

Anticipatory Pleasure Predicts Motivation for Reward in Major Depression

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Anhedonia, the lack of interest or pleasure in response to hedonic stimuli or experiences, is a cardinal symptom of depression. This deficit in hedonic processing has been posited to influence depressed individuals' motivation to engage in potentially rewarding experiences. Accumulating evidence indicates that hedonic processing is not a unitary construct but rather consists of an anticipatory and a consummatory phase. We examined how these components of hedonic processing influence motivation to obtain reward in participants diagnosed with major depression and in never-disordered controls. Thirty-eight currently depressed and 30 never-disordered control participants rated their liking of humorous and nonhumorous cartoons and then made a series of choices between viewing a cartoon from either group. Each choice was associated with a specified amount of effort participants would have to exert before viewing the chosen cartoon. Although depressed and control participants did not differ in their consummatory liking of the rewards, levels of reward liking predicted motivation to expend effort for the rewards only in the control participants; in the depressed participants, liking and motivation were dissociated. In the depressed group, levels of anticipatory anhedonia predicted motivation to exert effort for the rewards. These findings support the formulation that anhedonia is not a unitary construct and suggest that, for depressed individuals, deficits in motivation for reward are driven primarily by low anticipatory pleasure and not by decreased consummatory liking.

Keywords: anhedonia, motivation, depression, reward, effort

Anhedonia, the loss of interest or pleasure in response to hedonic stimuli or experiences, is one of the cardinal symptoms of Major Depressive Disorder [MDD; American Psychiatric Association (APA), 2000]. Despite the hedonic focus of this definition, anhedonia is often used as a blanket term to describe a broad spectrum of reward-related deficits, including impaired reward learning and reinforcement conditioning, attenuated positive emotional expressivity and reactivity, and decreased appetitive motivation (e.g., Henriques & Davidson, 2000; Pizzagalli, Iosifescu, Hallett, Ratner, & Fava, 2008; Rottenberg, Kasch, Gross, & Gotlib, 2002; Shankman, Klein, Tenke, & Bruder, 2007). This overgeneralization in the definition and measurement of anhedonia may obscure the specificity of certain reward-related dysfunctions in MDD and their precise mechanisms. In this context, the distinction between consummatory and motivational deficits may be particularly important (Treadway & Zald, 2011).

Accumulating evidence indicates that reward processing is not a unitary construct. Investigators have demonstrated that reward processing can be separated into an anticipatory and a consummatory phase. Indeed, almost 30 years ago, Klein (1987) emphasized this temporal distinction within the context of depression, proposing that, whereas anticipatory pleasure is related more strongly to reward motivation and goal-directed activity targeting desired outcomes (i.e., 'wanting'), consummatory pleasure is related more closely to satiation and in-the-moment pleasure (i.e., 'liking'). Importantly, working with animal models, Berridge and Robinson (1998, 2003) identified discrete neural circuits responsible for 'wanting' versus 'liking' a reward. Investigators using both behavioral and functional neuroimaging methods have demonstrated a similar differentiation in humans (Dillon et al., 2007; Knutson, Fong, Adams, Varner, & Hommer, 2001; Waugh & Gotlib, 2008). Despite Klein's early contention that elucidating the affective chronometry of reward processing has important implications for both the understanding and treatment of depression, few investigators have examined the temporal features of reward processing in MDD or their functional significance.

Although the 'wanting' and 'liking' systems are typically highly coupled, such that 'liking' a reward often appears to promote the further 'wanting' of that reward, some research suggests that under certain conditions these two systems can become dissociated. Kring and colleagues (Gard, Kring, Gard, Horan, & Green, 2007; Germans & Kring, 2000), for example, found that schizophrenia is characterized by impaired anticipatory pleasure but relatively intact consummatory pleasure. Interestingly, these anticipatory def-

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icits have been posited to underlie decreased appetitive motivation ('wanting'), while sparing the ability to respond to reward in the moment ('liking') (Gard et al., 2007). This dissociation between 'wanting' and 'liking' is paralleled in recent studies of reward processing in animals and in rodent models of anhedonia. These studies have revealed that dopamine (DA), previously thought of as a "pleasure molecule" that mediates the hedonic impact of a rewarding stimulus (Wise, Spindler, deWit, & Gerberg, 1978; Wise, 1980), is critically involved in *anticipatory* or appetitive processing, but is less involved in the consummatory response to rewarding stimuli (Berridge & Robinson, 1998, 2003). For example, in rodents, mesolimbic DA depletion fails to alter the hedonic impact of primary rewards (Berridge, 1996; Berridge & Robinson, 1998), but results in a reduced willingness to exert effort to obtain these rewards (Correa, Carlson, Wisniecki, & Salamone, 2002; Salamone, Correa, Farrar, & Mingote, 2007). Thus, it appears that the mesolimbic DA system plays a critical role in regulating behavioral activation and reward '*wanting*' specifically, without affecting reward '*liking*.'

Reward 'liking' and 'wanting' are properties that are not always bound solely to a given reward stimulus but rather can also become associated with reward-predicting *cues*. Through a process of Pavlovian conditioning, such cues can take on affective and incentive motivational properties, becoming attractive and capable of acting as motivational forces in their own right. Importantly, there are individual differences in the tendency to infuse reward cues with affective and incentive motivational properties. In a basic Pavlovian conditioning paradigm in rodents, after the repeated association between a conditioned stimulus (CS) (e.g., a light) and an unconditioned stimulus (US) (e.g., a sugar pellet delivered in a food tray on the other side of the cage), two distinct patterns of conditioned response (CR) emerge. Whereas some animals begin to approach and engage the CS (touching and sniffing the light), other animals approach and engage the location of US delivery directly (approaching and sniffing the food tray). The former style of CR is called 'sign-tracking,' because the animals' approach behaviors are directed toward the reward cue, or sign. The latter style of CR is called 'goal-tracking,' because the animals' approach behaviors are directed toward the reward goal itself rather than to the predictive cue. Importantly, reward learning and prediction occur effectively in both goal-trackers and sign-trackers, as evidenced by the evocation of a reliable CR; however, only in sign-trackers is the CS attributed with incentive salience in addition to its predictive utility (Flagel et al., 2011; Robinson & Flagel, 2009). In other words, in sign-trackers the CS becomes infused with incentive motivational value and is capable itself of acting as a motivating reinforcer.

Evidence suggests a specific role for DA in this type of Pavlovian learning, with mesolimbic DA activity being more critical for sign-tracking than for goal-tracking. Flagel et al. (2011) recorded phasic DA release from the NAcc over a six-day Pavlovian conditioning period. Markedly different patterns emerged for sign-trackers than for goal-trackers. In sign-trackers, DA release followed a classic learning signal or prediction error model (Schultz, 1998), with DA spikes initially occurring in response to reward outcomes but gradually propagating back to the CS. In contrast, goal-trackers showed no such transfer of DA release to the CS. Because sign-trackers and goal-trackers did not differ in their predictive learning (i.e., both groups acquired a CR at equivalent

rates), the development of DA release in response to the CS does not track reward prediction (nor encode the strength of such predictions) but instead appears to track with the attribution of incentive salience to the CS. In a second phase of the study, Flagel et al. demonstrated that administration of a DA antagonist selectively interfered with sign-tracking, but not goal-tracking, behavior. Thus, DA appears to play a specific role in mediating the motivational value rather than the predictive utility of reward cues.

It is noteworthy that several theorists have proposed that symptoms of anhedonia in depression are related to blunted DA response to rewarding stimuli, particularly in the ventral striatum (Epstein et al., 2006; Keedwell, Andrew, Williams, Brammer, & Phillips, 2005; Nestler & Carlezon, 2006). Depressed individuals have also been found to demonstrate patterns of NAcc activation more consistent with goal-tracking than with sign-tracking during a Pavlovian conditioning task (Kumar et al., 2008). It is likely, therefore, that motivational impairments in MDD arise from deficits in processing related primarily to incentive salience and anticipatory pleasure rather than to consummatory pleasure. In fact, in a recent review of anhedonia in depression, Dichter (2010) asserts that, to the extent that MDD is characterized by deficits in mesolimbic DA outputs, anhedonia in MDD is likely to be characterized by decreased anticipatory pleasure, without necessitating a corresponding decrease in consummatory pleasure. Dichter concludes with a call for future studies to assess potential shifts in "cost-benefit gradients" of behavioral output in MDD.

To date, no studies have examined the relation between 'wanting' and 'liking' in depressed individuals or assessed the relative motivational impact of consummatory and anticipatory pleasure. In fact, only three studies have examined this dissociation in humans (Litt, Khan, & Shiv, 2010; Treadway, Buckholtz, Schwartzman, Lambert, & Zald, 2009; Waugh & Gotlib, 2008), each of which examined nonclinical samples. Further, only two of these investigations measured reward 'wanting' within the context of effort-related decision-making and goal pursuit. Waugh and Gotlib (2008) demonstrated in a healthy community sample that reward 'liking' was related to reward motivation only under low levels of effort; as levels of effort required to obtain a reward increased, Waugh and Gotlib observed a decoupling of 'liking' and 'wanting.' Studying a nonclinical sample of undergraduate students, Treadway et al. (2009) found an association between anhedonia and reduced motivation in an effort-based decision-making task; unfortunately, Treadway et al. did not report levels of reward liking, nor did they differentiate consummatory and anticipatory anhedonia.

The present study was designed to address this gap in the literature. We used clinical rating scales to assess anticipatory and consummatory anhedonia in MDD and administered a modified version of an effort-reward task (Waugh & Gotlib, 2008) both to dissociate the motivational (i.e., effort-related) and hedonic (i.e., pleasure-related) underpinnings of reward processing and to elucidate the potential role of anticipatory pleasure in promoting reward 'wanting' and motivation. In the effort-reward task, participants rate their enjoyment of stimuli (cartoons) from "reward" (i.e., humorous) and "nonreward" (i.e., nonhumorous) categories and then make a series of choices concerning viewing a stimulus from either group under varying levels of effort. Each choice is associated with a specified amount of effort that participants will have to exert before viewing a cartoon from the selected group.

Based on previous findings and theories of decreased approach motivation in depression (e.g., Henriques & Davidson, 2000; Kring & Bachorowski, 1999; Shankman, Klein, Tenke, & Bruder, 2007), we hypothesized that depressed participants would exhibit impaired motivation to exert effort to obtain the rewarding stimuli. We further hypothesized that, in depressed participants, decreased motivation for the reward (i.e., 'wanting') would be associated with anticipatory anhedonia, rather than with consummatory anhedonia, or decreased 'liking.' In contrast, control participants, who presumably are not characterized by impaired anticipatory processing, would not exhibit this dissociation of 'wanting' and 'liking;' consequently, we predicted that in control participants, reward 'liking' would predict reward 'wanting' and motivation.

Finally, to probe individual differences in goal-tracking versus sign-tracking (i.e., the tendency to attribute the reward cues with affective and incentive properties), we administered an affective priming task in which we assessed the extent to which participants formed conditioned positive affective associations with reward cues. The affective priming task draws on findings that evaluative processing of an affectively valenced target word (e.g., love) is facilitated when it is preceded by a similarly valenced prime word (e.g., happiness) rather than by an inconsistent, or differently valenced, prime word (e.g., death) (Fazio, Sanbonmatsu, Powell, & Kardes, 1986). In the effort-reward task, reward and nonreward stimulus category groups were assigned nonsense-word category names ("GUP" and "LUM"). At the outset of the task, these category labels should have no affective meaning for participants. Over the course of the study, however, they may become imbued with any positive or negative feelings associated with the reward categories. We hypothesized that if participants form positive associations with the reward cues, then using the reward category label (e.g., "LUM") as a prime in the affective priming task should facilitate evaluations of positively valenced target words. We hypothesized further (given the proposed dopaminergic mediation of incentive salience and reinforcement; Berridge, 2007; Flagel et al., 2011) that MDD participants would fail to develop positive associations with the reward cues and thus would not demonstrate this positive facilitation effect.

Method

Participants

Participants were recruited through advertisements posted in numerous locations within the community (e.g., Internet bulletin boards, university kiosks, supermarkets). Participants' responses to a telephone interview provided initial selection information. This phone screen established that participants were fluent in English and were between 18 and 60 years of age. Participants were excluded if they reported severe head trauma, learning disabilities, psychotic symptoms, bipolar disorder, or alcohol or substance abuse within the past six months. Eligible individuals were invited to come to the laboratory for a more extensive interview. Participants were included in the depressed group (MDD) if they met *DSM-IV* criteria for current major depression. The never-disordered control group (CTL) consisted of individuals with no current diagnosis and no history of any Axis I disorder. Participants were scheduled for a second session consisting of "computer activities," usually one to two weeks after the interview (all ses-

sions were scheduled within three weeks of the interview). Sixty-eight individuals participated in the study (38 MDD and 30 CTL).

Diagnostic Assessment

Trained interviewers administered the Structured Clinical Interview for the *DSM-IV* (SCID; First, Gibbon, Spitzer, & Williams, 1995) to participants during their first session in the study. This interview assesses Diagnostic and Statistical Manual of Mental Disorders (4th ed., *DSM-IV*; APA, 2000) current and lifetime diagnoses for anxiety, mood, psychotic, alcohol and substance use, somatoform, and eating disorders. The SCID has demonstrated good reliability for the majority of the disorders covered in the interview (Skre, Onstad, Torgersen, & Kringlen, 1991; Williams et al., 1992). All interviewers had extensive training in the use of the SCID. In previous studies with similar samples, our team of interviewers achieved excellent interrater reliability. The k coefficients were .93 for the diagnosis of major depressive disorder (MDD) and .92 for the "nonpsychiatric control" diagnosis (i.e., the absence of current or lifetime psychiatric diagnoses). For the current study, two independent raters rated a randomly selected sample of 25% of the SCID recordings and achieved perfect agreement with the original interviewers. Although this obviously represents excellent reliability, we should note that the interviewers used the "skip out" strategy of the SCID, which may have reduced the opportunities for the independent raters to disagree with the diagnoses (Gotlib, Krasnoperova, Yue, & Joormann, 2004). The Global Assessment of Functioning Scale (GAF, Axis V, *DSM-IV*, APA, 2000) was used to assess global functioning. The GAF is a single-rating scale used to evaluate an individual's overall level of psychological, social, and occupational functioning that correlates robustly with other measures of illness severity (Endicott, Spitzer, Fleiss, & Cohen, 1976; Rottenberg et al., 2002). Ratings are made on the basis of the SCID interview and range from 1 (*lowest level of functioning*) to 100 (*highest level of functioning*). The high reliability of the GAF has been demonstrated in prior work (Endicott et al., 1976) and with this team of interviewers (Knutson, Bhanji, Cooney, Atlas, & Gotlib, 2008).

Questionnaires and Materials

Depressive symptoms. Participants completed the Beck Depression Inventory-II (BDI; Beck, Steer, & Brown, 1996), a 21-item, self-report measure of the severity of depressive symptoms. The acceptable reliability and validity of the BDI has been well-documented (Beck, Steer et al., 1988).

Consummatory anhedonia. To assess consummatory anhedonia, participants completed the Snaith-Hamilton Pleasure Scale (SHPS; Snaith et al., 1995). The SHPS is a well-validated, 14-item instrument used to assess the experience of pleasure. Participants were asked to rate on a five-point likert scale the extent to which they agreed or disagreed with statements regarding various experiences that are generally considered pleasurable (e.g., "I enjoy my favorite meal," "I enjoy a warm bath or refreshing shower"). These items assess in-the-moment or consummatory aspects of pleasure; consequently, we used the SHPS as our measure of consummatory anhedonia. Following recent recommendations (Franken, Rassin, & Muris, 2007), we used interval (rather than the original dichotomous) scoring. Specifically, items answered with

“strongly disagree” were coded as “5,” while a “strongly agree” response was coded as “1.” Therefore, scores on the SHPS can range from 14 to 70, with higher scores corresponding to less hedonic tone and therefore more severe levels of consummatory anhedonia. The SHPS has been found to have satisfactory test-retest validity in healthy participants over an interval of three weeks (intraclass correlation coefficient (ICC): $r = .70, p < .001$; Franken et al., 2007).

Anticipatory anhedonia. Following the SCID, interviewers administered a semistructured version of the 17-item Hamilton Rating Scale for Depression (HAM-D; Hamilton, 1967). For the current study, two independent raters rated a randomly selected sample of 15 HAM-D recordings and achieved excellent interrater reliability, ICC: $r = .89$. Item 2 on the HAM-D, rated on a five-point scale (0 to 4), assesses anhedonic symptoms with the following questions: “How have you been spending your time this past week (when not at work)?” “Have you felt interested in doing [those things], or do you feel you have to push yourself to do them?” “Have you stopped doing anything you used to do?” “Is there anything you look forward to?” Because these questions assess anticipatory components of anhedonia, we used these items as our measure of anticipatory anhedonia. The interrater reliability for the item-2 scale for the 15 randomly selected HAM-D recordings was also strong, ICC: $r = .89$. Within the MDD participants, this item was correlated significantly with scores on the SHPS, $r = .35, p = .04$.

Design and Procedure

Reward stimuli. We used humorous and nonhumorous single-panel cartoons as the reward and nonreward stimuli, respectively. Similar to other rewarding stimuli (e.g., money, juice), cartoons such as these have been shown to activate mesolimbic reward regions of the brain (Mobbs, Greicius, Abdel-Azim, Menon, & Reiss, 2003). Unlike money, however, humor does not have an inherently anticipatory component to its reward value, which lends itself to a more precise assessment of consummatory liking. In addition, compared with juice, humor is less susceptible to satiation effects in which the value of the reward decreases with increased consumption, allowing us to present several trials and, thereby, to assess effort more reliably (Waugh & Gotlib, 2008). A total of 104 different cartoons were used, half of which were made nonhumorous by replacing the humorous caption with a nonhumorous caption. These 104 cartoons were selected from an initial group of 200 for which we collected normative ratings from 80 volunteers from both the community and online message boards. Volunteers viewed the cartoons (order was randomized) and rated them using a 10-point scale ranging from 1 (not at all funny) to 10 (extremely funny); cartoons with an average rating of 6 or higher were selected for the humorous group, and cartoons with an average rating of 1 were selected for the nonhumorous group.

Humorous and nonhumorous cartoons were presented to participants as belonging to two separate “decks” of cartoons. To avoid influencing ratings or choice behavior, we used the nonsense words “LUM” and “GUP” to label the two decks of cartoons. The assignment of these names to the humorous or nonhumorous decks was counterbalanced across participants.

Effort-Reward Task

Preference ratings. To index the extent of participants’ preference for the humorous over the nonhumorous cartoons, participants were first shown 10 pairs of cartoons side by side on the computer monitor. In each pair, one of the cartoons was a humorous cartoon and the other was a nonhumorous cartoon (position on the screen was counterbalanced) and their respective deck labels (“LUM,” “GUP”) appeared above them. Participants rated their preference for the cartoons on a scale from 1 (strongly prefer LEFT cartoon) to 7 (strongly prefer RIGHT cartoon), with a rating of 4 representing a lack of preference for either cartoon.

Reward ‘liking.’ To assess consummatory ‘liking’ of the reward, participants were then presented with the same 10 cartoons from the preference task, one at a time (along with their deck label of “LUM” or “GUP”). Participants rated how much they liked the cartoon by clicking on a bipolar visual analog scale that extended along the bottom half of the computer screen from 0 pixels (‘extremely disliked’) to 1000 pixels (‘extremely liked’), with a white bar in the middle indicating “neither liked nor disliked.”

Motivation (‘Wanting’). Motivation was operationalized as the amount of effort participants were willing to exert to view cartoons from the preferred deck. Participants were given the opportunity to choose between viewing a novel cartoon from the “LUM” deck or from the “GUP” deck. Each deck choice was associated with a ‘click-cost’ that specified how many times the participants would have to click on a moving square (i.e., how much effort they would have to exert) before viewing the cartoon from the chosen deck. In this square-clicking task, a 2×2 in. black square appeared at random locations on the computer screen. Participants used the mouse to click on the square, at which point the mouse cursor returned to the center of the screen and the square “jumped” to a new location. This square-clicking task is similar to tasks used in previous studies to induce effort (Klein, Bhatt, & Zentall, 2005) and was designed to be engaging but neutral (Waugh & Gotlib, 2008). After participants completed the requisite number of clicks for their choice, they viewed a cartoon from their chosen deck and then rated how much they liked that cartoon using the visual analogue scale described above. The task included a series of 36 choice trials.

Click-costs were set so that the humorous deck was always associated with more effort than was the nonhumorous deck, which was always anchored at either 0 or 15 clicks. At each choice, the click-cost for the humorous deck was determined by a random adjusting-amount algorithm adapted from Richards, Zhang, Mitchell, & de Wit, 1999. The algorithm was programmed to use previous choices to narrow the range of values from which the subsequent click-cost was selected. Across trials, the number of clicks required to view a cartoon from the humorous deck was adjusted (in increments of five clicks) relative to the nonhumorous deck until the range of the upper and lower bounds of the click-cost reached five clicks. This represented the indifference point—the click-cost for the humorous deck at which the participant was indifferent between the two choices (i.e., was equally likely to choose either deck). This indifference point served as an index of motivation for each participant.

Two indifference points were calculated for each participant—one for when the nonhumorous deck’s click-cost was set to 0 clicks and one for when the click-cost for the nonhumorous deck

was set to 15 clicks. This permitted an examination of any potential effects of inertia, such that participants may be less willing to work for reward when there is a no-work, or “opt out,” option than when they must exert some amount of effort regardless of their choice. Once the indifference point was calculated, randomly selected click counts were presented until the participants completed the full 36 trials.

There were 29 instances (out of 146) in which the algorithm was unable to calculate a participant’s indifference point by the end of the 36 choice trials. The number of participants for whom an indifference point was successfully calculated versus those for whom it was not did not differ by group, $\chi^2(1, n = 68) < 1$. In these instances, we calculated an approximate indifference point by adjusting the required range between the upper and lower bounds of the click-cost to be 10 clicks instead of five. Substituting these approximated indifference points recovered 16 of the missing data points. Thirteen indifference points were not able to be calculated, thereby excluding 11 participants from subsequent analyses (seven MDD participants, four CTL participants; leaving 31 MDD participants and 26 CTL participants). The MDD and CTL groups did not differ with respect to the proportion of included and excluded individuals ($p = .69$, Fisher’s exact test).

Effort liking. As a baseline at the beginning of the task, and after each block of 13 trials, participants took a short break (<1 min) and rated on the bipolar visual analog scale (the same as that used in the cartoon liking ratings described above) how much they liked the square-clicking task.

Affective Priming Task

Anticipatory processing and affective associations. To assess whether participants formed positive affective associations with the reward cues, participants completed a brief affective priming task after the effort-reward task. Participants were presented with a prime word for 300 ms, followed by a target word. They were asked to ignore the prime word and to indicate as quickly and as accurately as possible with a button press whether the target word was “good” or “bad.” Three primes were used: reward (the name of the humorous cartoon deck, e.g., “LUM”), nonreward (the name of the nonhumorous cartoon deck, e.g., “GUP”), and novel (a similar nonsense word not seen previously in the task, “ZEB”). Targets were 10 clearly positive and 10 clearly negative adjectives taken from the Affective Norms for English Words (ANEW; Bradley & Lang, 1999). Each prime was paired with each target word once, for a total of 60 trials, and affective priming was assessed through reaction times (RTs) to evaluate the target words after the primes. Only correct trials went into RT calculations, which excluded 24 of a total of 4080 trials (0.5%).

Results

Participant Characteristics

Demographic and clinical characteristics of the MDD and control participants are presented in Table 1. The two groups of participants did not differ significantly with respect to level of education, $t(65) = .17, d = .04$, income, $t(56) = 1.04, d = .28$, ethnicity ($p = .72$, Fisher’s exact test), number of children, $t(57) = .94, d = .25$, marital status, $\chi^2(5, n = 67) = 2.97$, or proportion of

women, $\chi^2(1, n = 68) = .08$, all $ps > .05$. Participants in the MDD group were older than were participants in the CTL group, $t(63) = 2.62, p = .01, d = .66$. As expected, the MDD participants obtained significantly higher scores on the BDI than did the CTL participants, $t(63) = 15.35, p < .001, d = 3.89$, as well as lower ratings on the interviewer-assessed GAF, $t(66) = 15.55, p < .001, d = 3.85$.

Consummatory anhedonia. MDD participants obtained significantly higher scores on the SHPS than did CTL participants, indicating greater self-reported consummatory anhedonia, $t(64) = 6.09, p = .02, d = 1.53$.

Anticipatory anhedonia. As predicted, MDD participants had significantly higher HAM-D total scores, $t(66) = 12.01, p < .001, d = 3.4$, and significantly higher scores for item 2, the anhedonia measure, $t(66) = 13.70, p < .001, d = 2.98$, than did CTL participants, indicating higher levels of anticipatory anhedonia. Because only three CTL participants received an item-2 score higher than 0, subsequent analyses of anticipatory anhedonia are conducted only within the group of MDD participants.

Motivation (‘Wanting’)

Indifference point. Indifference points for the MDD and control participants are presented in Table 2. To examine differences in motivation, or reward ‘wanting,’ we conducted a two-way repeated measures analysis of variance (ANOVA) on indifference points with group as the between-subjects factor (MDD, CTL) and effort level for the nonhumorous cartoon as the within-subject factor (0 clicks, 15 clicks). Contrary to our hypothesis of decreased reward motivation in MDD participants, this analysis did not yield a significant effect for group, $F(1, 55) = .40, p = .53$, or a significant interaction of group and effort level, $F(1, 55) = .68, p = .41$, but did yield a significant main effect of effort level, $F(1, 55) = 41.99, p < .001, \eta^2 = .43$: participants were willing to exert more effort to view cartoons from the humorous deck when the nonhumorous deck was set to 15 clicks than when it was set to 0 clicks, $t(56) = 6.45, p < .001, d = .79$.

Square-clicking task. Ratings of liking for the square-clicking task are presented in Table 2. Overall, participants reported neither significantly liking nor disliking the square-clicking task [$M = 397.43, SE = 25.68$ (a score of 400 represents “neither liking nor disliking”), $t(54) = .10, p = .92$. There were no group differences in ratings of the square-clicking task, $t(53) = .51, p = .61, d = .14$, or in RTs during the task, $t(65) = .91, p = .86, d = .23$, indicating that the subjective cost of effort was equivalent in the two groups of participants.

Reward ‘Liking’

To determine whether MDD and CTL participants differed in reward ‘liking,’ we examined participants’ preference and ‘liking’ ratings for the humorous and nonhumorous cartoons (see Table 2). MDD and CTL participants did not differ in their preference ratings for humorous versus nonhumorous cartoons,

¹ We included age as a covariate in all subsequent analyses; because age was not a significant factor in any of these analyses, we report results without using age as a covariate.

Table 1
Demographic and Clinical Characteristics of Participants

Variable	Group	
	MDD	CTL
<i>n</i> (Female)	38 (19)	30 (14)
Age	44.42 (13.4)	35.97 (12.18)
Income*	3.24 (2.06)	3.72 (1.14)
Level of education (% holding college or advanced degree)	60.5	56.7
Married or living with domestic partner (%)	29	20
No. children	.63 (1.03)	.41 (.73)
Currently taking psychotropic medication (%)	37.8	0
GAF	52.05 (9.53)	85.23 (7.60)
BDI-II score	31.83 (10.37)	1.5 (2.58)
SHPS score	35.72 (11.12)	21.66 (6.24)
HAM-D item 2 (anticipatory anhedonia)	2.37 (.94)	.13 (.43)
HAM-D score	16.41 (5.27)	2.18 (2.21)

Note. Standard deviations are shown in parentheses. MDD = Major Depressive Disorder; CTL = never-disordered control; GAF = Global Assessment of Functioning; BDI-II = Beck Depression Inventory-II; SHPS = Snaith Hamilton Pleasure Scale; HAM-D = Hamilton Ratings Scale for Depression.

*Incomes were coded as follows: 1 = \$10,000, 2 = \$10,000–\$25,000, 3 = \$25,000–\$50,000, 4 = \$50,000–\$75,000, 5 = \$75,000–\$100,000, 6 = \$100,000.

$t(63) = .79, p = .43, d = .2$; indeed, all participants reported a preference for the humorous deck [$M = 5.89, SD = .70$ (a score of 4 represents “prefer neither deck”)], $t(64) = 21.72, p < .001$. To examine differences in ‘liking’ ratings of the cartoons, we conducted a two-way [Group (MDD, CTL); Deck (humorous, nonhumorous)] repeated measures ANOVA. This analysis did not yield a significant group effect for ‘liking’ ratings, $F(1, 65) = 1.53, p = .22$, or a significant group by deck interaction, $F(1, 65) = .06, p = .81$ but did yield a significant main effect of deck, $F(1, 65) = 205.99, p < .001, \eta^2 = .31$. Not surprisingly, participants reported ‘liking’ the humorous cartoons more than they did the nonhumorous cartoons, $t(66) = 14.62, p < .001, d = 2.53$. In sum, there were no differences between MDD and CTL participants in their ‘liking’ of the reward stimuli.

Relation Between Reward ‘Liking’ and Motivation (‘Wanting’)

To examine the relation between reward liking and motivation (‘wanting’), we conducted a multiple regression analysis with

indifference point (for when the nonhumorous deck was set to 15 clicks) as the dependent variable and reward ‘liking,’ group, and their interaction as predictors. ‘Liking’ was centered to reduce colinearity. Consistent with the previous analysis, there was no significant effect of group on indifference point. There was a significant main effect of ‘liking,’ $b = .05, t = 2.38, p = .02$, which was qualified by a significant interaction of group and ‘liking,’ $b = -.12, t = -2.90, p = .005; R^2 = .21, F(1, 57) = 4.93, p = .004$. Within-group correlations revealed that this interaction was attributable to the predicted positive correlation between ‘liking’ and indifference point in the CTL group, such that greater self-reported ‘liking’ of the humorous cartoons predicted greater motivation to exert effort to view the cartoons, $r = .56, p = .002$; by contrast, and also as predicted, ‘liking’ and motivation were unrelated in the depressed participants, $r = -.02, p = .90$ (see Figure 1).

Relations Between Anhedonia and Motivation

Consummatory anhedonia. To examine the relation between consummatory anhedonia and motivation, we conducted a

Table 2
Effort and ‘Liking’ Ratings for Depressed and Nondepressed Participants

Variable	Group	
	MDD	CTL
Indifference point		
Click-cost for nonhumorous deck was 0	31.32 (15.19)	26.43 (14.71)
Click-cost for nonhumorous deck was 15	41.62 (14.55)	42.04 (22.29)
‘Liking’ rating for humorous cartoons	716.30 (113.65)	733.32 (116.67)
‘Liking’ rating for nonhumorous cartoons	398.87 (122.47)	426.25 (101.03)
Preference for humorous cartoons	5.83 (.71)	5.97 (.71)
Liking rating for effort (square-clicking) task	386.16 (201.02)	413.11 (177.86)

Note. Standard deviations are shown in parentheses. There were no significant differences between MDDs and CTLs on any of these measures. MDD = Major Depressive Disorder; CTL = never-disordered control.

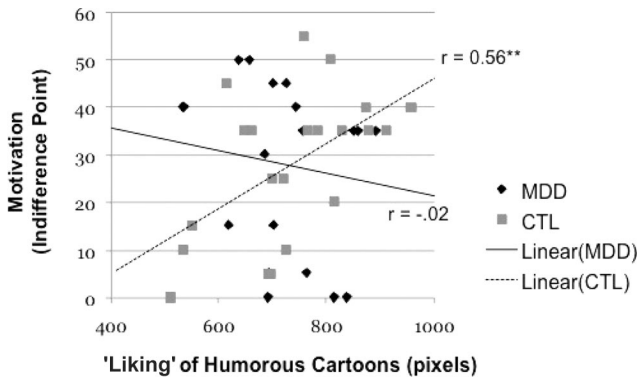


Figure 1. Relation between consummatory 'liking' ('liking' ratings for humorous cartoons – pixels on visual analogue scale) and reward motivation (indifference point). MDD = Major Depressive Disorder; CTL = never-disordered controls. ** $p < .01$.

multiple regression analysis predicting indifference point by group, SHPS scores, and their interaction. SHPS scores were centered before creating the interaction term to reduce colinearity. This analysis yielded no significant main effects or interaction (all $ps > .05$), indicating that there is no relation between consummatory anhedonia and motivation.

Anticipatory anhedonia. To examine the relation between anticipatory anhedonia and motivation, we conducted a multiple regression analysis within the MDD participants predicting indifference point by anticipatory anhedonia score. Consistent with our hypothesis, anticipatory anhedonia significantly predicted motivation, $r = -.46, p = .006$, even after controlling for BDI scores, $r = -.48, p = .006$, with increasing anticipatory anhedonia predicting decreased motivation (i.e., lower indifference points).

Anticipatory Processing and Affective Associations With Reward Cues

To examine whether participants formed positive associations with the reward cues (e.g., LUM, GUP), we conducted a repeated-measures ANOVA on RTs to positive target words with Group (MDD, CTL) as the between-subjects factor and Prime (reward cue, novel cue) as the within-subject factor.² The results of this analysis yielded a significant effect of prime, $F(1, 65) = 4.24, p = .04, \eta^2 = .06$, which was qualified by a marginally significant interaction of group and prime, $F(1, 65) = 3.44, p = .07, \eta^2 = .05$. Planned contrasts indicated that CTL participants exhibited greater positive facilitation to the reward primes than did MDD participants. Whereas CTL participants had significantly faster RTs for positive targets that were preceded by a reward prime than they did for positive targets that were preceded by a novel prime, $F(1, 65) = 6.75, p = .01, d = 1.01$, MDD participants had equivalent RTs to positive targets that were preceded by reward and by novel primes, $F(1, 65) = 0.024, p = .88$. In addition, the CTL participants had significantly faster RTs than did the MDD participants to positive targets that were preceded by the reward primes $F(1, 65) = 6.92, p = .01, d = .37$; the two groups of participants did not differ significantly in RTs to positive targets that were preceded by novel primes, $F(1, 65) = 0.00004, p = .99$ (see Figure 2).

Discussion

Theories of decreased approach motivation and anhedonia in depression posit that depressed individuals are less driven to seek reward than are nondepressed individuals because they find the reward itself less enjoyable (Clark & Watson, 1991; Davidson, 1992, 1998; Meehl, 1975). Though appealingly intuitive, this explanation fails to consider the discrete components of reward processing, relying instead on a relatively diffuse definition of anhedonia that conflates the consummatory and motivational aspects of reward (Treadway & Zald, 2011). If decreased motivation were accounted for entirely by consummatory anhedonia, one would not expect treatments such as cognitive-behavioral therapy or behavioral activation therapy, which encourage patients to approach sources of positive reinforcement in their lives, to be effective. While theorists have suggested that anticipatory pleasure is important in activating reward-seeking behavior (e.g., Klein, 1987), few studies examining reward processing in depression have examined empirically the temporal dynamics of reward processing or have attempted to disentangle the hedonic and the motivational value of reward. The present study was designed to dissociate these components of reward processing in depression and to assess the relative motivational impact of consummatory and anticipatory pleasure.

We found that depressed and never-disordered control participants did not differ in their consummatory responses to reward. Although consistent with a growing literature examining anhedonia in schizophrenia (for a recent review, see Kring & Caponigro, 2010), the lack of group differences in consummatory pleasure ('liking') may be surprising given previous work documenting decreased hedonic responding in depression. In this context, it is important to note that previous studies have relied heavily on reinforcement strategies in which reward value is indexed by the extent to which it successfully modulates behavior (e.g., Henriques & Davidson, 2000; Pizzagalli, Jahn et al., 2005; Pizzagalli, Iosifescu et al., 2008). Given findings of impaired reinforcement learning in depression (Pizzagalli et al., 2008), these studies may conflate the consummatory 'liking' of a reward with the incentive salience of that reward (i.e., the ability of the reward to act as a reinforcer capable of leveraging behavior). Another potentially important difference between previous work and the present study involves our use of humor as a reward. Much of the research examining reward processing in depression has used money (e.g., Forbes, Shaw, & Dahl, 2007; Knutson et al., 2008; Pizzagalli, Jahn, & O'Shea, 2005; Pizzagalli et al., 2008), which may confound anticipatory and consummatory aspects of hedonic responding (i.e., the reward value of money is contingent on the ability to anticipate the pleasure that will come from spending it). In addition, previous studies that have reported group differences between depressed and nondepressed participants' ratings of positive material have used such stimuli as films or pictures (e.g., Allen, Trinder, & Brennan, 1999; Rottenberg et al., 2002; Sloan, Strauss, Quirk, & Sajatovic, 1997; Sloan, Strauss, & Wisner, 2001), which

² Because there was no significant difference between RTs for targets that were preceded by nonreward primes and for targets that were preceded by novel primes, $t(66) = .07, p = .94$, in the subsequent analyses we ignored nonreward primes and compared RTs only for targets that were preceded by reward versus novel primes.

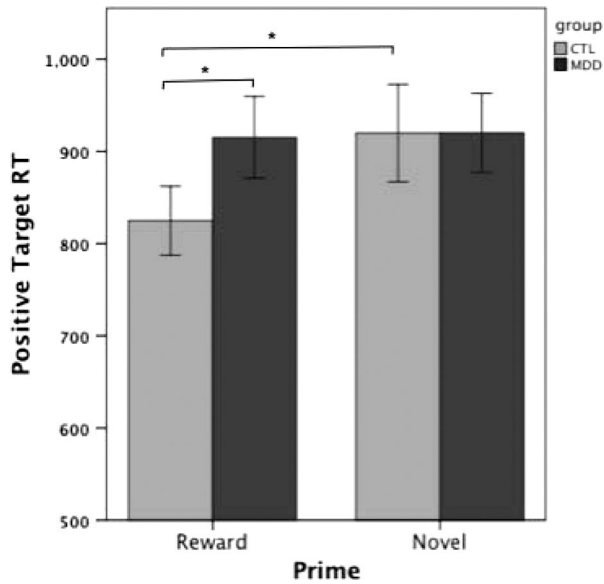


Figure 2. Mean RT in MDD and CTL groups for positive target words in reward prime and novel prime conditions. RT = Reaction Time; MDD = Major Depressive Disorder; CTL = never-disordered controls. * $p < .05$, ** $p < .01$.

may be more readily incorporated into participants' depressive schemas than is humor. For example, an image depicting friends laughing may lead healthy individuals to recall happy times with friends, but may remind depressed persons of how lonely or sad they feel in contrast to the people pictured. Humorous cartoons are likely to be more resistant to self-relevant appraisal and assimilation. More evidence is needed to determine the precise nature and extent of consummatory responding during online experience of reward in depression. In this context, it is worth noting that depressed participants did report higher levels of consummatory anhedonia as measured by the SHPS. The lack of group differences in ratings of reward 'liking,' despite group differences on the SHPS, is intriguing and suggests that current tools for the assessment of anhedonia are not sufficient. One possibility for this difference is that trait-based, self-report measures of pleasure (such as the SHPS) are inherently retrospective (or prospective) in nature, requiring participants to recall or imagine a pleasurable event. Thus, these measures may tap into a temporal dimension of hedonic processing that is more similar to the imagination or memory of a pleasurable event than it is to the actual consummatory experience of the event.

Although depressed and nondepressed participants did not differ in their consummatory 'liking' of reward, we found that 'liking' predicted willingness to work *only* in the nondepressed participants; 'liking' and motivation ('wanting') were dissociated in depressed participants. Distinguishing between the consummatory and anticipatory components of hedonic processing revealed that motivation in the depressed individuals was driven specifically by the anticipatory processing of reward. Together, these results indicate that "anhedonic" decreases in appetitive motivation and reward-seeking behavior could be attributable to a failure of the positive affect system to come online in response to the anticipation of reward rather than in response to its consummation/receipt.

Given that much of reward-seeking behavior occurs outside of the immediate reward context—indeed, humans often must maintain goals over prolonged periods of time and persevere in the face of numerous obstacles—the ability to experience pleasure during the mere anticipation of an eventual reward appears to be crucial in rallying and maintaining the motivation to obtain the reward. It is worth noting that in this study we used only a one-item measure of anticipatory anhedonia; future studies should use scales specifically developed to measure consummatory and anticipatory pleasure, such as the Temporal Experience of Pleasure Scale (Gard, Kring, & John, 2006).

To elicit anticipatory pleasure and approach-motivated behavior, reward cues must first take on positive associations related to the reward stimulus itself. The results of the affective priming task indicated that never-disordered individuals formed positive associations with reward cues, as evidenced by their facilitated responding to positively valenced target words that were preceded by the label for the humorous cartoon deck (e.g., "LUM"). In contrast, depressed participants formed relatively weak positive associations with these reward cues. This "affective tagging" of reward cues may represent a critical process through which such cues are attributed with incentive motivational properties—triggering DA release and enhancing appetitive approach to the goal. The ability of reward-related feelings to infuse otherwise neutral cues may be particularly adaptive and beneficial during long-term or incremental goal pursuit in which motivation must be sustained over extended periods of time, often in the face of uncertain outcomes. It will be important for future research to build on the present findings to determine whether these positive feeling states are instrumental in activating appetitive or goal-directed behavior. Similarly, it remains for future research to elucidate the relative motivational value of *knowing* a reward is likely to follow some action versus viscerally *feeling* the affect during anticipation.

We found that depressed and nondepressed participants did not differ in their level of motivation for reward, as indexed by the amount of effort they were willing to exert to view the cartoons. Support for the hypothesis of decreased motivation in the MDD participants was obtained only among those depressed participants who were characterized by high levels of anticipatory anhedonia. This finding underscores not only the heterogeneity of depressive symptomatology but also the importance of developing a more nuanced parsing and assessment of anhedonia to understand motivation and affective functioning in MDD. Future studies should focus on determining whether anticipatory anhedonia represents a useful subtyping in this disorder. It is also important to note here that, in the present study, the effort task used to measure motivation was designed to be neutral; indeed, participants rated this task as neutral. Further research is necessary to determine whether group differences in reward motivation will emerge with more aversive forms of required effort. Moreover, the present study examined only motivation for reward. Future research should examine potential differences in approach and avoidance motivation; if depressed participants are disproportionately motivated to avoid negative outcomes, such increases in threat-related motivation could override approach-motivated behavior, particularly in situations of conflicting goals or uncertain outcomes. A final, related, point concerns the deterministic nature of the effort-reward task used in the present study. In day-to-day functioning, actions

are rarely deterministic but instead are probabilistically associated with reward. Depressed individuals may be less likely to experience motivational impairment in deterministic settings, but in a probabilistic context may overintegrate negative outcomes and be quick to abandon previously rewarded behaviors. Such a sensitivity to punishment could also reinforce patterns of behavioral inhibition and undermine reward-seeking behavior.

In closing, we should note that the present study is among the first to attempt to dissociate the hedonic and the motivational value of reward and to assess the relative motivational impact of consummatory and anticipatory pleasure in depressed participants. The results of this study suggest that the decreases in reward-seeking behavior observed in depression are not attributable to blunted consummatory pleasure but instead are driven by deficits in anticipatory pleasure that disrupt the natural correlation between 'liking' and 'wanting' seen in healthy individuals. Future research is needed to replicate these findings, as well as to examine the motivational effects of uncertain rewards or aversive outcomes. A more fine-grained comprehension of the motivational and hedonic deficits in depression is important not only for improving our understanding and assessment of this disorder but also for developing more targeted and effective approaches to the treatment of MDD.

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