Working to win vs. working to keep: Prospect Theory and effort-based decision-making in humans

Olivia C. Roman

Vanderbilt University

Abstract

 Reward processing studies of anhedonia have provided a great deal of support to the idea that this common symptom of depression and schizophrenia is characterized in part by decreased motivation to pursue rewards. However, there is also compelling evidence that reward and loss processing are linked, suggesting that anhedonic individuals may also experience reduced motivation to avoid a loss. Using a modified version of the Effort Expenditure for Rewards Task, this study examined undergraduates’ behavior when working to win money versus working to avoid losing money, and how this behavior reflected trait anhedonia, depression, and anxiety. Consistent with Prospect Theory, participants were more likely to expend effort to avoid a loss. However, no correlations were observed between performance and self-reported personality/psychopathological traits.

INTRODUCTION

Anhedonia is a prevalent symptom in several major psychiatric disorders, including major depressive disorder (MDD) and schizophrenia. It is one of the two required symptoms for the diagnosis of a major depressive episode, according to the DSM-IV-TR (American Psychiatric Association, 1994). Literally meaning “without pleasure,” anhedonia is traditionally classified as the inability to experience feelings of enjoyment toward normally pleasurable stimuli, such as hobbies or social interactions (Ribot, 1896). It is not difficult to imagine the implications of such a symptom; the experience of pleasure in the things we do is a key factor in our ability to lead functional, productive lives, and lacking that ability may lead to a long list of negative consequences.

 Surely, relief merely from anhedonia would significantly improve the lives of many individuals affected by MDD, but unfortunately, this symptom has proven particularly difficult to treat (Shelton & Tomarken, 2001; Treadway & Zald, 2010). Pharmacologically, there have been few interventions that effectively alleviate anhedonia. Selective-serotonin reuptake inhibitors (SSRIs), one of the most popular classes of antidepressant drugs currently on the market, have not been shown to relieve this symptom in a significant number of patients (Dunlop & Nemeroff, 2007; Treadway & Zald 2010).

 The treatment of anhedonia may be further hindered by its own definition. As stated previously, anhedonia has typically been described as the inability to feel pleasure. While it may seem that, at least on the surface, this explanation is sufficient enough to account for the behavioral patterns seen in anhedonia, there is reason to believe that there is much more to the story. Psychologists are beginning to argue that anhedonia can be broken down into the more specific components of consummatory anhedonia (deficits in liking rewards), motivational (deficits in wanting rewards), and decisional anhedonia (deficits in reward-related decision making) (Treadway & Zald, 2010; Berridge & Robinson, 1998). This distinction is critical, as it may help to resolve some puzzling discrepancies in the anhedonia literature. For instance, there have been past studies of anhedonia in MDD that have focused largely on the hedonic response to the experience of pleasing emotional stimuli, such as positively-valenced pictures and video clips (Berenbaum, 1992a; Berenbaum & Oltmanns, 1992b; Sloan et al., 2001; Wexler et al., 1994; see Bylsma et al., 2008 for a meta-analysis), and to sensory stimuli, such as taste (Amsterdam et al., 1997; Berlin et al., 1998; Chentsova-Dutton & Hanley, 2010; Germans & Kring, 2000). Interestingly, studies employing taste stimuli as the primary measure rarely show a significant difference between the pleasure ratings of the depressed versus healthy control subjects. However, studies investigating emotional stimuli do show a discrepancy between depressed and control groups. Clearly, both of these types of studies are attempting to assess hedonic functioning, but, oddly, they produce two conflicting results. It has been hypothesized that the enjoyment of taste stimuli ⎯ which are primary, immediate rewards that, at least in the laboratory, require no external effort to consume ⎯ is evidence that people suffering from anhedonia do not, in fact, simply lose the “ability” to experience the pleasing effects of rewarding stimuli (Treadway & Zald, 2010; Germans & Kring, 2000; Bylsma et al., 2008). As for emotional stimuli, it has been theorized that the lowered ratings of pleasure in these cases is a result difficulty remaining emotionally engaged with the pictures and videos, possibly due to altered cognitive function often seen in individuals with MDD or schizophrenia (Joormann & Gotlib, 2008; Joormann et al., 2009; Hamilton & Gotlib, 2008; Barch, 2005) and/or a reduced capacity to sustain positive emotion (Heller et al., 2009).

The research reviewed above clearly indicates that hedonic dysfunction limited to the experience of positive affect is not sufficient enough to explain anhedonic symptoms. However, studies of reward processing and dopaminergic function provide insights that appear to allow new ways of conceptualizing and characterizing anhedonia.

**Reward Processing**

 Reflecting the proposed division of anhedonia into facets of consummatory and motivational anhedonia, the basic science literature has increasingly demonstrated that reward-related processes involve multiple components. In the past, however, reward processing was mainly characterized as a function of an individual’s subjective experience of pleasure following a stimulus, mirroring the traditional definition of anhedonia (Berridge & Robinson, 1998**)**. This led to the narrow interpretation that if an organism likes something, it will surely desire it as well, and vice versa (Treadway & Zald, 2010). This belief was strengthened by early studies of the neurotransmitter dopamine (DA), which seemed to support the theory by demonstrating, for instance, that there is substantial dopaminergic activity in response to drugs of addiction (for reviews see Berke & Hyman, 2000; Seiden et al., 1993) or even to the taste of a pleasing food. These findings indicated to many that hedonic function was potentially of highest importance in reward processing and related behaviors.

However, other research has indicated that DA’s role in reward processing is not as simple as originally assumed. Notably, Berridge et al. (1989) conducted a study in which rats with depleted DA levels experienced completely normal hedonic processing in three major areas: affective response to pleasurable and aversive tastes, hedonic association learning, and increased hedonic response after non-DA pharmacological administration. The researchers subsequently argued that DA is key to incentive salience, or wanting of a reward. This hypothesis is supported by a growing body of work, including that discussed in a review by Salamone et al. (2007), which involved DA-depleted rats in behavioral measures of wanting. In one instance, it was demonstrated that reducing DA levels in the nucleus accumbens (NAcc) resulted in diminished lever pressing in order to obtain food (Salamone et al., 1991). However, when the food was freely available, the DA-depleted rats consumed more of it than normal rats. In another instance, the rats were put in a T-maze with two options: a) they could put in minimal effort to obtain a basic food reward in one arm of the maze, or b) they could put in more effort to climb over a barrier in order to earn a special treat in the other arm (Cousins et al., 1996). The DA-depleted rats were significantly less likely to scale the barrier, even for the sake of a treat. Importantly, a subsequent study in which both the basic reward and the treat required equal amounts of effort to obtain showed no difference in behavior between the DA-depleted and control rats; both groups clearly favored the treat. These findings clearly suggest that DA has relevance less to the actual enjoyment of a reward and more to the motivational drive needed to obtain it (Barbano & Cador, 2007). When we combine this research with the studies of hedonic processing discussed above, compelling evidence is presented that anhedonia is characterized at least in part by a disruption of motivational processes, but not necessarily by the incapacity to experience feelings of pleasure. Essentially, this theory holds that an individual suffering from motivational anhedonia is unable to imagine or convince himself of the value of performing a certain action, and therefore will be less willing to seek out rewarding experiences (Treadway & Zald, 2010). However, if a reward is readily available, anhedonic individuals will enjoy it just as much as those who are healthy.

Nevertheless, even though DA has been shown to be more essential to motivation than pleasure, we should not infer that the pleasurable aspects of a reward are irrelevant in decision-making; in fact, it seems that these factors interact closely to influence the actions an individual takes in a given situation. For instance, hedonic processes can be further broken down into the subcomponents of anticipation (one’s ability to imagine what the enjoyable effects may be like), experience (one’s in-the-moment feelings of enjoyment), and recall (one’s ability to accurately remember the enjoyment that was experienced) (Chentsova-Dutton & Hanley, 2010; Berridge & Robinson, 1998; Barbano & Cador, 2007). These three elements are all inter-dependent; for instance, a person’s memory of an experience will then influence his anticipatory opinion of it in the future, which could have an effect on his subsequent re-experience, which will contribute to and potentially reshape his memories, and so on in a repeating cycle. All of this factors in to one’s desire for reward, but requires sustained cognitive processes such as attention, imagination, appraisal and memory, which, notably, are often impaired in individuals with disorders characterized by anhedonia (namely MDD and schizophrenia) (Barch, 2005; Chentsova-Dutton & Hanley, 2010; Joormann & Gotlib, 2008).

**Punishment processing**

The research discussed above illustrates how individuals experiencing anhedonia appear to be victims of poor motivational drive for reward, as opposed to reduced hedonic capacity. However, there is new evidence that people suffering from depression and anhedonia do not just experience motivational deficits in regards to reward. New studies have provided reason to believe that depressed individuals are also less likely to feel motivated to avoid punishment. In a study by Henriques and Davidson (2000), it was found that in a word memory task with a neutral condition as well as monetary reward and punishment conditions, depressed participants were less likely than controls to alter their response tendencies in both the reward and punishment contingencies (in relation to the neutral condition). It is important to note that this effect was found only after anxiety scores had been controlled for, suggesting that anxious symptoms lead to an increase in punishment-avoidant behavior. Moreover, another study by Brinkmann et al. (2009) used a mental effort mobilization task with three different conditions (neutral, monetary reward, and monetary punishment) to assess physiological reactivity in depressed and control patients. Subjects’ blood pressure was measured during the task, and it was determined that the depressed subjects showed less change in blood pressure than controls to both reward and punishment. The authors of this study interpreted this finding to mean that the patients were less reactive to, and therefore cared less about, receiving reward and punishment. Taken together, these two studies provide evidence that depression also affects punishment processing.

On top of these behavioral findings, discoveries in the neuroimaging domain further support the idea of altered punishment processing. Research by Reynolds and Berridge (2008) examined motivationally-driven appetitive and fearful behavior in rats. In the study, rats were placed in both a preferred environment and a stressful one, and the connections in the medial shell of the NAcc were monitored. It was found that in the preferred environment, a majority of the medial shell was dedicated to eliciting greater appetitive behavior, namely eating and drinking. In the stressful environment, it was found that the medial shell became largely devoted to generating fearful behavior (in this case, defensive treading). Importantly, the region involved in this fear behavior is the same region implicated in reward processing, suggesting that they may share some common neural substrates.

Similar findings have been observed in humans. In a study performed by Kim et al. (2006), participants completed a task in which they could choose to either win a reward or avoid a punishment during a functional magnetic resonance imaging (fMRI) scan. As the researchers predicted, certain areas of the brain, and in particular the orbito-frontal cortex (OFC) fired during receipt of reward also fired when the subject avoided punishment, suggesting that escaping punishment is processed in a similar manner to reward. These results further support the idea that reward and punishment are processed, at least partly, in the same circuits. We can infer, then, that problems with one half of the equation will mean that there are also problems on the other half. When paired with the behavioral findings discussed above, it seems reasonable to speculate that anhedonia is the result of a general blunting of mechanisms that manage reinforcement contingencies, expressing itself as reduced motivation, and potentially a form of apathy toward negative consequences. However, it should be noted that punishment processing in a task that assesses motivation in terms of effort-based decision-making has not yet been measured; it is important to make this next step in order to properly associate motivational aspects of reward and punishment.

**The EEfRT as a motivational measure**

 Although much of the behavioral research with humans reviewed above has shown that anhedonic symptoms are not necessarily or exclusively a question of reduced hedonic capacity, tools for examining the motivational components of anhedonia have been limited. To address this need, the Effort-Expenditure for Rewards Task (EEfRT) was developed as a translational model of the lever-press and T-maze rat studies described previously (Treadway et al., 2009). The EEfRT consists of multiple trials in which subjects may win various amounts of money, depending on the trial and whether they choose to perform an “easy” button-pressing task for less money (always $1.00) or a “hard” button-pressing task for a larger amount, which changes from trial to trial. In addition, subjects must take into account the probability (low, medium, or high) that they will actually receive the money offered should they complete the chosen task. In a recent study of undergraduate students, performance on the EEfRT was inversely correlated with self-reported anhedonia ratings (Treadway et al., 2009). Moreover, the EEfRT has been shown to be sensitive to major depression, with depressed subjects showing reduced selection of hard task/high reward options (Treadway et al., in press). It is currently unknown, however, whether similar results would be observed if subjects were trying to avoid loss. For this purpose, a new version of the EEfRT was created in which subjects played with the goal of avoiding losing money; the specifics of this version will be discussed later.

In essence, while playing the EEfRT subjects must weigh their options and decide whether or not they are motivated to perform the hard task. The new version created for the present study also raises the question of how framing the trials in terms of “winning” and “avoiding loss” affects decision-making. For these reasons we must note the relevance of Prospect Theory (Kahneman & Tversky, 1979) in the context of the EEfRT. Prospect Theory was first published by Kahneman and Tversky in 1979 as a rebuttal to the long-popular Expected Utility Theory, which assumed that humans would, given multiple options, make the choice that was most favorable to them (Keeney & Raiffa, 1976). However, with a series of studies that asked subjects to choose between various hypothetical option pairs involving different value and probability levels (for instance, choosing between a 50% chance of winning $1000 or winning a guaranteed $500), it was possible to demonstrate a general pattern of behavior in risk-influenced decision-making that differed from a rationale-actor model of decision-making. More specifically, Kahneman and Tversky noticed that individuals were risk-averse when trying to win, but risk-seeking when trying to avoid a loss. Even when mathematical computation shows that a risky move in a win situation, or a safe and certain move in a loss situation, is the better option, people are still more likely to adhere to the pattern just described. In essence, the possibility of loss is a stronger stimulus than the possibility of a win of equal value.

Furthermore, this research demonstrated that the subjective difference between the values of the given options is important to the decision-making process as well. For instance, the difference between $100 and $200 seems more significant than the difference between $10,100 and $10,200, even though the actual difference for both pairs is $100. As the absolute value of the given amounts increases, it takes more of a difference between those amounts before that difference seems significant. Therefore a win/loss of $200 over $100 would most likely seem more substantial than a win/loss of $10,200 over $10,100. A similar finding applies to probability as well, in that as two compared events become more and more (or less and less) likely to happen, the differences in the probabilities of those events needs to be greater in order to make more of an impact on decision-making (Kahneman & Tversky, 1979).

Additionally, in a follow-up study, Tversky and Kahneman (1981) described to subjects situations in which they had to choose between different strategies aimed at saving lives. In each situation, the strategies were worded either in terms of actively saving a certain amount of lives, or in terms of letting a certain number of people die. The catch was, however, that each strategy actually had the same probabilistic outcome. In other words, each strategy was simply framed differently. The researchers found that, just as when money is the goal, people are risk-averse when the question is phrased about saving lives (analogous to gains), while they are risk-seeking when the question is phrased about letting people die (analogous to losses). Known as the framing effect, this phenomenon demonstrates the importance of context when presenting an individual with different options; getting people to think in a certain way can greatly influence their decision-making. A more recent study by De Martino et al. (2006) found neural evidence for the framing effect, in that fMRI images taken while subjects performed a framing effect task showed activations of the bilateral amygdala, anterior cingulate (AC), OFC, and ventro-medial prefrontal cortex (VMPFC), which the authors interpreted as a sign of emotional involvement, via the amygdala, and computational/reasoning processes modulated by the AC, OFC, and VMPFC. Interestingly, several of these areas are the same ones that responded to both winning and avoiding a loss in the Kim et al. (2006) study.

The goal of the current study was to integrate the research discussed above in a way that would behaviorally measure punishment avoidance motivation and its relation to motivation for rewards and self-reported anhedonia. The evidence that there is a motivational subcomponent of anhedonia has already generated a body of research that has linked several neural structures in its biological basis. Subsequent studies have also suggested that this circuitry applies to losses as well, indicating that motivational anhedonia may include a reduced willingness to work to avoid losses or punishment. Furthermore, when considering the evidence that the neural basis for the framing effect is similar to that of reward and punishment processing, we could speculate that Prospect Theory can be applied to motivation, in that people are more likely to work to avoid a loss than they are to earn a gain of equal value.

Based on Prospect Theory, it was hypothesized that, in general, participants would be more willing to work to avoid a monetary loss than they would be to earn an equally-valued monetary gain. However, taking into account the neural evidence that reward and punishment circuitry are closely related, higher ratings of self-reported anhedonia, as measured by the Mood and Anxiety Symptoms Questionnaire (MASQ; Clark & Watson, 1991), were predicted to be correlated with a relatively decreased willingness to perform the hard task to avoid losing larger amounts of money in the loss trials of the modified EEfRT. Furthermore, it was hypothesized that willingness to choose the hard task would be inversely correlated with overall depression ratings, but positively related to anxiety scores, which were assessed by both the MASQ and several other self-report measures concentrating on various facets of anxiety and anhedonia, which will be described in more detail below.

METHODS

*Participants*

 This study involved 34 undergraduate students (64% female) of Vanderbilt University, ages 18-22, who were recruited from the Department of Psychology’s online research recruitment website. The students were offered class credit in return for their participation, and there were no screening requirements in order to participate. Each participant was asked to read and sign an IRB-approved written informed consent form prior to beginning the study.

*Modified EEfRT Design*

The modified EEfRT task was programmed using MATLAB software (Mathworks Inc., Natick, MA). Each participant performed the modified EEfRT on a Dell PC and standard monitor.

Participants played win and loss-avoidance trials in two independent blocks. The order was counterbalanced, such that half the participants played the loss-avoidance trials first and the win trials second, in order to control for any task order effects. The wording of “loss-avoidance” was chosen based on the findings of the Kim et al. (2006) study that showed that winning and *avoiding* punishment shared similar neural substrates.

All trials started with a fixation cross for 1000 ms, followed by a screen that indicated the probability of them winning or avoiding losing money on that given trial (either 88% [high] probability, 50% [middle] probability, or 12% [low] probability), as well as the maximum amount of money they could win or avoid losing on that trial. Upon receiving this information, participants were asked to choose, within five seconds, whether they preferred to perform the easy task (21 button presses in ten seconds with the dominant index finger) or hard task (98 button presses in twenty-one seconds with the non-dominant little finger) on that trial. If they failed to make a decision within five seconds, the computer randomly assigned them to either the easy or hard task.

 During the win trials, choosing the easy task potentially allowed the participants to earn $1.00 (this was constant across all trials), while the hard task was worth anywhere between $1.25 and $4.12. During loss-avoidance trials, on the other hand, performing the hard task put participants at risk of losing only $1.00, while choosing the easy task risked losing between $1.25 and $4.12. Even though participants were playing to avoid losing money, there was always a chance that despite their physical efforts something would be lost; it was a matter of *how much* would be lost, depending on the decision made. For instance, on a trial with 88% probability of avoiding the loss, choosing the hard task meant there was still a 12% chance of losing $1.00 despite successfully completing the required button presses, and choosing the easy task meant there was still a 12% chance of losing an amount in the range described above.

 Afterwards, two win trials and two loss trials (called incentive trials) were selected at random to determine how much the participant was to be paid. The sum of the loss trials was subtracted from the sum of the win trials. To prevent a negative total in the case of the total losses being greater than the total wins, each participant was given an endowment of $6.00 (the most that they could lose was $8.00 on loss trials, and the least that they could gain was $2.00 on win trials). This fact was made explicit to them at the beginning of the session, before they began the modified EEfRT task.

*Procedure*

 Once consent had been obtained, participants read a PowerPoint presentation of instructions for the first block (either win or loss-avoidance), and afterwards were given the chance to perform four practice trials. If they indicated that they felt confident about the task, they were allowed to play for fifteen minutes. Once the fifteen minutes were finished, participants were given the seven self-report measures described below to finish complete before performing the second block of EEfRT trials. This break between blocks was applied to limit fatigue and to help prevent participants from noticing that the probability and reward information were similar for each corresponding trial in each block (which simplified trial comparisons in each block). After completing the questionnaires, they read a new PowerPoint presentation with instructions for the second block, completed four more practice trials, and then played for another fifteen minutes. Finally, they were debriefed on the experiment and paid.

*Measures*

 Each participant completed a series of self-report questionnaires, the most primary being the MASQ (Watson & Clark, 1991; Clark & Watson, 1991), because of its comprehensive investigation of both anxiety and depression, including features of anhedonia. This measure is comprised of five subscales, each concentrating on a different aspect of either anxiety or depression: General Distress: Mixed Symptoms (GDM), General Distress: Anxious Symptoms (GDA), Anxious Arousal (AA), General Distress: Depressive Symptoms (GDD), and Anhedonic Depression (AD). Test items consist of statements describing various mood states, and participants must rate how much they have felt that way in the past week, using a Likert scale.

 There were several other self-report measures included for exploratory purposes. These included the Chapman Physical and Social Anhedonia Scales, which assess hedonic capacity by describing various pleasurable activities and asking whether or not the answerer personally finds them pleasurable (Chapman et al., 1976). An alternative anxiety measure, the Perceived Stress Scale (PSS; Cohen, 1988), focuses on participants’ recent experience of stress through the use of a Likert scale. The Behavioral Inhibition System and Behavioral Activation System Scales (BISBAS; Carver & White, 1994) were included to evaluate participants’ approach and avoidance behavior. This measure also employs a Likert scale and asks individuals to rate the degree to which the different items describe them. These items are further divided into four subscales: Behavioral Activation: Drive (BAS-D), Behavioral Activation: Fun-Seeking (BAS-FS), Behavioral Activation: Reward Responsiveness (BAS-RR), and Behavioral Inhibition (BIS). Finally, participants completed the Monetary Choice Questionnaire (MCQ; Kirby et al., 1999), which gauges monetary delay discounting by offering a choice between a smaller, immediate award and a larger, delayed award, with monetary amounts and length of delay varying from item to item.

RESULTS

*Participants*

 Table 1 displays participant demographics and questionnaire results.

*Data Reduction*

 Because participants played each block of trials for only fifteen minutes, the number of trials each individual completed varied (mean win trials completed = 40, SD = 3.11, range = 36-47 trials; mean loss trials completed = 38, SD = 3.18, range = 31-44 trials). To promote uniformity, only the first 34 trials in each block were used in data analyses. This enabled us to examine participants’ choices in analogous reward contingencies, as the corresponding trials in each block contained the same probability and reward values.

*Performance on Win vs. Loss Trials*

A Repeated Measures ANOVA was performed to examine the effect of task block (2 levels: win vs. loss) and probability level (3 levels) on the proportion of hard task choices. More specifically, high probability in the win block (HW) was compared with low probability in the loss (LL), middle probability in win (MW) with middle in loss (ML), and low probability in win (LW) with high probability in loss (HL); this was due to the framing of “avoiding a loss” making lower probability trials in the loss block equivalent to the high probability trials in the win block. There was a main effect of win/loss (*p* < 0.01) such that the proportion of hard task choices during the loss-avoidance block (M = 0.55, SD = 0.14) was greater than those during the win block (M = 0.48, SD = 0.13) (*F*(1,33) = 8.103, *p* < 0.01). Consistent with prior results on gain-only versions of the EEfRT (Treadway et al., 2009), this analysis also identified a main effect of probability level on proportion of hard task choices (*F*(1,33) = 163.95, *p* < 0.00). However, there was no significant interaction of win/loss condition and probability (*F*(1) = 1.19, *p* > 0.10) Planned follow-up paired samples T-tests compared performance at corresponding probability levels in the win and loss-avoidance blocks. Only the MW-ML comparison was significant (t(33) = -2.09, *p* < .05), although there was a near-significant trend for LW-HL (t(33) = -1.828, *p* < 0.10). There was no effect found for HW-LL (t(33) = 0.191, *p* > 0.10). Figure 1 displays the mean proportions of hard tasks completed for each probability level in both blocks.

Despite the significant difference found in the proportion of hard task choices made between the win and loss avoidance blocks, there was also a strong positive correlation of performance between the two (Pearson coefficient = 0.46, *p* < 0.01).

*Order Effects*

 There was also an unexpected effect of win/loss-avoidance by order, in that whether participants played the win block or the loss-avoidance block first impacted the number of hard task choices made in the loss-avoidance block. A paired-samples t-test showed that participants who played the win block first were subsequently much more likely to work harder to avoid a loss (t(16) = -6.14, *p* = 0.00) than those who played the loss-avoidance block first, who made the same number of hard task choices in both blocks (t(16) = 0.23, *p* > 0.10). A repeated measures ANOVA that included order as an independent variable confirmed the interaction (*F*(1) = 15.92, *p* = 0.00) between order and loss/win condition.

*Correlation with Self-Report Scores*

 Correlations were calculated between overall proportion of hard task choices in both the win and loss blocks with self-report measures. These results are presented in Table 2. Contrary to our hypotheses, none of these variables showed a significant association with hard-task choices during either the win or loss-avoidance blocks. We also calculated the relative difference of participants’ performance across win and loss avoidance blocks and ran correlations with the self-report measures. The biases were calculated by dividing the difference of individuals’ hard task proportion in the win block and that in the loss avoidance block by the overall average of the hard task proportions in the two blocks combined. However, as Table 2 shows, these results were non-significant as well.

*Split-Half Reliability*

 In order to determine the internal reliability of each block of trials, even-odd split-half reliability tests were calculated. Both the correlations for the win block (Spearman-Brown coefficient = 0.25) and the loss avoidance block (Spearman-Brown coefficient = -0.21) were relatively weak, suggesting low internal reliability.

DISCUSSION

 To our knowledge this study was the first test of whether the predictions of Prospect Theory apply to decisions regarding physical effort, and therefore was able to provide novel findings to an already well-established body of evidence in support of the theory. Overall, the current study had three main goals: 1) to determine whether, in the context of wins and losses, Prospect Theory would be maintained in an effort-based motivational behavioral task, 2) to investigate whether higher self-reported trait anhedonia and depression would lead to a decreased motivation to perform the hard task on the EEfRT in order to avoid losing money just as it does in a gains situation, and 3) to discern a potential correlation between anxious traits and a relatively increased willingness to perform the hard task to avoid a loss. As expected, the results demonstrated a significant effect of win/loss condition, in that participants chose to complete the hard task more often to avoid a loss than they did to gain money. In particular, this effect was strongest for the middle and LW-HL probability trials.

There was also a strong overall correlation of number of hard task choices completed in both the win and loss avoidance blocks. This correlation is probably a result of individuals’ personal levels of motivation being relatively consistent in both conditions, but it does not necessarily diminish the significance of the differential performance present between the two blocks.

 The findings that there were significant effects of both the win/loss and probability variables appear to adhere to the expectations of Prospect Theory, both that losses are weighted more heavily than gains and that a loss condition leads to risk-seeking behavior while a gain condition leads to risk-avoidance. This study adds a new component to these precepts, in that they can be applied in a motivational context. We employed a behavioral task that required effort mobilization and therefore more closely mimicked real-life situations where individuals must choose how to devote resources (be they physical, monetary, intellectual, etc.) in decision-making. Also, to our knowledge, previous studies did not require costs in terms of differential expenditures, unlike this one (Kahneman & Tversky, 1979; Tversky & Kahneman, 1981; Tversky & Kahneman, 1991; O’Connor, 1989; Miller & Fagley, 1991; Johnson et al., 1993). The findings suggest that in circumstances where one’s personal assets must be expended in order to achieve an outcome, people are still likely to consider potential losses to be more significant than gains, and that they are more likely to employ more resources or effort to avoid a loss than to earn a reward. We view this as analogous to risk-seeking behavior, in that people are more likely to sacrifice more in the hopes of avoiding a negative outcome. In other words, loss-aversion ironically compels people to put more of what they already have at risk in order to prevent the loss of something else, but when people stand to gain something, they are more cautious. Perhaps this is because the successful prevention of a loss is itself a sort of reward. This hypothesis is also supported by the Kim et al. (2006) study mentioned previously, which, based on the comparable firing patterns in response to both reward receipt and punishment avoidance, came to a similar conclusion.

 It was also observed that there was a significant difference between the proportion of hard task choices made on middle probability level trials, as well as a near-significant trend in the LW-HL trials, across the win and loss-avoidance blocks. More specifically, participants were more likely to choose the hard task on these trials in the loss avoidance block than in the win block. However, this outcome was not observed in the HW-LL trials. We suggest that this is due to the certainty of desired outcome provided by the high probability of both winning and losing on those trials (recall that there is an 88% chance of winning and a 12% chance of avoiding the loss, or an 88% chance of losing). As Kahneman & Tversky (1979) originally demonstrated, as probability of a gain increases, people grow more and more risk-seeking. Similarly, as probability of a loss increases, people also favor riskier options. Our results show that these patterns apply to effort expenditure and motivation as well: participants put in more work to achieve a probable gain and also to avoid a probable loss.

The impact of playing order on performance was unexpected. Playing the win block first was predictive of increased number of hard task choices in the loss-avoidance block, but if the order was switched participants tended to make approximately the same number of hard task choices in each block. This pattern is consistent with another aspect of Prospect Theory, the endowment effect, which posits that people are much less willing to give up or risk losing what they already have (Thaler, 1980). In this case, it would be predicted that participants who played the win blocks first subsequently wanted to ensure that the money they had already earned would not be lost in the next round. By contrast, individuals who experienced the loss-avoidance block first did not have any incentive to work extra hard to protect their money, since they had not yet been given the chance to earn anything. Together, these results give support to our finding that Prospect Theory is applicable in situations involving effort mobilization.

 Our hypotheses that higher trait anhedonia and depression would be negatively correlated with hard task choice while higher anxiety would be positively correlated were not supported by the data. Results showed no associations with any of the self-report measure scores, including the MASQ scales. Correlations with calculated win/loss biases were not significant either. These findings are inconsistent with past reports involving the EEfRT. Treadway et al. (2009) showed a strong inverse correlation between anhedonia scores, as determined by the Chapman Scales, and hard task choice in the original EEfRT. While the null findings regarding the loss-avoidance block of trials is not necessarily surprising, the same null findings in the win block were unexpected. We can think of several possible reasons for this outcome, however. First, this study involved a relatively healthy population of Vanderbilt undergraduate students, with self-report scores (most importantly those on the MASQ) lower than what one would expect to find in a patient population (see Watson et al., 1995). The fact that this group did not display particularly significant symptomatology resulted in scores that did not provide an adequate range to allow much variability. It also did not assess the targeted population of people experiencing higher ratings of anhedonia, depression, and anxiety. It would be useful to re-attempt this experiment with a clinical population.

 Further problems with self-report measures may have also contributed to the null findings in this study, including recall bias. As Solhan et al. (2009) explain, questionnaires, although efficient and cost-effective, are limited by the fact that they require participants to re-imagine past emotional states. It has been well-established that memory is subject to inaccuracy, due to various effects, including current mood-state referencing, use of heuristics, variability of emotional experiences, etc. (Solhan et al., 2009; McFarland et al., 1989; Perrine & Schroder, 2005). Because of this, it is possible that the self-report scores obtained in this study did not provide a completely accurate representation of participants’ true emotional states.

 We must alternatively consider the possibility that the modified EEfRT actually measures something that the self-report questionnaires do not capture. More specifically, the true value of the EEfRT may lie in its translational qualities, in that it has been successfully used in DA studies modeled after the preclinical literature on DA function and motivation described above. A recent study showed that increasing DA levels in human participants by administering a dose of amphetamine also increased the amount of hard tasks performed on the original EEfRT (Wardle et al., 2011). This finding suggests that the EEfRT is fundamentally a measure of motivation. The questionnaires employed in this study, on the contrary, are not limited to an assessment of motivation. For this reason, it is feasible that the lack of correlation between task performance and self-report scores is a consequence of their mismatched applications.

A potentially limiting factor was the relatively small sample size. For an individual differences study, thirty-four participants is a rather low number, providing limited statistical power. A replication of this study with a larger sample may yield different results that might better support our hypothesis. Relatedly, another limitation of this study may have been the overall analytic approach taken, in that we did not use Generalized Estimating Equations (GEE) as the authors of the original EEfRT study did (Treadway et al., 2009). Performing these calculations may have allowed greater sensitivity to variation among a greater number of parameters, especially in a multi-faceted task such as the modified EEfRT, which involves factors such as reward magnitude, probability level, win versus loss-avoidance, expected value, etc.

 Finally, it is also possible that the length of time that participants played each block of trials, 15 minutes, may not have been long enough to obtain an adequate number of trials to use in analyses. This length of time was chosen both in order to reduce fatigue and to keep the overall length of the study from being too long. The original EEfRT study, however, had participants play one round for a total of 20 minutes, which enabled the authors to use a total of 50 trials per person, a much more substantial amount than the 34 we used in this study (Treadway et al., 2009). Since the split-half reliability tests conducted also produced rather weak internal correlations, we suggest that more trials are needed to increase reliability. It would be worthwhile to attempt this study again with a slightly different set-up, perhaps involving two separate sessions in which participants play the win block in one session for 20 minutes and the loss block in the other session for 20 minutes. Hopefully this format would significantly increase the total number of trials used in data analysis and create greater statistical sensitivity and reliability without leading to participant fatigue.

*Conclusions*

 This study attempted to examine the effects of a win frame and a loss-avoidance frame on individuals’ willingness to perform an effortful task. On one hand, we obtained results consistent with our hypothesis that participants would be more likely to perform the more difficult task in order to avoid losing money than they would be to win money, particularly at the 50% and LW-HL probability levels. In general, this is consistent with Prospect Theory, which demonstrates that people view losses as more aversive than gains are rewarding. However, our hypotheses regarding the role of anhedonia, depression, and anxiety were not supported by the data. Due to some notable limitations in the structure of the experiment, it would be worthwhile to re-attempt this study after having addressed those issues.

References

American Psychiatric Association (1994). *Diagnostic and statistical manual of mental disorders* (4th ed.). Washington, D.C.: Author.

Amsterdam, J. D., Settle, R. G., Doty, R. L., Abelman, E., Winokur, A. (1987). Taste and smell perception in depression. *Biological Psychiatry, 22*, 1481-1485.

Barbano, M. F., & Cador, M. (2007). Opioids for hedonic experience and dopamine to get ready for it. *Psychopharmacology, 191*, 497-506.

Barch, D. M. (2005). The relationships among cognition, motivation, and emotion in schizophrenia: How much and how little we know. *Schizophrenia Bulletin, 31*, 875-881.

Berenbaum, H. (1992a). Posed facial expressions of emotion in schizophrenia and depression. *Psychological Medicine,* *22*, 929-937.

Berenbaum, H., Oltmanns, T. F. (1992b). Emotional experience and expression in schizophrenia and depression. *Journal of Abnormal Psychology, 101*, 37-44.

Berke, J. D., & Hyman, S. E. (2000). Addiction, dopamine, and the molecular mechanisms of memory. *Neuron, 25*, 515-532.

Berlin, I., Givry-Steiner, L., Lecrubier, Y., Puech, A. J. (1998). Measures of anhedonia and hedonic responses to sucrose in depressive and scizophrenic patients in comparison with healthy subjects. *European Psychiatry, 13*, 303-309.

Berridge, K. C., & Robinson, T. E. (1998). What is the role of dopamine in reward: hedonic impact, reward learning, or incentive salience? *Brain Research Reviews, 28*, 309-369.

Berridge, K. C., Venier, I. L., & Robinson, T. E. (1989). Taste reactivity analysis of 6- hydroxydopamine-induced aphagia: Implications for arousal and anhedonia hypotheses of dopamine function. *Behavioral Neuroscience, 103*, 36-45.

Brinkmann, K., Schüpbach, L., Joye, I. A., & Gendolla, G. H. E. (2009). Anhedonia and effort mobilization in dysphoria: Reduced cardiovascular response to reward and punishment. *International Journal of Psychophysiology, 74*, 250-258.

Clark, L. A., & Watson, D. W. (1991). Tripartite model of anxiety and depression: Psychometric evidence and taxonomic implications. *Journal of Abnormal Psychology, 100*, 316-336.

# Chentsova-Dutton, Y., & Hanley, K. (2010). The effects of anhedonia and depression on hedonic responses. *Psychiatry Research, 179*, 176-180.

# Cousins, M. S., Atherton, A., Turner, L., & Salamone, J. D. (1996). Nucleus accumbens dopamine depletions alter relative response allocation in a T-maze cost/benefit task. *Behavioral Brain Research, 74,* 189-197.

# De Martino, B., Kumaran, D., Seymour, B., & Dolan, R. J. (2006). Frames, biases, and rational decision-making in the human brain. *Science, 313*, 684-687.

# Dunlop, B. W., & Nemeroff, C. B. (2007). The role of dopamine in the pathophysiology of depression. *Archives of General Psychiatry, 64,* 327-337.

# Germans, M. K., & Kring, A. M. (2000). Hedonic deficit in anhedonia: support for the role of approach motivation. *Personality and Individual Differences, 28*, 659-672.

# Gershon, A. A., Vishne, T., & Grunhaus, L. (2007). Dopamine D2-like receptors and the antidepressant response. *Biological Psychiatry, 61*, 145-153.

# Hamilton, J. P., & Gotlib, I. H. (2008). Neural substrates of increased memory sensitivity for negative stimuli in major depression. *Biological Psychiatry, 63,* 1155-1162.

# Heller, A. S., Johnstone, T., Shackman, A. J., Light, S. N., Peterson, M. J., Kolden, G. G., Kalin, N. H., & Davidson, R. J. (2009). Reduced capacity to sustain positive emotion in major depression reflects diminished maintenance of fronto-striatal brain activation. *Proceedings of the National Academy of Sciences of the United States of America, 106*, 22445-22450.

# Henriques, J. B., & Davidson, R. J. (2000). Decreased responsiveness to reward in depression. *Cognition and Emotion, 14*, 711-724.

# Johnson, E. J., Hershey, J., Meszaros, J., & Kunreuther, H. (1993). Framing, probability distortions, and insurance decisions. *Journal of Risk and Uncertainty, 7*, 35-51.

# Joormann, J., & Gotlib, I. H. (2008). Updating the contents of working memory in depression: Interference from irrelevant negative material. *Journal of Abnormal Psychology, 117*, 182-192.

# Joormann, J., Teachman, B. A., & Gotlib, I. H. (2009). Sadder and less accurate? False memory for negative material in depression. *Journal of Abnormal Psychology, 118*, 412- 417.

Kahneman, D., & Tversky, A. (1979). Prospect Theory: An analysis of decision under risk. *Econometrica, 47,* 263-292.

Keeney, R. L., & Raiffa, H. (1976). *Decisions with multiple objectives: Preferences and value tradeoffs*. New York: Wiley.

Kim. H., Shimojo, S., & O’Doherty, J. P. (2006). Is avoiding an aversive outcome rewarding? Neural substrates of avoidance learning in the human brain. *PLoS Biology, 4(8*), e233. doi:10.1371/journal.pbio.0040233.

McFarland, C., Ross, M., & DeCourville, N. (1989). Women’s theories of menstruation and biases in recall of menstrual symptoms. *Journal of Personality and Social Psychology, 57*, 522-531.

Miller, P. M., & Fagley, N. S. (1991). The effects of framing, problem variations, and providing rationale on choice. *Personality and Social Psychology Bulletin, 17*, 517-522.

O’Connor, A. M. (1989). Effects of framing and level of probability on patients’ preferences for cancer chemotherapy. *Journal of Clinical Epidemiology, 42*, 119-126.

Perrine, M. W., & Schroder, K. E. (2005). How many drinks did you have on September 11, 2001? *Journal of Studies on Alcohol and Drugs, 66*, 536-544.

Pizzagalli, D. A., Iosifescu, D., Hallett, L. A., Ratner, K. G., & Fava, M. (2008). Reduced hedonic capacity in major depressive disorder: Evidence from a probabilistic reward task. *Journal of Psychiatric Research, 43*, 76-87.

Reynolds, S. M., & Berridge, K. C. (2008). Emotional environments retune the valence of appetitive versus fearful functions in nucleus accumbens. *Nature Neuroscience, 11*, 423- 425.

Ribot, T. (1896). *La psychologie des sentiment [The psychology of feelings]*. Felix Alcan., Paris.

# Salamone, J. D., Correa, M., Farrar, A., & Mingote, S.M. (2007). Effort-related functions of nucleus accumbens DA and associated forebrain circuits. *Psychopharmacology, 191*, 461-482.

# Salamone, J. D., Steinpreis, R. E., McCullough, L. D., Smith, P., Grebel, D., & Mahan, K. (1991). Haloperidol and nucleus accumbens dopamine depletion suppress lever pressing for food but increase free food consumption in a novel food choice procedure. *Psychopharmacology, 104*, 515-521.

Seiden, L. S., Sabol, K. E., & Ricaurte, G. A. (1993). Amphetamine: Effects on catecholamine systems and behavior. *Annual Review of Pharmacology and Toxicology, 32*, 639-677.

# Shelton, R. C., & Tomarken, A. J. (2001). Can recovery from depression be achieved? *Psychiatric Services*, *52*, 1469-1478.

Sloan, D. M., Strauss, M. E., Wisner, K. L. (2001). Diminished response to pleasant stimuli by depressed women. *Journal of Abnormal Psychology, 110*, 488-493.

Solhan, M. B., Trull, T. J., Jahng, S., & Wood, P. K. (2009). Clinical assessment of affective instability: Comparing EMA indices, questionnaire reports, and retrospective recall. *Psychological Assessment, 21*, 425-436.

Thaler, R. (1980). Toward a positive theory of consumer choice. *Journal of Economic Behavior and Organization, 1*, 39-60.

Treadway, M. T., Bossaller, N. A., Shelton, R. C., & Zald, D. H. (in press). Effort-based decision-making in major depressive disorder: A translational model of decisional anhedonia. *Journal of Abnormal Psychology*.

# Treadway, M. T., Buckholtz, J. W., Schwartzman, A. N., Lambert, W. E., & Zald, D. H. (2009). Worth the ‘EEfRT’? The Effort Expenditure for Rewards Task as an objective measure of motivation and anhedonia. *PLoS ONE, 4*, e6598.

# Treadway, M. T., & Zald, D. H. (2010). Reconsidering anhedonia in depression: Lessons from translational neuroscience. *Neuroscience & Biobehavioral Reviews, 35*, 537-555.

Tversky, A., & Kahneman, D. (1981). The framing of decisions and the psychology of choice. *Science, 211,* 453-458.

Tversky, A., & Kahneman, D. (1991). Loss aversion in riskless choice: A reference-dependent model. *The Quarterly Journal of Economics, 106,* 1039-1061.

Wardle, M. C., Treadway, M. T., Mayo, L. M., Zald, D. H., & de Wit, H. (2011). Amping up effort: Effects of d-amphetamine on human effort-based decision-making. *Journal of Neuroscience, 31*, 16597-16602

Watson, D., & Clark, L. A. (1991). The Mood and Anxiety Symptom Questionnaire. Unpublished manuscript, University of Iowa, Department of Psychology, Iowa City.

Watson, D. W., Clark, L. A., Weber, K. Assenheimer, J. S., Strauss, M. E., & McCormick, R. A. (1995). Testing a tripartite model: I. Evaluating the convergent and discriminant validity of anxiety and depression symptom scales. *Journal of Abnormal Psychology, 104*, 3-14.

Wexler, B. E., Levenson, L., Warrenburg, S., Price, L. H. (1994). Decreased perceptual sensitivity to emotion-evoking stimuli in depression. *Journal of Psychiatry Research, 51*, 127-138.

TABLES

**Table 1. Demographic and Self-Report Data**

|  |  |  |  |
| --- | --- | --- | --- |
| Variable | *n* | Mean | SD |
| Female Participants | 22 (64%) |   |   |
| MASQ - GDM | 34 | 32.56 | 6.46 |
| MASQ - GDA | 34 | 20.62 | 4.89 |
| MASQ - AA | 34 | 24.88 | 5.36 |
| MASQ - GDD | 34 | 24.79 | 7.32 |
| MASQ - AD | 34 | 52.21 | 11.03 |
| Chapman - Total | 34 | 17.71 | 11.12 |
| PSS | 34 | 16.62 | 5.19 |
| BAS-D | 34 | 11.94 | 2.52 |
| BAS-FS | 34 | 12.24 | 2.45 |
| BAS-RR | 34 | 18.24 | 1.56 |
| BIS | 34 | 23.35 | 3.61 |
| MCQ | 34 | 13.71 | 3.68 |

**Table 2. Correlations between self-report scores and proportion of hard task choices and bias in win and loss blocks**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Measure |   | Win | Loss | Bias |
| MASQ - GDM | Pearson Corr. | 0.21 | 0.09 | 0.17 |
|   | Sig. (2-tailed) | 0.23 | 0.63 | 0.33 |
| MASQ - GDA | Pearson Corr. | 0.04 | 0.07 | 0.07 |
|   | Sig. (2-tailed) | 0.81 | 0.71 | 0.71 |
| MASQ - AA | Pearson Corr. | -0.02 | 0.00 | -0.01 |
|   | Sig. (2-tailed) | 0.91 | 0.99 | 0.95 |
| MASQ - GDD | Pearson Corr. | 0.06 | 0.02 | 0.04 |
|   | Sig. (2-tailed) | 0.73 | 0.90 | 0.8 |
| MASQ - AD | Pearson Corr. | 0.09 | -0.16 | -0.05 |
|   | Sig. (2-tailed) | 0.63 | 0.36 | 0.77 |
| Chapman - Total | Pearson Corr. | -0.03 | -0.01 | -0.03 |
|   | Sig. (2-tailed) | 0.86 | 0.98 | 0.89 |
| PSS | Pearson Corr. | -0.03 | 0.05 | 0.01 |
|   | Sig. (2-tailed) | 0.88 | 0.76 | 0.96 |
| BAS-D | Pearson Corr. | 0.08 | 0.31 | 0.24 |
|   | Sig. (2-tailed) | 0.67 | 0.07 | 0.18 |
| BAS-FS | Pearson Corr. | 0.05 | 0.08 | 0.08 |
|   | Sig. (2-tailed) | 0.8 | 0.65 | 0.65 |
| BAS-RR | Pearson Corr. | 0.04 | 0.3 | 0.2 |
|   | Sig. (2-tailed) | 0.83 | 0.09 | 0.26 |
| BIS | Pearson Corr. | 0 | 0.11 | 0.06 |
|   | Sig. (2-tailed) | 0.99 | 0.54 | 0.72 |
| MCQ | Pearson Corr. | -0.09 | 0.04 | -0.03 |
|   | Sig. (2-tailed) | 0.6 | 0.81 | 0.89 |

**Figure 1. Proportion of hard tasks by probability level in win and loss-avoidance trials**