

The Impact of Depression on Social Economic Decision Making

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Although the role of emotion in social economic decision making has been increasingly recognized, the impact of mood disorders, such as depression, on such decisions has been surprisingly neglected. To address this gap, 15 depressed and 23 nondepressed individuals completed a well-known economic task, in which they had to accept or reject monetary offers from other players. Although depressed individuals reported a more negative emotional reaction to unfair offers, they accepted significantly more of these offers than did controls. A positive relationship was observed in the depressed group, but not in controls, between acceptance rates of unfair offers and resting cardiac vagal control, a physiological index of emotion regulation capacity. The discrepancy between depressed individuals' increased emotional reactions to unfair offers and their decisions to accept more of these offers contrasts with recent findings that negative mood in nondepressed individuals can lead to lower acceptance rates. This suggests distinct biasing processes in depression, which may be related to higher reliance on regulating negative emotion.

Keywords: decision making, depression, cardiac vagal control

Cognitive biases or distortions are well documented in depression (Beck, 2008) and are often the focus of therapeutic intervention with cognitive behavioral therapy (Whisman, Miller, Norman, & Keitner, 1991). Much of the empirical literature focuses on alteration in attributions, but comparatively little research has examined on how such cognitive alterations in depression influence decision making. Outside of treatment decisions, very few studies have actually examined the degree to which decision making is altered in depression, and whether any such disturbances lead to suboptimal outcomes. As the role of both task-related and incidental emotion in decision making is increasingly incorporated in general economic models of decision making (Loewenstein & Lerner, 2003), *social* decision making (i.e., involving interactions of two or more individuals) has been shown to engage an ensemble of neural systems relevant to emotion, reward valuation, and planning (Sanfey, 2007). Therefore, mood disturbances, such as those observed in depression, may well lead to decision biases in a social context (Strack & Coyne, 1983). These types of decisions may in fact have the greatest influence on the day-to-day lives of patients, and thus such research may contribute to practical efforts to improve depressed individuals' confidence, self-esteem, and social connectedness.

Reward in Depression

The limited decision-making research with unmedicated patients suggests that depression is associated with decreased approach-related behavior and reduced sensitivity to reward, which appears to underlie a failure to maximize potential monetary earnings (Henriques & Davidson, 2000; Pizzagalli, Iosifescu, Hallett, Ratner, & Fava, 2008). These findings are consistent with both anhedonia and the tendency to neglect pleasurable stimuli often found in depression as well as with research showing that sad affect may focus attention more on threatening cues (Forgas, 2003) than on opportunities to profit (Lerner, Small, & Loewenstein, 2004). Recent neuroimaging research further suggests that depressed individuals' decreased sensitivity to reward may stem more from a relative increase in affective conflict and monitoring efforts than failure to engage dopaminergic reward systems (Holmes & Pizzagalli, 2008; Knutson, Bhanji, Cooney, Atlas, & Gotlib, 2008). Although these investigations do not directly touch on social contexts, they do provide evidence of distinct patterns of decision making in depression.

Social Decision Making

In order to examine the impact of depression on social decision making, we used a well-known economic task, the Ultimatum Game (UG; Guth, Schmittberger, & Schwarze, 1982), in which one player (the "proposer") makes an offer to another player (the "responder") regarding how to split an amount of money between them. The responder can either accept the offer, in which case the money is split as proposed, or reject the offer, in which case neither player receives anything. Whereas standard economic models would predict that responders should accept any nonzero offers (still preferable to no gain at all), individuals typically accept about 50% of unfair offers (defined as 30% or less of the pot; Camerer, 2003) and experience a negative emotional response and increased arousal when receiving unfair offers (Sanfey, Rill-

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ing, Aronson, Nystrom, & Cohen, 2003; van't Wout, Kahn, Sanfey, & Aleman, 2006). Although social decision making has been extensively studied, the use of this task in clinical populations is still in its infancy (Agay, Kron, Carmel, Mendlovic, & Levkovitz, 2008). Two recent studies, however, suggest that characteristics associated with depression, sad affect and serotonin depletion, may lead to more aggressiveness and retaliation in the UG. Our group recently reported that induced sad mood resulted in lower acceptance rates of unfair UG offers, with sad participants also reporting significantly more anger than neutral participants when receiving unfair offers (Harlé & Sanfey, 2007). Another study (Crockett, Clark, Tabibnia, Lieberman, & Robbins, 2008) found that nondepressed participants undergoing tryptophan depletion, which leads to decreased brain serotonin and has been associated with more social aggressiveness, exhibited lower acceptance rates of unfair offers as compared with a placebo control group. Because sadness and disruption of serotonergic neurotransmission have been implicated in clinical depression (Porter, Mulder, Joyce, Miller, & Kennedy, 2008), one hypothesis is that depressed individuals may process unfair offers as more offensive and thus might be more sensitive and aggressive toward negative social signals. Compared with controls, the depressed group might then, on average, accept fewer unfair offers and report a more negative emotional reaction when receiving these offers.

Alternatively, some research has shown that depressed individuals are more accurate than nondepressed in estimating contingencies between behavior and external events and that such estimation is not affected by the valence of such prediction outcomes (e.g., reward vs. loss). Thus, depressed individuals may be more realistic about their degree of control over certain transaction outcomes (Alloy & Abramson, 1979). If depressed individuals are indeed more realistic in assessing unfair offers, then they may be less likely than controls to think that their decisions will affect either their partners or the subsequent offers they will receive, and thus may expect lower offers in the first place (i.e., being more realistic regarding the opportunistic nature of proposers). Therefore, an alternative hypothesis is that depressed individuals may exhibit higher acceptance rates of unfair offers compared with controls. These higher rates may be independent of their emotional reaction to unfair offers (e.g., they may still react more negatively to unfairness), particularly if they more realistically assess the lack of impact of their decisions.

Emotion Regulation

In addition to assessing behavioral performance and emotion, in the present study, we examined the role of physiologically driven emotion regulation processes in such decisions, as research suggests that brain regions subserving one's ability to regulate emotion are involved in responders' ability to accept unfair UG offers (Koenigs & Tranel, 2007). Numerous studies have suggested that parasympathetically driven cardiac vagal control (CVC; i.e., respiratory-linked changes in heart rate) may index one's ability to regulate emotion and respond adaptively to various stressors, with higher CVC reflecting a stronger ability to self-regulate (Porges, 2007; Thayer & Lane, 2000). Moreover, there is evidence that, compared with nondepressed individuals, depressed individuals' CVC may be reduced (Booij et al., 2006), suggesting emotion regulation may be impaired in depression, although others have

failed to show such group differences (Lehofer et al., 1997). Thus, it is of interest to examine whether individual differences in CVC are related to UG decisions, potentially due to CVC's putative influence on emotion regulation.

Method

Participants

Participants were recruited from among students who participated in a four-session study of psychophysiological indicators of risk for depression, and in which individuals with a wide range of depression, ranging from nondepressed to clinical severity, were examined. A total of 38 participants (15 depressed; 23 controls) aged 18–24 consented to complete the UG at the conclusion of the fourth session. Two groups were derived on the basis of participants' scores on the Beck Depression Inventory (BDI-II; Beck, Steer, & Garbin, 1988) on the day of the UG task. The "depressed" group was defined as those with BDI scores greater than 16 and included 11 meeting *Diagnostic and Statistical Manual of Mental Disorders*, 4th edition (*DSM-IV*; American Psychiatric Association, 1994) criteria for major depressive disorder (MDD) and four having subthreshold MDD, defined as meeting at least four out of five *DSM-IV* symptoms for MDD or scoring > 30 on the BDI on the UG day. The "control" group was defined as those with no current or past MDD diagnostic and a BDI score below 5. MDD diagnostics were based on intake interviews with the Structured Clinical Interview (SCID) for the *DSM-IV* (First, Spitzer, Gibbon, & Williams, 1994) conducted by master's- doctoral-level clinical psychology graduate students ($\kappa = .81$) about 2 weeks prior the UG session. Exclusion criteria for the study included: any other current Axis I diagnosis as assessed by the SCID, any current psychotropic pharmacological treatment (e.g., antidepressant medication), history of psychosis or mania, substance abuse/dependence within the past 4 months, and any medical disorder or central nervous system history that could affect emotional function.¹ All procedures were approved by the Human Subjects Protection Program at the University of Arizona.

Experimental Procedure

In addition to the SCID and BDI measures, participants were administered the Hamilton Rating Scale for Depression (HRSD; Hamilton, 1967), to obtain a clinician-based measure of depression, and completed the State-Trait Anxiety Inventory (STAI; Spielberger, Vagg, Barker, Donham, & Westberry, 1980) at the intake session, in order to assess the relationship between anxiety and CVC. In addition, the Positive and Negative Affect Scale (PANAS; Watson, Clark, & Tellegen, 1988) was administered at the start of the fourth experimental session to assess the potential mediating role of negative affect in participants' emotional reaction to unfair offers.

¹Forty-four participants (54%) were excluded during the recruitment period; UG and excluded participants did not differ in average BDI, $t(80) = 0.64$, *ns*, in proportion of individuals with current MDD, $\chi^2(1, N = 78) = 0.89$, *ns*, and in gender distribution, $\chi^2(1, N = 78) = 3.1$, *ns*.

Cardiac activity. Resting electrocardiographic (ECG) activity was recorded for two 8-min periods before participants played the UG. ECG was recorded using silver-silver chloride electrodes placed on the left clavicle and digitized at 2000 Hz. Participants were instructed to rest quietly. Interbeat interval (IBI) series were derived from the ECG and were hand-corrected for artifacts and ectopic beats. In addition to heart rate, respiratory sinus arrhythmia (RSA), a vagal-based measure of heart rate variability in the high-frequency band (0.12–0.4 Hz), was extracted using CMetX software (Allen, Chambers, & Towers, 2007). This program converts the IBI series to a time series sampled at 10 Hz, filters the series using a 0.12–0.4 Hz finite impulse response filter, and then takes the natural log of the variance of this filtered waveform as the estimate of RSA.

Decision making. Participants first filled out a short instructional handout about the UG summarizing the basic rules (mentioned above) and asking them about their expectations in the game (e.g., range of offers expected, etc.). They were told they would play as responders and receive one-time offers from various proposers. After completing two practice trials and indicating that they fully understood the game, participants played the UG, receiving 24 different offers presented in a randomized order. Each offer involved a \$10 split, and participants were informed they would be playing for real money and would be paid in cash on the basis of a percentage of their earnings in the game. A computerized version of the UG was used, and participants were told that they would be playing the game over a computer network with partners located at other universities. The pictures that participants saw were selected from a pool of actual UG players' photographs with equal proportion of males and females and with emotionally neutral expressions (Harlé & Sanfey, 2007; Sanfey et al., 2003). On each trial, participants saw a picture of their proposer partner for 4 s. They then saw the proposer's offer, at which point they were instructed to choose from two options (accept or reject) by way of a buttonpress. They had a maximum of 10 s to decide to either accept or reject this offer. After the decision, the outcome (e.g., how much each player received) was presented for 4 s. On the basis of the assumption that proposers would behave sensibly (i.e., not offer more than half of the pot), proposer offers ranged from \$0.50 to \$5 and included six fair offers (3 × \$5, 3 × \$4), six slightly unfair offers (3 × \$3, 3 × \$2.50), six moderately unfair offers (3 × \$2, 3 × \$1.50), and six highly unfair offers (3 × \$1 and 3 × \$0.50). At the end of the task, participants completed a brief questionnaire asking them to rate the extent to which they felt each of 12 basic emotions "when receiving unfair offers (e.g., \$1 or \$2 out of \$10)," each rated using an 8-point Likert scale from (Harlé & Sanfey, 2007).

Results

Clinical Profile

The depressed group (mean BDI = 27.8) included 11 (73%) individuals diagnosed with current MDD. The depressed group had higher HRSD scores ($M = 14.5$) than the control group ($M = 1.6$), $t(36) = 5.3$, $p < .001$. Depressed participants also reported higher state ($M = 56.4$), $t(36) = 9.2$, $p < .001$, and trait ($M = 56.1$), $t(36) = 9.1$, $p < .001$, anxiety than controls ($M = 29.6$ and $M = 32.0$, respectively), as measured by the STAI. Groups did not

differ in age ($M = 19.0$), $t() = 0.98$, *ns*. No significant gender group difference was observed, $\chi^2(1, N = 38) = 2.5$, *ns*, although the depressed group had more women (78%) than did the control group (52%). However, gender did not relate to the dependent variables in the present study and did not affect the main analyses results when added as a predictor or moderator. We conducted data analyses of CVC (RSA) after removing three participants with ectopic cardiac patterns (two controls and one depressed) as well as one (depressed) outlier based on Cook's distance. RSA in the control group ($M = 6.83$) did not differ significantly from RSA in the depressed group ($M = 6.76$), $t(32) = .26$, *ns*. Nonetheless, within the depressed sample, BDI scores were negatively related to RSA ($r = -.56$, $p < .05$). This relationship, however, was mediated by trait anxiety ($R^2 = .78$) using the hierarchical regression method advocated by Baron and Kenny (1986). After accounting for anxiety scores ($\beta = -.66$), $t(10) = -3.56$, $p < .05$, depression severity (measured by BDI scores) no longer significantly predicted RSA ($\beta = -.33$), $t(10) = -2.15$, *ns*, consistent with partial mediation.

Decision Making

The primary metric of interest in the UG was the proportion of offers accepted for each offer amount. We also computed two aggregate acceptance rates for "fair" (i.e., \$4–\$5) and "unfair" (i.e., \$0.50–\$3) offers, respectively. These categories were based on questionnaire data confirming that \$4 and \$5 offers were consistently considered fair by most participants, as in previous UG studies (Camerer, 2003; Harlé & Sanfey, 2007). Depressed and control participants did not differ in their pretask perceived cutoff between unfair and fair offers ($M = \$4.10$, $SD = \$0.80$) or in the offer they would typically make as a proposer ($M = \$4.20$, $SD = \$1.10$). On the basis of debriefing results, no participants indicated any suspicion of deception with regards to the use of virtual partners.

After mean centering all independent variables, we fit a linear mixed model (LMM; West, Welch, & Galecki, 2007) to the data using offer acceptance rate as the dependent variable, offer amount as a within-subject (Level 1) factor, and clinical status as a between-subject factor (Level 2). Subject was modeled as a random factor, and a diagonal matrix structure was specified to model residual variance across offer amounts (allowing the model to fit a different variance component at each level). Significant main effects of offer amount, $F(1, 104) = 393.0$, $p < .001$; and clinical status, $F(1, 53) = 4.3$, $p < .05$; as well as a significant Offer × Clinical Status interaction, $F(1, 104) = 13.6$, $p < .001$, were obtained. More specifically, the depressed group accepted significantly more \$0.50, \$1.00, \$1.50, \$2.00, and \$2.50 offers than the nondepressed group ($p < .05$ with Bonferroni corrections), whereas groups did not differ in accepting \$3.00, \$4.00, and \$5.00 offers.

In terms of aggregate acceptance rates, and thus consistent with our alternative hypothesis, groups did not differ in their acceptance rates of fair offers (average acceptance rate = 99%, $SEM = 0.8\%$), but depressed participants accepted significantly more unfair offers (61%, $SEM = 7.1\%$) than controls (41%, $SEM = 5.7\%$), $t(36) = 2.2$, $p < .05$, Cohen's $d = 0.74$ (see Figure 1). Total earnings in the game were \$50.30 for the depressed group and \$43.02 for the control group, $t(36) = 2.4$, $p < .05$, $d = 0.87$.

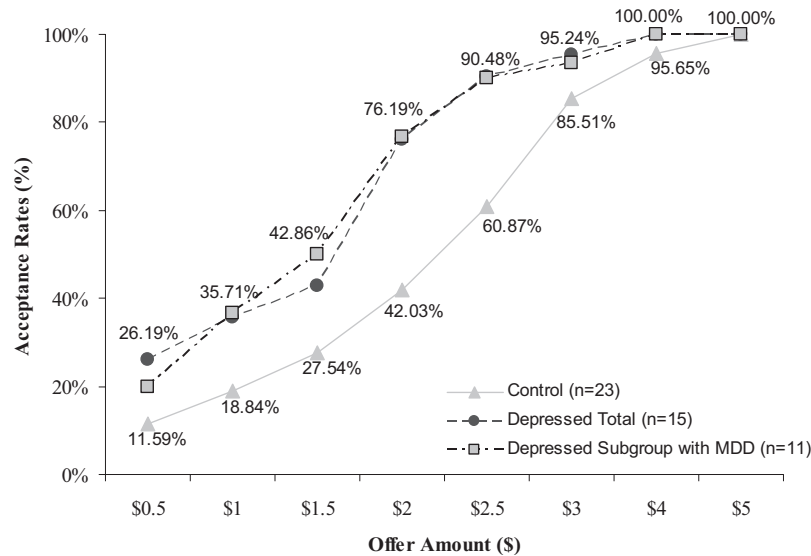


Figure 1. Acceptance rates by offer amount. Depressed total includes participants with and without a current *Diagnostic and Statistical Manual of Mental Disorders*, 4th edition (*DSM-IV*) diagnosis of major depression disorder (MDD), whereas Depressed with MDD includes only those with a *DSM-IV* diagnosis of MDD.

Emotional Reaction to Unfair Offers

Following the UG, participants rated their subjective emotional state for unfair offers. Twelve basic emotions, including both positive and negative emotions (anger, arousal, amusement, confusion, contentment, disgust, fear, happiness, pain, sadness, surprise, and tension), were rated using an 8-point Likert scale ranging from 0 (*did not feel even the slightest bit of the emotion*) to 8 (*the most you have ever felt in your life*). Compared with the controls, depressed participants reported significantly higher levels of disgust, $t(35) = -2.33, p < .05, d = 0.78$, as well as surprise, $t(35) = -2.58, p < .05, d = 0.71$. Depressed participants also showed a trend in reporting greater levels of anger ($p = .07, d = 0.59$). No group differences emerged regarding the other emotions.

We conducted regression analyses to assess whether the clinical status still had an impact on these emotion ratings above and beyond the generally more negative affect observed in depressed individuals. Clinical status significantly predicted disgust, $F(2, 34) = 6.6, p < .05$, adjusted $R^2 = .14$, and surprise, $F(2, 34) = 10.4, p < .05$, adjusted $R^2 = .21$, in response to unfair offers, with depressed status resulting in higher levels of these negative emotions. Clinical status remained a statistically significant predictor in models that included participants' negative reported affect (from the PANAS) as an additional continuous independent variable. Squared semipartial correlations for clinical status were .12 and .11 when predicting disgust and surprise, respectively, while simultaneously accounting for negative affect.

CVC (RSA) and Acceptance Rates

Using regression analysis, we examined CVC (indexed by RSA) as a predictor of acceptance rates of unfair UG offers, with clinical status as a potential moderator. A moderated regression model was statistically significant, $F(3, 32) = 3.13, p < .05$, adjusted $R^2 = .17$, with a significant effect of clinical status ($\beta = .38$), $t(34) =$

$2.37, p < .05$, and a Clinical Status \times RSA interaction ($\beta = .43, p = .05$) that approached significance. More specifically, we observed a statistically significant positive relationship between RSA and acceptance rates of unfair offers in the depressed group ($r = .59, p < .05$), which was not evident in the control group ($r = .01, ns$; see Figure 2).²

Discussion

This sample of depressed, unmedicated participants demonstrated significantly altered social decision-making patterns compared with controls, accepting more unfair monetary offers than control participants in a well-studied social decision-making task. Interestingly, such increased acceptance rates in depressed individuals would appear more "rational" from a standard economic standpoint (i.e., maximizing financial gain), and indeed this group made more money in the task. However, despite higher acceptance rates, the depressed group actually reported higher levels of disgust, anger, and surprise upon receiving unfair offers.

The finding of greater disgust, surprise, and anger in the depressed group upon receiving the offers appears consistent with recent empirical findings showing that both transient sad mood manipulations (Harlé & Sanfey, 2007) and acute tryptophan depletion (Crockett et al., 2008) prompt a similar emotional reaction to unfairness using the same task. Such findings raise the possibility that the same reaction of anger in both the depressed group

² Data analyses were redone, defining the depressed group to include only MDD. The LMM Offer \times Group interaction remained statistically significant ($p < .005$), with similar effect sizes for group mean differences in acceptance rates of unfair offers ($p = .06, d = 0.74$), reported disgust ($p < .05, d = 0.84$), surprise ($p = .07, d = 0.71$), and anger ($p < .05, d = 0.91$) when receiving unfair offers, and in the correlation between RSA and acceptance rates of unfair offers ($r = .53, p = .11$).

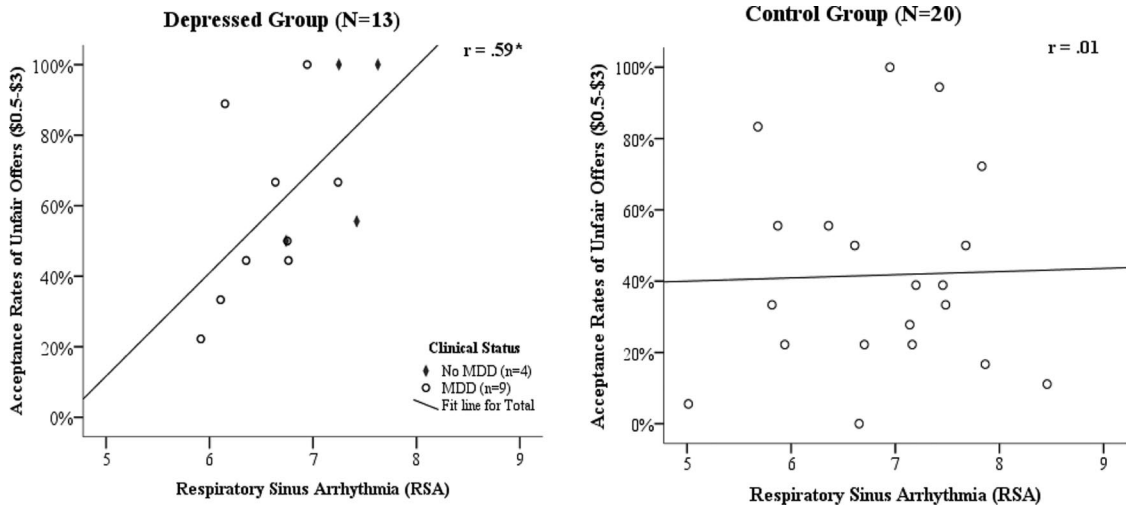


Figure 2. Acceptance rates of unfair offers as a function of respiratory sinus arrhythmia (RSA) by clinical group.

and the transiently sad nondepressed group (Harlé & Sanfey, 2007) may involve similar neural systems. One hypothesis is that a depressed state or a sad mood may engage the anterior insula, a neural region associated with the processing of bodily emotions and also previously implicated when responders receive unfair UG offers (Sanfey et al., 2003). Thus, depression, like sad mood, may result in an increased negative perception of the social signal underlying unfair offers, mediated by increased activity in anterior insula. In addition, serotonergic reserves may be lower in depressed individuals than in nondepressed adults (Porter et al., 2008), which may contribute to a more aggressive emotional reaction to unfairness (Crockett et al., 2008).

Despite this, we observed higher acceptance rates of unfair offers among the depressed participants, which contrast with the findings of the aforementioned studies. Thus, although the depth of emotional reactivity may be similar across depressed and sad but nondepressed groups, it appears that in clinical depression, distinct processes may intervene prior to the decision itself. One possibility for such behavioral discrepancy is that the increased acceptance of unfair offers observed in depressed individuals reflects more realistic expectations in the UG task (Alloy & Abramson, 1979). Though depressed participants did not differ from controls in terms of their expectations of offers and fairness in the task, they may still have been more realistic (perhaps resulting from a more analytic processing style or negative cognitive bias) about the impact their decisions have on their partners.

Another more plausible potential explanation for the higher acceptance rates observed in the depressed group relates to emotion regulation processes, with psychophysiological data indicating a possible relationship between CVC and the ability to manage one's emotional reaction to unfair offers in order to maximize one's economic gain. Although the depressed and control groups did not differ in terms of average RSA, we observed a positive relationship between RSA and acceptance rates in the depressed group but not in the control group. These findings suggest that depressed individuals' larger negative emotional responses to unfair offers may prompt a stronger reliance on regulating these

emotions, as compared with nondepressed participants (who are not as indignant about lower offers). Thus, independent of trait or baseline capacity to regulate emotion, depressed individuals may be more likely to use emotion regulation processes when making these social interactive decisions, which may in fact help them in managing emotional reactions, and in turn lead to more acceptances. Additionally, nondepressed individuals may have various strategies available to regulate their emotional responses to unfairness besides RSA-driven mechanisms (e.g., more global, optimistic framing), whereas such alternative processes may be impaired or insufficient in depressed individuals, leaving CVC as a primary option to self-regulate. Nonetheless, caution is warranted in interpreting these results, as we did not measure phasic changes in RSA during the task itself in the present study. Future research should assess for group differences in RSA suppression in response to unfair UG offers.

The similar resting levels of CVC (RSA) between depressed and control participants may appear inconsistent with research in which lower heart rate variability in depressed groups is reported (Booij et al., 2006). Other work, however, has shown no difference in vagal control between depressed and control groups (Lehofer et al., 1997). Some studies have also shown that anxiety symptoms, and not depression severity, are typically more strongly associated with lower CVC (Friedman, 2007), which is further consistent with the presently observed negative relationship between RSA and trait anxiety in the depressed group. Moreover, to control for confounding variables of a clinical nature, participants in the present study were excluded on the basis of clinical conditions other than unipolar depression, including anxiety disorders. Thus, the range of state and trait anxiety measures within the present sample may be more constrained and lower than in other depressed groups described in the literature, and thus less inclusive of high-anxiety/low-CVC individuals. This may, in turn, explain why the depressed sample did not have lower average RSA than the control group.

The present study has some limitations, including a small sample size (particularly for depressed individuals), stringent exclu-

sion criteria, the use of recalled posttask emotion ratings, and the use of an undergraduate student sample, limiting the generalizability of our results. BDI scores were also used in the present study to establish depression status as opposed to MDD diagnosis-based *DSM-IV* criteria to maximize sample size and favor depression severity on the day of the decision-making task, which limits generalizability to a pure MDD population. However, most individuals in the depressed sample (73%) had a current diagnosis of MDD, and effect sizes were similar when including only those with current MDD in the analyses. In addition, internal validity is increased by the use of a nonmedicated sample.

In conclusion, the present study revealed a nuanced emotional and behavioral pattern in unmedicated depressed individuals when they make simple interactive financial decisions. These results suggest that the impact of clinical depression on social decision making may be more complex than the impact of sad mood or even serotonin deficiency in nondepressed individuals. In fact, despite a well-documented pattern of negative cognitive framing in depression, depressed individuals actually ended the task monetarily better off than nondepressed controls. Thus, the present study emphasizes the importance of studying decision making within a realistic and ecologically valid context, for instance, using socially interactive tasks with real financial contingencies. These findings underscore the need to refine researchers' understanding of higher order cognitive processes in depression.

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