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A Behavior Genetic Analysis of Pleasant Events, Depressive Symptoms, and Their Covariation

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Abstract

Although pleasant events figure prominently in behavioral models of depression, little is known regarding characteristics that may predispose people to engage in pleasant events and derive pleasure from these events. The present study was conducted to evaluate genetic and environmental influences on the experience of pleasant events, depressive symptoms, and their covariation in a sample of 148 twin pairs. A multivariate twin modeling approach was used to examine the genetic and environmental covariance of pleasant events and depressive symptoms. Results indicated that the experience of pleasant events was moderately heritable and that the same genetic factors influence both the experience of pleasant events and depressive symptoms. These findings suggest that genetic factors may give rise to dispositional tendencies to experience both pleasant events and depression.

Keywords

heritability; pleasant events; depression; twin; behavior theory

In recent years, there has been a resurgence of interest in the behavioral model of depression, a model of depression that has a 40-year history in clinical and experimental psychology (for a review of the theoretical and empirical foundations of the behavioral theory and treatment of depression, see Dimidjian, Barrera, Martell, Muñoz, & Lewinsohn, 2011). This increased interest in the behavioral model can be attributed, in large part, to Jacobson and colleagues' (1996) component analysis of cognitive-behavior therapy study, which aimed to identify the active ingredients of cognitive-behavior therapy of depression. Results from the study suggested that a condition that was based only on behavioral activation performed as well as the full cognitive therapy condition, both at the end of treatment (Jacobson et al., 1996) and at two-year follow-up (Gortner et al., 1998). The efficacy of behavioral activation (BA) in treating depression has been replicated in several studies (for a review, see Mazzucchelli, Kane, & Rees, 2009) and BA is now considered one of the primary interventions for treating depression.

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BA is based, in part, on the traditional behavioral model of depression, which posits that depression is the result of losses of, reductions in, or chronically low levels of response-contingent positive reinforcement. Specifically, Lewinsohn (1974) proposed that response-contingent positive reinforcement is a function of three factors: (a) differences in what is reinforcing to the individual, (b) availability of what is reinforcing to a particular individual, and (c) the individual's skill in obtaining and maintaining contact with that reinforcement (see Manos, Kanter, & Busch, 2010).

Prior research supports the basic tenets of Lewinsohn's (1974) behavioral model in demonstrating that depression is associated with low rates of positive reinforcement, which is most commonly operationalized in terms of the experience of self-reported pleasant events. For example, daily ratings of pleasant events are associated with daily ratings of depressed mood (e.g., Lewinsohn & Graf, 1973) and ratings of the frequency and enjoyment of pleasant events differentiates clinically depressed individuals from both nondepressed psychiatric controls and nondepressed controls (e.g., Lewinsohn & Graf, 1973). In addition, treatment-induced changes in ratings of pleasant events are associated with changes in depression (Lewinsohn, Youngren, & Grosscup, 1979) and interventions designed to increase pleasant events are effective in reducing depression (Lewinsohn, Sullivan, & Grosscup, 1980). More recent findings regarding pleasant events and depression are consistent with these earlier studies evaluating the behavioral model of depression (e.g., Mausbach, Roepke, Depp, Patterson, & Grant, 2009). For example, in a 2-year follow-up of people who responded to cognitive-behavior therapy, people with lower ratings of enjoyment from pleasant events were more likely to relapse than people with higher ratings of enjoyment (Gollan, Gortner, & Dobson, 2006).

Although research supports predictions from the behavioral model of depression regarding pleasant events, Lewinsohn's original behavioral (1974) and integrated (Lewinsohn et al., 1985a) models of depression posited that there are predisposing characteristics that influence an individual's likelihood of experiencing depression, in part, through reducing the frequency or enjoyment of pleasant events. Little is known, however, regarding individual characteristics that may predispose people to engage in pleasant events and derive pleasure from these events. Prior research suggests that genetic predispositions influence people to either evoke or select certain environments and life events (Kendler & Baker, 2007). This phenomenon has been described as evocative or active gene-environment correlation (Plomin, DeFries, & Loehlin, 1977), and suggests that individuals evoke from their environment responses that complement their genetic makeup or actively seek environments and experiences that are consistent with their genetic influences. Therefore, genetically influenced characteristics may determine what is potentially reinforcing to the individual, as well as their skill in obtaining and maintaining contact with that reinforcement. Genetically informed designs (i.e., twin studies) could aid in identifying the degree to which the experience of pleasant events is genetically and environmentally influenced.

Heritability is defined as the proportion of individual differences for a trait in a particular population that results from inter-individual genetic differences. Although several studies have evaluated the heritability of the experience of stressful life events (for a review, see Kendler & Baker, 2007), we know of only one study that has evaluated the heritability of the

experience of pleasant events.¹ Wierzbicki (1989) evaluated the genetic influence on the experience of pleasant events in a small sample of monozygotic ($n = 41$) and same-sex dizygotic twins ($n = 29$). Results from the study suggest a heritability of approximately .30 for the experience of pleasant events.

Thus, evidence suggests that pleasant events and depression have strong phenotypic correlations (Lewinsohn & Graf, 1973), and both the experience of pleasant events (Wierzbicki, 1989) and depressive symptoms (Johnson, McGue, Gaist, Vaupel, & Christensen, 2002) are at least moderately heritable. In synthesizing these areas of research, the question arises as to whether the genetic influences on the experience of pleasant events are the same as those that influence depression. A finding of genetic influences on the associations between the experience of pleasant events and depressive symptoms, for example, would suggest the possibility of a common underlying liability that influences both. Alternatively, genetic factors might influence the experience of pleasant events (or depressive symptoms), which in turn could influence depressive symptoms (or the experience of pleasant events). Finally, genetic factors might influence a third factor that could then influence both the experience of pleasant events and depressive symptoms.

In the present study, we used a multivariate twin modeling approach to examine the genetic and environmental influences on the experience of pleasant events, depressive symptoms, and their covariation. Based on the results from the Wierzbicki (1989) study regarding the heritability of pleasant events, as well as the results from prior research on life events, which has found that events that probably result from a person's own behavior (i.e., dependent events) are more heritable than events that are probably unrelated to a person's own behavior (i.e., independent events) (Kendler & Baker, 2007), we hypothesized that the experience of pleasant events would be moderately heritable. Furthermore, given the results from prior studies that have found shared genetic influences between stressful life events and depression (e.g., Kendler et al., 1995), we hypothesized that the genetic influences on the experience of pleasant events would be shared with the genetic influences on depressive symptoms.

Methods

Participants

Data from the study comes from the National Survey of Midlife Development in the United States (MIDUS), a population-based national survey of Americans aged 25 to 74, conducted by the John D. and Catherine T. MacArthur Foundation network on Successful Midlife Development in 1995. The MIDUS included several samples, and the present analyses are based on the twin sample, which was recruited using a two-part sampling design (screening of a representative national sample of approximately 50,000 households for the presence of

¹There are several studies that have examined the genetic and environmental influences on major life events that are positive or desirable, such as "getting married" or "major improvements in financial status" (e.g., Plomin, Lichtenstein, Pedersen, McClearn & Nesselroade, 1990; Saudino, Pedersen, Lichtenstein, McClearn, & Plomin, 1997). Although these events are positive, the measure used in these studies was modeled after the Social Readjustment Rating Scale (Holmes & Rahe, 1967), and therefore the events are best conceptualized as *stressful* life events because they require change in one's ongoing or accustomed pattern of life. Therefore, the positive events examined in these other studies are conceptually different than the pleasant events measured in the current study.

a twin, followed by contact and recruitment of twins from these twin households). A 10-year follow-up study was conducted on the original sample in 2004–2006 – the MIDUS II – and biological samples and self-administered questionnaire data, including the data examined in this study, were collected on a subsample of MIDUS II respondents as part of the Biomarker Project (Ryff, Seeman, & Weinstein, 2010).

We excluded twin pairs who were missing data or who were not classifiable due to missing or indeterminate information used to determine zygosity (e.g., eye and hair color, degree to which others were confused as to their identity during childhood). The final sample included 148 twin pairs: 48 monozygotic (MZ) female pairs, 29 dizygotic (DZ) female pairs, 33 MZ male pairs, 9 DZ male pairs, and 29 DZ opposite sex pairs. The sample included 183 women and 113 men, and participants had a mean age of 53.4 years ($SD = 11.4$; range = 34 – 82). The racial distribution of the sample was 96% White, 2% Black, 1% Native American or Alaska Native, and 1% other.

Measures

Pleasant Events Schedule (PES; MacPhillamy & Lewinshon, 1982)—The PES is a self-report measure of the experience of commonly rewarding events. Items are rated first on a 3-point scale of frequency during the past month (0 = did not happen, 1 = happened a few times, 2 = happened often), then on a 3-point scale of enjoyment (0 = not pleasant, 1 = somewhat pleasant, 2 = very pleasant). As pleasant events are viewed as largely under the control of the individual (i.e., they are viewed as dependent events), the PES has been used clinically to identify behaviors whose frequency could be increased to raise the reinforcement that depressed individuals receive in their lives (Lewinsohn et al., 1980). A variety of scales have been derived from the 320 events in the original PES (MacPhillamy & Lewinshon, 1982). The MIDUS II included a modified version of the Mood Related (MR) subscale of the PES (Lewinsohn & Amenson, 1978). The MR subscale was developed in a study on daily engagement of pleasant activities and mood (Lewinsohn & Graf, 1973), and the scale consists of 49 PES items that were significantly correlated with reported mood in at least 10% of participants who recorded their own activities and mood daily for 30 consecutive days; sample items included “Reading stories, novels, poems, or plays”, “Going to a party”, and “Seeing beautiful scenery.” The assumption is that events that are accompanied by positive mood by a substantial proportion of the population represent events that have reinforcing properties in the population at large and therefore are hypothesized to be of special relevance to depression and reinforcement (Lewinsohn & Amenson, 1978). Frequency and enjoyment scales are created by computing the mean of the items, with the resulting scale having a range of 0 – 2; higher scores reflect more frequent participation in pleasant events and more enjoyment derived from these events, respectively. A multiplicative score is obtained by multiplying each item’s frequency score by its enjoyment score and computing the mean of these multiplicative item scores; the resulting scale has a range of 0 – 4. This multiplicative score is referred to as obtained pleasure (MacPhillamy & Lewinshon, 1982), and it is viewed as an approximate measure of response-contingent positive reinforcement (Lewinsohn & Amenson, 1978). In the current sample, good internal consistency was obtained for the frequency ($\alpha = .89$), enjoyment ($\alpha = .93$), and obtained pleasure ($\alpha = .91$) scales.

Depression—Depressive symptoms were measured with the Center for Epidemiologic Studies Depression Scale (CES-D; Radloff, 1977), which is a 20-item measure developed for use in community samples. Items are rated on a 4-point scale for the frequency of occurrence during the past week, and a summary score was computed by reverse scoring the positive items and computing the sum of the items, with higher scores indicating greater depression severity. The CES-D demonstrated good internal consistency in this sample ($\alpha = .88$).

Statistical Analyses

Mplus (Muthen & Muthen, 1998–2010) was used to conduct the data analyses. The Maximum Likelihood (ML) estimator was used for all univariate and bivariate analyses. The statistical significance of the parameters was determined by their p values, which are based on the ratio of each parameter to its standard error, yielding a z statistic. Given that the χ^2 is sensitive to sample size, additional fit indices were assessed, including the comparative fit index (CFI), the Tucker-Lewis index (TLI), and the root mean square error of approximation (RMSEA). A CFI and TLI greater than .95 and RMSEA less than .06 indicate good model fit (Hu & Bentler, 1999).

Phenotypic and Twin Correlations—A set of correlations was calculated for pleasant events and depressive symptoms: Cross-trait phenotypic correlations (e.g., the association between pleasant events in twin 1 and depressive symptoms in twin 1); within-trait cross-twin correlations (e.g., the association between pleasant events for twin 1 and twin 2); and cross-trait cross-twin correlations (e.g., the association between pleasant events for twin 1 and depressive symptoms for twin 2). Phenotypic correlations were fixed to be equal between twin 1 and twin 2 and between MZ and DZ twin pairs; within-trait cross-twin correlations and cross-trait cross-twin correlations varied between MZ and DZ twin pairs; and equivalent cross-trait cross-twin correlations between twin 1 and twin 2 were fixed to be equal.

Based on the assumption that MZ twins share 100% of their genes and DZ twins share 50% of their genes identical by descent on average, comparing the magnitude of the within-trait and cross-trait cross-twin correlations can provide information about the magnitude of genetic and environmental influences on pleasant events, depressive symptoms, and their covariation. Genetic influences are indicated when correlations in MZ twin pairs are greater than those in DZ twin pairs ($r_{MZ} > r_{DZ}$). Dominant genetic effects are indicated when the r_{MZ} is greater than twice the r_{DZ} , whereas shared environmental effects are indicated when the r_{MZ} is less than twice the r_{DZ} .

Model Fitting—In order to estimate the magnitude of genetic and environmental influences on the PES, the CES-D, and their association, we conducted a Cholesky decomposition, which provides an atheoretical assessment of genetic and environmental influences on phenotypes. This model estimates the magnitude of genetic (a^2), shared environmental (c^2), and nonshared environmental (e^2) influences. Figure 1 illustrates a bivariate Cholesky decomposition. Latent variable A1 represents genetic influences on the experience of pleasant events that also influence depressive symptoms and A2 represents

genetic influences that influence depressive symptoms, but not pleasant events (C and E variables represent influences of the shared environment and nonshared environment, respectively).

Results

The mean CES-D score was 6.73 ($SD = 6.86$; range 0 – 49) and 8.8% of the sample scored 16 on the measure, which is the cutoff for defining clinically elevated depression (Radloff, 1977). Mean scores on the PES subscales were 1.26 ($SD = .25$) for frequency, 1.64 ($SD = .26$) for enjoyment, and 2.15 ($SD = .61$) for obtained pleasure; these means are comparable to normative data on the scale (MacPhillamy & Lewinshon, 1982).

There were significant effects of gender for all three subscales of the PES (all p values < .01; higher ratings in women), whereas the effects of gender were not significant for the CES-D ($p = .68$). To control for gender differences in the PES subscales, we regressed each measure on gender, then conducted subsequent analyses on the standardized residuals. All subscales of the PES were normally distributed, with acceptable skewness and kurtosis values. The CES-D yielded a skewed distribution, but log-transformation of this variable resulted in a normal distribution.

Correlations

The phenotypic correlations between the PES subscales and the CES-D were negative and moderate in magnitude (frequency, $r = -.31$, $p < .01$; enjoyment, $r = -.44$, $p < .01$; obtained pleasure, $r = -.42$, $p < .01$). Table 1 presents within-trait cross-twin and cross-trait cross-twin correlations for pleasant events and depressive symptoms. Results of these correlations provide evidence of additive genetic effects on pleasant events and the covariance between pleasant events and depressive symptoms, as MZ correlations are greater than twice the DZ correlations. In contrast, results suggest a combination of genetic and shared environmental effects on depressive symptoms, indicated by an MZ correlation that is less than twice the DZ correlation.

Model Fitting Results

Univariate analyses were conducted to determine the relative contribution of genetic, shared environmental, and nonshared environmental influences to the obtained pleasure subscale of the PES and the CES-D. Models fit the data well for pleasant events, $\chi^2(6) = 1.58$, $p = .95$, CFI = 1.0, TLI = 1.0, RMSEA = 0.0, and depressive symptoms, $\chi^2(6) = 7.01$, $p = .32$, CFI = .94, TLI = .98, RMSEA = .05. Results suggest that the construct assessed by the obtained pleasure subscale of the PES is moderately heritable ($a^2 = 46\%$) and is also influenced by nonshared environmental factors ($e^2 = 53\%$). Univariate and bivariate analyses were also conducted using the frequency and enjoyment subscales and results were very similar to those using the obtained pleasure subscale. All univariate models for the three subscales fit the data well (all TLIs > .99; all CFIs > .99; all $\chi^2(7) < 2.02$, $p > .92$) and parameter estimates were largely consistent in magnitude across the subscales (frequency: $a^2 = 42\%$, $e^2 = 58\%$; enjoyment: $a^2 = 41\%$, $e^2 = 59\%$). There was little evidence of shared environmental influences on any of the PES subscales, and this parameter could be dropped from the

models without a significant decrement in fit. Given the consistency of results across subscales, we present further results only for the obtained pleasure subscale.

Results also indicate that depressive symptoms are substantially influenced by the nonshared environment ($e^2 = 61\%$), and moderately influenced by genes ($a^2 = 24\%$) and the shared environment ($c^2 = 16\%$). The within-trait cross-twin correlations for CES-D presented in Table 1 suggest a heritability estimate smaller in magnitude than the estimate provided in the univariate model. This may be due to the fact that the MZ variances for CES-D (twin 1 = .15; twin 2 = .17) are smaller in magnitude than DZ variances (twin 1 = .20; twin 2 = .20), whereas in the univariate model, variances are constrained to be equal for MZ and DZ twin pairs.

Bivariate twin modeling was conducted to evaluate the extent to which the phenotypic association between pleasant events and depressive symptoms was due to common genetic and environmental influences. Figure 1 presents parameter estimates for the bivariate Cholesky decomposition of pleasant events and depressive symptoms. The final model fit the data well, $\chi^2(18) = 12.56$, $p = .86$, CFI = 1.0, TLI = 1.0, RMSEA = 0.0. Results suggest that the negative covariance between these constructs is explained mostly by genetic influences (i.e., paths from A1 to PES and CES-D), and, to a lesser extent, nonshared environmental influences (i.e., paths from E1 to PES and CES-D); 65% of the negative covariance is due to genetic factors and 35% of the covariance is due to nonshared environmental influences. Additionally, results indicate that there is no genetic variance unique to depressive symptoms over and above that which is shared with pleasant events (i.e., A2 to CES-D). In contrast, there is less overlap between the nonshared environmental factors influencing pleasant events and those influencing depressive symptoms (path from E1 to CES-D). Rather, results suggest that the majority of the nonshared environmental influences on pleasant events are specific to pleasant events (paths from E1 to PES and E2 to CES-D). Consistent with univariate results, the shared environment had no influence on pleasant events. Given this pattern of results, the path representing shared environmental influences on the covariation between pleasant events and depressive symptoms (C1 to CES-D) was dropped from the final model. There were modest shared environmental influences that were specific to depressive symptoms (C2 to CES-D).

Discussion

The present study was conducted to evaluate the genetic and environmental influences on the experience of pleasant events, depressive symptoms, and their covariation. Understanding the genetic and environmental influences on these variables is important for identifying individuals at risk for depression and for understanding causal models of depression.

Looking first at the results from the univariate analyses, results suggest that depressive symptoms are substantially influenced by the nonshared environment and modestly influenced by genes and by the shared environment, which is consistent with prior twin studies (Johnson et al., 2002). Results also indicated that the experience of pleasant events is moderately heritable ($h^2 = .46$) and is also influenced by nonshared environmental factors

($e^2 = .53$). Results for the frequency and enjoyment subscales individually were very consistent with those for the obtained pleasure scale, which suggests that genetic influences on the experience of pleasant events are not simply reflecting the subjective experience of events (i.e., enjoyment) but also the more objective exposure to pleasant events (i.e., frequency). The heritability estimate of the experience of pleasant events obtained in the current study is somewhat higher than that obtained by Wierzbicki (1989), whose results suggest a heritability of approximately .30 for the experience of pleasant events. Differences in the estimates of heritability between the two studies could be due to differences in sample characteristics, as the Wierzbicki (1989) results were obtained from a small, convenience sample of predominately female twin pairs who on average were in their mid-30s. As noted by Wierzbicki (1989), this small sample size likely yielded unstable parameter estimates of heritability. In comparison, the current results are based on a larger sample of male and female twin pairs who on average were in their mid-50s.

The current finding that the experience of pleasant events is heritable is consistent with behavioral genetic research on the heritability of related constructs. For example, prior research has shown significant genetic influences on positive or desirable events, with heritability estimates similar to those observed in the current study (e.g., Plomin et al., 1990; Saudino et al., 1997). The events examined in prior studies, although positive, are conceptualized as stressful events and therefore differ from the measure of pleasant events used in this study (see Footnote 1). In addition, prior research has shown significant genetic influences on reward responsiveness, which refers to an individual's ability to modify behavior according to reinforcement history and which is measured by a laboratory-based reward task (Bogdan & Pizzagalli, 2010). Taken together, these results provide converging evidence for genetic influences on phenotypes associated with positive environmental reinforcement.

Turning next to the findings for the bivariate analyses, results indicate that the majority (65%) of the negative covariance between the experience of pleasant events and depressive symptoms is due to genetic factors, with 35% of the covariance due to nonshared environmental influences. Additionally, results indicate that there is no genetic variance unique to depression over and above that which is shared with pleasant events. The finding that the genetic influences on the experience of pleasant events are largely similar to the genetic influences on depressive symptoms suggests that genetic factors may give rise to dispositional tendencies to experience both pleasant events and depression. These results are similar to those obtained by Bogdan and Pizzagalli (2009), who found common genetic influences for the association between reward responsiveness and depressive symptoms.

There are three major implications of the current findings. First, results from the study have implications for theoretical perspectives on the sources of influence on behavior in behavioral models of depression. As previously noted, Lewinsohn (1974) conceptualized depression as the result of low rates of response-contingent positive reinforcement. For Lewinsohn, *response contingent* meant that reinforcement was dependent on the individual's actions. The evidence of heritability for the experience of pleasant events provides support for this perspective, and highlights the importance of genetically influenced characteristics of individuals that affect their experience of environmental events. In comparison,

contemporary behavioral models of depression generally focus on external, environmental consequences of behavior (i.e., environmental contingencies and situational influences), that function to maintain behavior (e.g., Martell, Dimidjian, & Herman-Dunn, 2010). Without minimizing the importance of such environmental influences on behavior, the current findings suggest there are also internal, genetic influences on the experience of these behaviors. That is, the current results suggest that the nature of the causal relationship between pleasant events and depression, at least in part, is from the individual to his or her environment, consistent with Lewinsohn's (1974) response contingent model (see Kendler & Baker, 2007, for a more detailed discussion of the influence of genetic factors on environmental experiences).

A second and related implication of the current results is that they serve to direct attention to the importance of genetically-influenced dispositional factors that may give rise both to the experience of pleasant events and depressive symptoms. Because genetic factors do not directly "code" for specific environments, researchers have studied possible mediators between genotype and environmental factors (Kendler & Baker, 2007). The most widely studied possible mediator of genetic effects on environmental events has been personality. Neuroticism (or negative affectivity) has figured prominently in theories of depression (Mineka, Watson, & Clark, 1998), and neuroticism demonstrated a significant negative correlation with the frequency, enjoyment, and obtained pleasure scales from the PES in a sample of psychiatric inpatients (Bouman & Luteijn, 1986). Furthermore, not only is neuroticism heritable (Loehlin, McCrae, & Costa, 1998), but the genes that influence neuroticism are also those that are likely to influence depression (Kendler & Myers, 2010).

Another personality factor that might contribute to the experience of pleasant events is positive emotionality. People who score high in positive emotionality present themselves as "being engaged in active, pleasurable, and efficacious transactions with their environment and as being ready to experience the positive emotions congruent with these involvements" (Tellegen et al., 1988, p. 1033). Furthermore, positive emotionality has been shown to be moderately heritable (Tellegen et al., 1988), and positive affect was significantly and positively associated with the frequency of pleasant events in a sample of spousal Alzheimer caregivers (Mausbach et al., 2009), suggesting that positive emotionality might mediate the association between genetic influences and the experience of pleasant events. In studying personality influences on pleasant events and depression, it is worth noting that facets of personality, such as narrow personality traits (vs. broad personality dispositions), may hold promise in providing stronger and more specific associations. For example, research on positive emotionality has shown that it is the positive affectivity facet, but not the sociability/extraversion facet, that is associated with depression (for a review, see Klein, Kotov, & Bufferd, 2011).

Another dispositional factor that might contribute both to the experience of pleasant events and to depressive symptoms is Gray's (1981) behavioral approach system (BAS), which is an appetitive motivational system that, among other things, is believed to be sensitive to signals of reward. As such, it may be that people with low levels of BAS are unresponsive to or less likely to pursue pleasant events. Furthermore, the BAS has been shown to be heritable (e.g., Takahashi et al., 2007) and low BAS functioning demonstrates cross-

sectional and longitudinal associations with depression (e.g., Kasch, Rottenberg, Arnow, & Gotlib, 2002). However, we are not aware of any studies that have evaluated the association between the BAS and the experience of pleasant events. Clearly, additional research is needed regarding the genetically influenced characteristics that may give rise both to the experience of pleasant events and depression.

A third implication of the results of the study is the possible role of genetically influenced traits in predicting the response to behavioral treatments of depression. BA treatments for depression aim to facilitate contact with potentially positively reinforcing events (Martell et al., 2010). However, the current findings for overlapping genetic influences on the experience of pleasant events and depression suggests that people with a genetic propensity for depression may be less likely to experience reinforcement when in contact with these potentially reinforcing events. As such, it may be that people who report receiving less enjoyment from the experience of pleasant events may be less likely to benefit from behavioral treatments for depression. In support of this perspective, Gollan et al. (2006) reported that lower enjoyment of pleasant events, but not frequency of pleasant events, was associated with higher relapse rates following cognitive and behavioral treatments of depression. Although there has been little research on predictors of outcome specifically on behavioral treatments for depression, the current findings suggest that genetic vulnerability, as evidenced by family history of depression or presence of genetically-influenced personality traits (e.g., high neuroticism, low positive emotionality), may predict poorer response to BA or higher relapse rates following BA. In partial support of this perspective, Gollan et al. (2006) found that a higher level of dependent personality traits was associated with greater likelihood of relapse following cognitive and behavioral treatments of depression, and that the association between enjoyment of pleasant events and depressive relapse was no longer significant when controlling for dependent personality. Therefore, to the extent that genetically influenced traits contribute both to the experience of pleasant events and depression, then individuals with high genetic vulnerability for depression may be less likely to respond to and more likely to relapse following behavioral treatments for depression. Furthermore, the current findings regarding genetic influences for both the frequency and enjoyment of pleasant events suggest that depressed individuals with high genetic vulnerability for depression may benefit from intervention strategies that focus on increasing event or activity pleasantness (cf. Dobson & Joffe, 1986), as well as those intervention strategies that focus on increasing the frequency of pleasant events and exposure to reinforcing activities.

In interpreting the results of the study, there are several ways to conceptualize the experience of pleasant events. For example, pleasant events can be conceptualized as environmental events, similar to other types of life events (e.g., stressful life events). Adopting this perspective, the current results can be interpreted as extending prior research that has found genetic influences on the experience of stressful life events (Kendler & Baker, 2007) and the co-occurrence between such events and depression (Kendler et al., 1995). Alternatively, pleasant events can be conceptualized as a proxy for reinforcement, consistent with the behavioral model of depression (Lewinsohn & Amenson, 1978). Adopting this perspective, the current results can be interpreted as providing evidence for common genetic influences on the co-occurrence of positive reinforcement and depressive

symptoms. Furthermore, it should be noted that whereas early behavioral theories of depression focused on positive reinforcement as operationalized in terms of the experience of pleasant events, contemporary behavioral theories of depression emphasize behavioral avoidance and idiographic, functional approaches to assessment and intervention over nomothetic approaches that focus on activities that are simply pleasant (Hopko, Lejuez, Ruggiero, & Eifert, 2003; Manos et al., 2010). Several measures have been developed to reflect these perspectives on behavioral assessment (for a review, see Manos et al., 2010), and future research is needed to evaluate the genetic influences on the constructs assessed by these measures, depression, and their covariation.

The results of the study should be interpreted in light of several limitations. First, the sample size was relatively small and predominantly White, and future research involving larger and more racially and ethnically diverse samples would be useful in confirming the generalizability of the results. Second, as evidence suggests that the magnitude of genetic influences on related constructs, such as negative life events, varies with age across childhood and adolescence (Johnson, Rhee, Whisman, Corley, & Hewitt, 2013), it would be informative to evaluate genetic influences on the experience of pleasant events, depressive symptoms, and their co-occurrence in younger samples and across time in longitudinal samples. Third, given our relatively small sample size, we could not examine gender differences. Evaluating gender differences and other potential moderators of genetic and environmental influences on the experience of pleasant events, depressive symptoms, and their covariation will be an important consideration in future research. Fourth, although the twin design provides a powerful method to assess genetic and environmental influences, there are limitations to this method (for a review, see Tenesa & Haley, 2013) and several statistical assumptions are necessary to conduct analyses. One limitation is that shared environmental influences (C) and non-additive genetic influences (D) cannot be included in the same model. Thus, we cannot be certain from this study that there are no non-additive genetic influences on pleasant events or depression. A statistical assumption of the twin design, the equal environments assumption (EEA), posits that MZ twins are not treated more similarly than DZ twins. If the EEA is violated, then heritability estimates will be biased upwards, as MZ twin similarity is necessarily captured by the genetic parameter in the twin model. However, several tests of the EEA have shown that it is a tenable assumption in twin studies examining psychiatric disorders (e.g., Kendler et al., 1993; 1994; Xian et al., 2000). Furthermore, the magnitude of parameter estimates for the experience of pleasant events and depressive symptoms in our study are consistent with those reported in studies examining other types of life events and depression (Kendler et al., 1995). Finally, studies using methods that are not subject to the limitations of the twin design (e.g. genome-wide complex trait analysis; adoption studies), have found heritability estimates for depression (Lubke et al., 2012; Sullivan et al., 2000) and life events (Bemmels et al., 2008; Power et al., 2012) that are consistent with the estimates in our sample.

In conclusion, results suggest that the experience of pleasant events is moderately heritable, and that the genetic influences on the experience of pleasant events are the same as those that influence depressive symptoms. These results suggest that genetic factors may give rise to dispositional tendencies to experience both pleasant events and depression. Furthermore, in finding shared genetic influences on the covariation between the experience of pleasant

events and depression, the results highlight a point of convergence between behavioral and genetic models of depression.

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Figure 1. Bivariate Cholesky Decomposition of Pleasant Events and Depressive Symptoms

Standardized parameter estimates are shown and parameter estimates marked with an asterisk are statistically significant ($p < .01$). The standard error of each estimate is presented in parentheses. Common shared environmental influences (indicated by a dashed line) were dropped from the model, given that the magnitude of shared environmental influences on pleasant events was zero. PES = Pleasant Events Scale (obtained pleasure subscale). CES-D = Center for Epidemiologic Studies Depression Scale; A1 = genetic influences common to both phenotypes; C1 = shared environmental influences common to both phenotypes; E1 = nonshared environmental influences common to both phenotypes; A2 = genetic influences

specific to depressive symptoms; C2 = shared environmental influences specific to depressive symptoms; E2 = nonshared environmental influences specific to depressive symptoms.

Table 1

Twin Correlations for Pleasant Events and Depressive Symptoms

Type of Correlation	MZ Correlation	DZ Correlation
Within-trait Cross-twin Correlations		
PES - Frequency	.42(.09) **	.23(.11) *
PES - Enjoyment	.42(.09) **	.20(.11)
PES - Obtained Pleasure	.47(.09) **	.21(.11)
CES-D	.37(.10) **	.32(.11) **
Cross-trait Cross-twin Correlations		
PES – Frequency with CES-D	–.21(.08) **	–.03(.09)
PES - Enjoyment with CES-D	–.33(.08) **	–.19(.08) *
PES – Obtained Pleasure with CES-D	–.31(.08) **	–.12(.09)

Note. MZ = monozygotic; DZ = dizygotic; PES = Pleasant Events Scale; CES-D = Center for Epidemiologic Studies – Depression Scale. The standard error of each correlation is presented in parentheses.

*
 $p < .05$.

**
 $p < .01$.