.

The structured clinical interview for the DSM-IV (SCID; Spitzer et al., 1992) was administered by a licensed psychologist or a clinical psychology post-doctoral fellow (under the supervision of a licensed psychologist) at the screening visit. The SCID-IV is a semi-structured interview designed to diagnose major DSM-IV mental disorders and has been considered the gold standard in determining the accuracy of clinical diagnoses.

### Depressive symptoms.

Depressive symptoms were measured using the Beck Depression Inventory-II (BDI-II). This 21-item self-report questionnaire assesses depressive symptoms on a four-point Likert-type scale and has shown good internal consistency ($\alpha$ = 0.73–0.95) and adequate test-retest reliability for non-depressed individuals ($r$ = 0.60–0.83) and psychiatric patients ($r$ = 0.48–0.93) (Beck et al., 1996; Wang & Gorenstein, 2013). Participants completed this questionnaire weekly and during the baseline and 6-month follow-up assessments. Coefficient $\alpha$ = .90 for the current study.

### Measures Administered at Baseline and 6-Month Follow-up

**Hedonic Capacity.:** Hedonic capacity was measured using the 36-item Fawcett-Clark Pleasure Capacity Scale (FCPS), which asks participants to rate imagined hedonic reactions to hypothetical pleasurable situations (Fawcett, et al., 1983). Hedonic capacity was measured because its inverse, anhedonia, is a core symptom of depression and may serve as an important mechanism of change in behavioral activation treatment for depression (Hopko et al., 2004). The FCPS is correlated with depression, but independent and distinguishable (Leventhal et al., 2006). This scale has demonstrated strong discriminability between depressed and non-depressed individuals (Loas et al., 1994). Coefficient $\alpha$ = .94 for the current study.

**Environmental Reward.:** Environmental reward was measured using the Environmental Reward Observation Scale (EROS). This 10-item self-report questionnaire is designed to measure the magnitude of reinforcing events, availability of reinforcement in the environment, and the ability of an individual to elicit positive reinforcement (Carvalho et al., 2011). EROS scores significantly correlate with measures of depression, anxiety, behavioral activation/inhibition, and pleasant events (Armento & Hopko, 2007). The EROS also has

superior discriminability over the BDI-II in assessing the duration of time spent in low and highly rewarding activities (Armento & Hopko, 2007). This brief self-report measure has strong internal consistency ($\alpha$ = 0.85–0.90) and test-retest reliability ($r$ = .85) (Armento & Hopko, 2007). Coefficient $\alpha$ = .89 for the current study.

**Work/School Impairment, Avoidance/Rumination, Social Impairment, and Goal-Directed Behavior:** The measurement of work/school impairment, avoidance/rumination, social impairment, and goal-directed behavior was performed using the Behavioral Activation for Depression Scale. This 25-item questionnaire is a measure of activation and avoidance *behaviors* related to behavioral activation treatment during the preceding week. The questionnaire is comprised of four subscales: activation (measuring general activation/goal directedness), avoidance/rumination, work/school impairment (measuring the extent to which inactivity interferes with responsibilities), and social impairment (measuring extent of inactivity regarding in the interpersonal realm). The Behavioral Activation for Depression Scale has been shown to be a valid measure of these constructs in a non-clinical undergraduate sample (Kanter et al., 2006) and in a community sample (Kanter et al., 2009) with elevated depressive symptoms. Coefficient $\alpha$'s = .69, .85, .83, and .85 for work/school impairment, avoidance/rumination, social impairment, and goal-directed behavior, respectively.

## Analytic Plan

Study variables were plotted using histograms and descriptive analyses were conducted. Skewness and kurtosis were formally analyzed to determine if data were normally distributed and met all required assumptions for parametric testing. The assumption of homoscedasticity was tested for both level 1 (i.e., time) and level 2 predictors (i.e., baseline psychosocial factors and psychosocial factors of change).

First baseline psychosocial factors of depression symptom change during the first ten weeks of BAD were investigated. Separate linear mixed models with restricted maximum likelihood estimation were computed for each baseline psychosocial factor. Each linear mixed effect model included the main effects (baseline psychosocial factor and time) and the interaction of baseline psychosocial factor and time to predict change in depression scores during the first ten weeks of BAD. If the interaction effect was non-significant, we examined the impact of the model's main effects on weekly depression scores.

Second, we examined whether change in psychosocial factors from baseline to the 6-month follow-up was concurrently related to change in depressive symptoms during the Be Active condition. Psychosocial factors of change in depression scores during BAD were not examined because hedonic capacity, environmental reward, work/school impairment, avoidance/rumination, social impairment, and goal directed behavior were not collected immediately following the end of BAD. To examine the psychosocial factors of change in depression scores from baseline to 6-month follow-up, change scores were computed for hedonic capacity, environmental reward, work/school impairment, avoidance/rumination, social impairment, and goal directed behavior. Participants' 6-month self-reported measures were subtracted from their self-reported measures at baseline to compute change. If

participants were missing data at either baseline or 6-month follow-up, change was not computed. The Behavioral Activation for Depression Scale was not administered until the fourth out of 8 waves of recruitment, after 37% of participants had been enrolled, which contributed to missing data for the Behavioral Activation for Depression subscales.

To examine time by change interaction effects, separate linear mixed effect models were conducted for each psychosocial factor (i.e., hedonic capacity, environmental reward, work/school impairment, avoidance/rumination, social impairment, and goal directed behavior). Within each model, all level 2 predictors represented the psychosocial factors of change. Hoffman and Stawski (2009) reported that both within-person (level 1 predictors) and between-person (level 2 predictors) have a differential impact on the outcome measure. Isolating the within-person component of the time varying predictor is needed because estimation of the combined effect between level 1 and level 2 predictors will result in biased model parameters (Curran & Bauer, 2011). Including relevant predictors at the levels in which they occur creates a more precise investigation of change processes.

For both sets of analyses, repeated observations of depression scores were observed within individuals with all psychosocial factors (level 2 predictors) over time (level 1 predictor). All depression scores from the Be Active condition were analyzed including missing or incomplete cases using restricted maximum likelihood estimation. All psychosocial factors were modeled using fixed effects. Intercepts and slopes were allowed to vary randomly. Semi-partial effect sizes for model parameters were computed for all significant level 2 predictors.

Previous reports from this trial found that greater baseline leisure time physical activity and change in weight were related to depressive symptom change (Pagoto et al., 2013; Busch et al., 2013). Therefore, we conducted sensitivity analyses using, baseline physical activity, baseline BMI and weight change as covariates in analyses examining the association between baseline psychosocial variables and weekly depression improvement during the 10 weeks of BAD. Since the psychosocial factors of interest were only administered at baseline and 6-month follow-up, but not at the end of acute depression treatment, the effects of BAD at 6 months were confounded with weight loss treatment. In an attempt to separate the impact of BAD from the impact of the weight loss treatment, sensitivity analyses were conducted using change in weight and change in physical activity as covariates in analyses examining the association between change in psychosocial variables and weekly depression improvement during the first six months of BAD and the lifestyle intervention.

All linear mixed effect model analyses were conducted using Statistical Package for the Social Sciences, Version 22.0 (SPSS, Chicago, IL).

## Results

Among the 78 women randomized to the Be Active condition, 12 participants were missing data for hedonic capacity (baseline=2; 6-month follow-up=10), and 13 were missing data for environmental reward (baseline=2; 6-month follow-up=11). Due to the Behavioral Activation for Depression Scale being administered later in the study, 41 participants were

missing data for work/school impairment, avoidance/rumination, and goal directed behavior (baseline =34; 6-month follow=7), and 42 participants were missing data for social impairment (baseline =35; 6-month follow=7). Final sample sizes for baseline psychosocial factors of depression improvement during the first ten weeks of BAD were as follows: hedonic capacity (n= 76), environmental reward (n=76), work/school impairment (n=44), avoidance/rumination (n=44), social impairment (n=43), and goal-directed behavior (n=44). The final sample sizes involving psychosocial factors of depression symptom change over 6 months were as follows: change in hedonic capacity (n=66), change in environmental reward (n=65), change in work/school impairment (n=37), change in avoidance/rumination (n=37), change in social impairment (n=36), and change in goal-directed behavior (n=37).

Among the entire sample, 8 (10.26%) completed high school, 40 (51.28%) completed trade school, some college, or an Associate's degree, 16 (20.51%) completed a Bachelor's degree, 7 (8.97%) completed some graduate school, and 7 (8.97%) completed a Master's or professional degree. Race and ethnicity of the participants included, 62 (79.49%) non-Hispanic white, 9 (11.54%) Hispanic, 4 (5.13%) African American, 2 (2.56%) multi-racial, and 1 (1.28%) Asian. Mean age was 45.6 years old (SD =10.9) with a mean baseline body mass index of 36.0 kg/$m^2$ (SD=3.2) and mean baseline depression score of 21.1 (SD=5.7; Table 1). Mean change in depression scores from baseline to end of treatment was −10.5 (SD=8.4), and mean change in depression scores from baseline to 6-month follow-up was −12.4 (SD=7.1).

## Depression Symptom Change During the First Ten Weeks of BAD in Relation to Baseline Psychosocial Factors

No significant interactions with time were observed for hedonic capacity, environmental reward, work/school impairment, avoidance/rumination, social impairment, or goal-directed behavior ($p$= 0.110 to 0.613). Baseline psychosocial factors of depression scores during the first ten weeks of BAD include main effects for time ($b$ = −0.76, 95% CI: −1.23–−0.29, $R^2_\beta$ = 0.23), and social impairment ($b$ = 0.46, 95% CI: 0.23–0.68, $R^2_\beta$ = 0.29). Sensitivity analyses that included weekly weight change, baseline physical activity, and baseline BMI as covariates were very similar to the main analyses: time ($b$ = −0.87, 95% CI: −1.38–−0.36, $R^2_\beta$ = 0.25), and social impairment ($b$ = 0.47, 95% CI: 0.21–0.72, $R^2_\beta$ = 0.28).

## Depression Symptom Change over 6 months in Relation to Psychosocial Factors

Separate linear mixed effect models were conducted for each psychosocial factor. Significant interactions with time were observed for hedonic capacity ($b$ = −0.01, 95% CI: −0.02–−0.004, $R^2_\beta$ = 0.17), environmental reward ($b$ = −0.03, 95% CI: −0.05–−0.01, $R^2_\beta$ = 0.17), work/school impairment ($b$ = 0.03, 95% CI: 0.007–0.05, $R^2_\beta$ = 0.16), and social impairment ($b$ =0.02, 95% CI: 0.005–0.04, $R^2_\beta$ = 0.19; Table 2). Participants with greater improvement in hedonic capacity (p<.001), environmental reward (p<.001), work/school impairment (p< .001), and social impairment (p< .001) experienced greater reductions in depressive symptoms during the Be Active condition (Figure 1). When weekly weight change, baseline physical activity, and baseline BMI were included in the model, only change in work/school impairment was no longer significant ($b$ = 0.04, 95% CI: −0.004–0.08). Baseline physical activity was significantly correlated with improvement in work/school impairment ($r$= −0.91,

$p$= 0.004), indicating that women with low physical activity at baseline were more likely to report work/school impairment. Baseline BMI was not significantly correlated with improvement in work/school impairment ($r$= 0.056, $p$= 0.069). When weekly weight change and change in physical activity were included in the model, results were very similar to the main analyses with change in work/school impairment remaining non-significant ($b$ = 0.04, 95% CI: −0.004–0.08). Change in physical activity was significantly correlated with improvement in work/school impairment ($r$=−0.23, $p$< .001), indicating that women who increased their level of physical activity were more likely to show improvements in work/school impairment. Neither change in avoidance/rumination ($b$ = 0.01, 95% CI: −0.001–0.02), nor change in goal-directed behavior ($b$ = −0.006, 95% CI: −0.02–0.007) was significantly associated with change in depressive symptoms during the Be Active condition.

Post hoc analyses were conducted to determine whether the results observed for participants in the Be Active condition, which demonstrated concurrent relationships between improvements in hedonic capacity, environmental reward, social impairment, and work/school impairment and reductions in depressive symptoms during the first 6 months of treatment, were similar for participants who received the Standard condition. Separate linear mixed models conducted with participants randomized to the Standard condition revealed significant interactions with time for work/school impairment ($b$ = 0.01, 95% CI: 0.003–0.03, $R^2_\beta$ = 0.13), avoidance/rumination ($b$ =0.02, 95% CI: 0.008–0.02, $R^2_\beta$ = 0.31), hedonic capacity ($b$ = −0.01, 95% CI: −0.02–−0.007, $R^2_\beta$ = 0.29), and environmental reward ($b$ = −0.03, 95% CI: −0.05–−0.02, $R^2_\beta$ = 0.29). Participants with greater improvement in work/school impairment (p< .001), and avoidance (p<.001), experienced greater reductions in depressive symptoms. In contrast to the results for work/school impairment and avoidance, participants with greater reductions in hedonic capacity (p< .001) and environmental reward (p< .001), experienced greater increases in depressive symptoms during the Standard condition. Neither change in social impairment ($b$ = 0.01, 95% CI: −0.01–0.02), nor change in goal-directed behavior ($b$ = −0.01, 95% CI: −0.02–0.0004) was significantly associated with change in depressive symptoms during the first 6 months of treatment.

## Discussion

BAD was effective among women with obesity and major depressive disorder, with an average improvement in depressive symptoms of over 10 points at 10 weeks. Baseline hedonic capacity, environmental reward, work/school impairment, avoidance/rumination, social impairment, and goal-directed behavior were not associated with improvement in depressive symptoms. Thus, baseline levels of BAD's purported mechanisms of change did not predict treatment response or distinguish which participants were most likely to benefit from treatment. To inform treatment selection, future research should continue to explore baseline predictors of response to BAD.

Improvements in hedonic capacity, environmental reward, social impairment, and work/school impairment were concurrently related with reductions in depressive symptoms over 6 months, a point at which participants had received both BAD and a lifestyle intervention. The connection between increases in hedonic capacity and improvement in depressive symptoms over 6 months could be explained in part by the limited access to positive

reinforcement and/or impairments in reward processing individuals with depression experience (Mayberg, 1997). Individuals with depression often display blunted emotional responses to pleasant cues (Sloan et al., 2001), low reward responsiveness (Henriques & Davidson, 2000), lack positivity bias in attentional tasks (Wang et al., 2006), and show dysfunction in the brain reward system (Keedwell et al., 2005). A study examining the effects of behavioral activation on neural responses to rewards in individuals with major depression observed functional changes in regions that mediate responses to rewards (Dichter et al., 2009). BAD in conjunction with a lifestyle intervention may serve as an effective treatment modality by increasing access to positive reinforcement, while also improving reward processing in women with comorbid obesity and major depressive disorder.

Increases in environmental reward were concurrently related with improvements in depression over 6 months, which is consistent with response-contingent positive reinforcement models of depression (Lewinsohn, 1974). Inadequate environmental reward reduces healthy behaviors and is consistently associated with negative affect and maintenance of depression (Hopko et al., 2003; Carvalho et al., 2011). BAD and the lifestyle intervention may have addressed environmental reward by increasing goal and value based activity levels, which likely elicited positive affect. In a randomized controlled trial examining the efficacy of BAD among Spanish-speaking Latinos with major depressive disorder, environmental reward increased more over time among those who received BAD compared to those who received supportive counseling (Collado et al., 2016). Attempts to increase rewarding activities to promote environmental reinforcement may help to reduce depressive symptoms and improve quality of life (Hopko et al., 2003). Women with comorbid obesity and major depressive disorder may also gain access to more environmental reward as they lose weight, thus weight loss may have contributed to change in both environmental reward and depressive symptoms. Future research is needed to elucidate these relationships.

Improvement in social impairment was also concurrently related to depression improvement over 6 months, which is consistent with previous research demonstrating that improving social engagement mediates depression outcome in participants who receive BAD (Rovner, et al., 2014). Graduated exposure to social situations and the development of social skills via BAD can reduce negative affect, improve social support, and increase positive social reinforcement (Hopko et al., 2015). Social isolation, a common characteristic of depression, may decrease opportunities for positive social reinforcement, thus facilitating depressed mood (Martell et al., 2001; Lejuez et al., 2001). Compared to non-depressed individuals, even mildly depressed individuals engage less frequently in social activities (Hopko & Mullane, 2008). BAD addresses social impairment by emphasizing value-based activity scheduling of social activities. Recent data indicates that about 20% of BAD homework assignments involve engagement in social activities (Busch et al., 2010).

Participation in the group-based lifestyle intervention after BAD likely contributed to improvements in hedonic capacity, environmental reward, social impairment, and work/school impairment. Although these psychosocial factors were administered at both baseline and 6-month follow-up, these measures were not administered at end of acute depression

treatment; thus, the effects of BAD at 6 months were confounded with weight loss treatment. Results cannot differentiate whether improvements in hedonic capacity, environmental reward, social impairment, and work/school impairment occurred via the lifestyle intervention or BAD. To partially address this issue, sensitivity analyses using change in weight and change in physical activity as covariates were used to control for their impact on weekly depressive symptom improvement. Only change in work/school impairment was no longer significant, which provides some support for the unique effect BAD had on hedonic capacity, environmental reward, and social impairment. Change in physical activity was significantly correlated with improvement in work/school impairment, indicating that women who increased their level of physical activity experienced greater improvements in work/school impairment on average. Nonetheless, the use of these variables as a proxy for the impact of weight loss treatment was not ideal as improvements in social impairment and environmental reward could have been due to social skills training and activity scheduling involved in BAD or from the social support and positive experiences (i.e., weight loss) received from the group-based lifestyle intervention.

To further help differentiate the effects of BAD from the lifestyle intervention at 6 months, post hoc analyses were conducted using participants in the Standard condition to determine if the concurrent changes in psychosocial factors and depressive symptoms were unique to BAD. Only improvements in avoidance/rumination and work/school impairment were concurrently related with reductions in depressive symptoms over 6 months in the Standard condition. Consistent with the sensitivity analyses, improvement in work/school impairment may not have been specific to BAD, but rather influenced by the lifestyle intervention and/or health education as well. Differences among conditions were also observed for changes in hedonic capacity and environmental reward. In the Standard condition, participants with greater reductions in hedonic capacity and environmental showed greater increases in depressive symptoms, indicating the Standard Condition was not as effective in changing psychosocial factors to promote depressive symptom change compared to the Be Active condition. The post-hoc results provided further support for the unique effect of BAD on hedonic capacity, environmental reward, and social impairment, though results are preliminary and must be interpreted with caution. Results observed in the Standard condition might have been different had that condition not encouraged behavior change via a behavioral weight loss treatment, which overlaps with the purported mechanism of behavioral activation. While behavioral weight loss treatment helps people make behavioral changes via behavioral strategies, it has no focus on mood or the impact of activities on mood. Activity monitoring and scheduling is limited to diet and exercise but only for tracking energy balance and facilitating weight loss, which is fundamentally different than how these strategies are executed in BAD. Throughout treatment, it is likely that different theorized predictors of change influenced one another, highlighting the need to better understand how psychosocial factors directly and indirectly interact to improve depressive symptoms during different treatments. Future research should continue to explore hedonic capacity, environmental reward, and social impairment as potential mechanisms of change in BAD alone (i.e., without being combined with a lifestyle intervention).

Contrary to our hypotheses, change in avoidance/rumination and goal-directed behavior from baseline to 6 months was not associated with improvement in depressive symptoms,

though avoidance/rumination was associated with improvement in the Standard condition. One possible explanation is that BAD emphasizes value-based activity scheduling to increase response-contingent positive reinforcement as opposed to explicitly targeting avoidance/rumination to improve depressive symptoms (Hopko et al., 2003) unlike other behavioral activation treatment manuals (Martell et al, 2001). Participation in the group-based lifestyle intervention after BAD likely impacted goal-directed behavior. Engagement in the weight loss intervention could have interfered with goal directed behavior designed to promote positive experiences that did not involve weight loss. Future research should explore the nature of different goal-directed behaviors and how activities or behaviors designed to accomplish goals in other areas of life (i.e., weight loss) impact treatment outcome.

The current study has several limitations. First, the Behavioral Activation for Depression subscales were added to the study assessments after about one-third of participants had been recruited, which reduced the sample size. We conducted a secondary data analysis of data from participants in one treatment arm of a randomized controlled trial, and thus did not formally test mediation due to low power concerns. Examination of concurrent relations among hedonic capacity, environmental reward, work/school impairment, avoidance/rumination, social impairment, goal-directed behavior and change in depression did not permit conclusions regarding temporality. Without evidence of temporal precedence of change, it is difficult to determine whether a theorized predictor of change is truly a mechanism of change or rather a correlate or consequence of symptom change (Kazdin, 2007). The use of post hoc analyses among participants in the Standard condition was not optimal as participation in the lifestyle intervention likely contributed to significant findings. The sample was comprised of mostly non-Hispanic white women, and excluded those with diabetes or severe depression, which limits the generalization of results. Additionally, participants actively sought participation in a weight loss intervention and thus the sample may not reflect women with comorbid obesity and major depressive disorder in the general population. Future research is needed to further explore psychosocial factors that predict better depression treatment outcomes in adults with comorbid obesity and major depressive disorder.

This study provided a unique opportunity to identify potential psychosocial factors related to improvements in depression among women with obesity and comorbid major depressive disorder receiving BAD followed by a lifestyle intervention. Based on these results, future research can implement more sophisticated statistical techniques that will allow modeling of idiographic processes of change (Molenaar & Campbell, 2009). By examining session-by-session changes in potential theorized mechanisms of change like hedonic capacity, environmental reward, and social impairment, future research could address the issue of temporality and improve the understanding of temporal sequences of change during BAD. Due to its simplicity, BAD is increasingly being used to treat depression in populations with comorbid medical conditions including cancer, obesity, heart disease, and chronic pain (Hopko et al., 2015; Hopko et al., 2005; MacPherson et al., 2010; Magidson et al., 2011; Snarski et al., 2011), and it can also be effectively administered by individuals with limited mental health treatment training (Richards et al., 2016). The current investigation highlights the potential role hedonic capacity, environmental reward, and social impairment has on

reducing depressive symptoms. Future research should continue to explore additional psychosocial factors that are likely to impact treatment efficacy including quality of sleep, sedentary behavior, and physical functioning, and how these factors impact different clinical populations.

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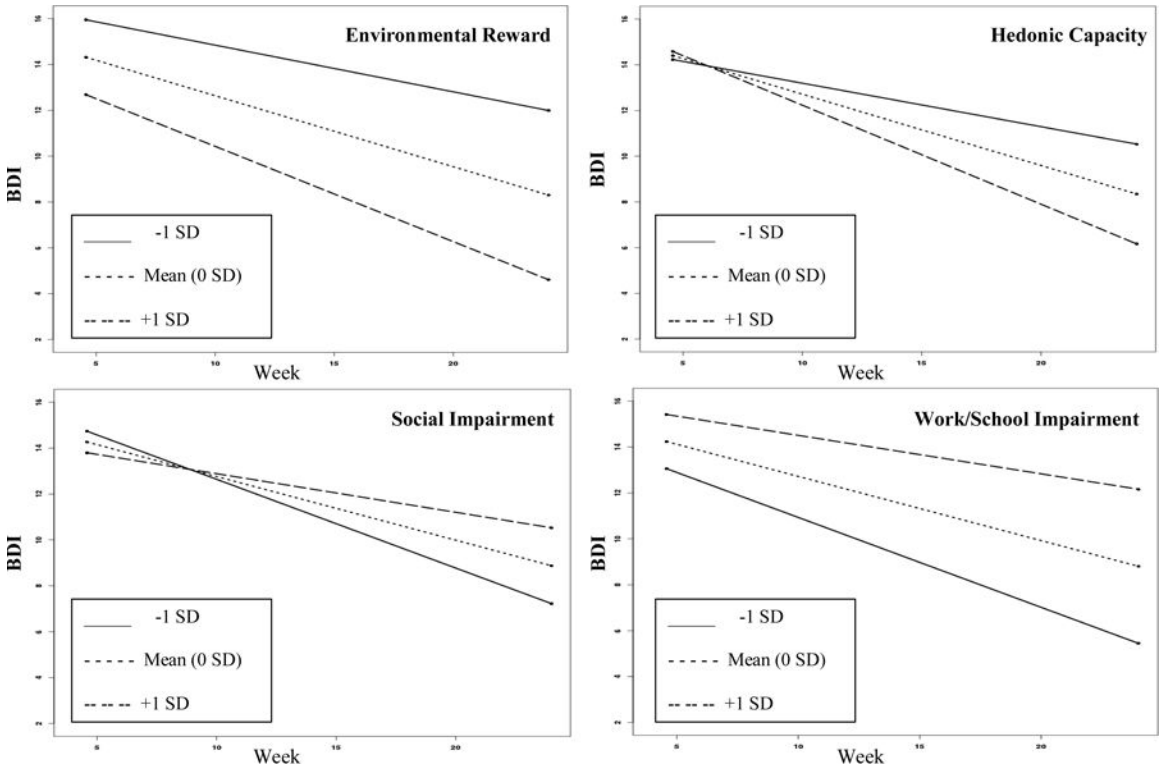


**Figure 1.**

Interactions of Changes in Factors with Time on Depressive Symptom Improvement (BDI-II) from Baseline to 6-Month Follow-Up among Women with Obesity and Major Depressive Disorder Receiving Behavioral Activation for Depression Treatment and a Lifestyle Intervention

Note. BDI-II; Beck Depression Inventory II

## Table 1

Characteristics of Women with Obesity and Major Depressive Disorder who Received Behavioral Activation Treatment for Depression and a Lifestyle Intervention

| **Baseline** | | |
|---|---|---|
| | **N** | **M (SD)** |
| Body mass index (kg/m$^2$) | 78 | 36.0 (3.2) |
| Weight (lbs.) | 78 | 211.0 (26.2) |
| Beck Depression Inventory-II | 78 | 21.1 (5.7) |
| Hedonic Capacity | 76 | 128.6 (19.0) |
| Environmental Reward | 76 | 22.4 (3.5) |
| Goal Directed Behavior | 44 | 12.3 (6.6) |
| Avoidance/Rumination | 44 | 18.5 (8.5) |
| Work/School Impairment | 44 | 12.8 (5.4) |
| Social Impairment | 43 | 11.2 (6.8) |
| **6-Months** | | |
| Body mass index (kg/m$^2$) | 78 | 30.3 (12.3) |
| Weight (lbs.) | 68 | 205.0 (28.0) |
| Beck Depression Inventory-II | 67 | 8.7 (7.5) |
| Hedonic Capacity | 67 | 138.2 (18.3) |
| Environmental Reward | 67 | 27.3 (5.5) |
| Goal Directed Behavior | 42 | 21.1 (8.1) |
| Avoidance/Rumination | 42 | 12.4 (8.8) |
| Work/School Impairment | 42 | 7.8 (5.2) |
| Social Impairment | 41 | 5.2 (5.1) |

**Table 2**

Interactions of Person–Level Change Factors with Time on Depressive Symptom Improvement (BDI-II) from Baseline to 6-Month Follow-Up among Women with Obesity and Major Depressive Disorder Receiving Behavioral Activation for Depression Treatment and a Lifestyle Intervention

| Psychosocial Factors | Fixed Effects: b (95% CI) | | | | | Fixed Effects: b (95% CI) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Intercept | Time | Main Effect | Time x Main Effect Interaction | $R^2_\beta$ | $\upsilon_{Intercept}$ | $\upsilon_{Time}$ | $\upsilon_{Cov}$ | e |
| Change in Hedonic Capacity (n=66) | 15.88 (14.48, 17.39) | −0.34 (−0.45, −0.24) | 0.06 (−0.02, 0.14) | −0.01 (−0.02, −0.04) | 0.17 | 25.30 (16.99, 37.66) | 0.10 (0.06, 0.16) | 0.01 (−0.50, 0.52) | 17.15 (15.65, 18.79) |
| Change in Environmental Reward (n=65) | 17.11 (15.37, 18.86) | −0.31 (−0.43, −0.19) | −0.17 (−0.42, 0.07) | −0.03 (−0.05, −0.01) | 0.17 | 24.92 (16.62, 37.37) | 0.10 (0.06, 0.17) | −0.28 (−0.83, 0.26) | 17.29 (15.77, 18.96) |
| Change in Goal Directed Behavior (n=37) | 17.20 (14.87, 19.53) | −0.33 (−0.51, −0.15) | −0.13 (−0.31, 0.05) | −0.1 (−0.02, 0.01) | 0.03 | 19.31 (11.02, 33.83) | 0.10 (0.05, 0.19) | −0.13 (−0.72, 0.47) | 18.75 (16.65, 21.12) |
| Change in Avoidance/ Rumination (n=37) | 16.77 (14.94, 18.61) | −0.33 (−0.46, −0.19) | 0.12 (−0.02, 0.27) | 0.01 (−0.001, 0.02) | 0.09 | 18.89 (10.74, 33.24) | 0.09 (0.05, 0.18) | −0.22 (−0.82, 0.37) | 18.73 (16.64, 21.09) |
| Change in Work/School Impairment (n=37) | 16.50 (14.16, 18.83) | −0.23 (−0.40, −0.07) | 0.09 (−0.23, 0.41) | 0.03 (0.01, 0.05) | 0.16 | 20.18 (11.58, 35.16) | 0.08 (0.04, 0.16) | −0.11 (−0.67, 0.45) | 18.74 (16.65, 21.10) |
| Change in Social Impairment (n=36) | 14.92 (12.61, 17.22) | −0.24 (−0.41, −0.08) | −0.17 (−0.42, 0.07) | 0.02 (0.01, 0.04) | 0.19 | 20.05 (11.41, 35.25) | 0.09 (0.04, 0.17) | 0.13 (−0.44, 0.69) | 18.73 (16.61, 21.12) |