Motiv Emot (2014) 38:790–801
DOI 10.1007/s11031-014-9437-y

ORIGINAL PAPER

I don't care about others' approval: Dysphoric individuals show reduced effort mobilization for obtaining a social reward

Kerstin Brinkmann · Jessica Franzen · Cyrielle Rossier · Guido H. E. Gendolla

Published online: 27 September 2014

Abstract Past research on reduced reward responsiveness in depression and dysphoria has mainly focused on monetary rewards. However, social rewards are important motivators and might be especially impaired in depression. The present study tested the hypothesis that nondysphoric individuals would mobilize more effort during a memory task without a clear performance standard when anticipating social approval for good performance. In contrast, dysphoric individuals were expected to be less sensitive to this reward and to mobilize less effort. Effort mobilization in this 2 (dysphoric vs. nondysphoric) × 2 (no reward vs. social approval) between-persons study was operationalized by participants' cardiovascular reactivity. Results confirmed that nondysphorics had higher reactivity of systolic blood pressure, diastolic blood pressure, and heart rate when expecting to enter their name in the alleged "best list", whereas dysphorics had lower cardiovascular reactivity. The present study expands evidence for reduced reward responsiveness in depression and dysphoria from an effort mobilization perspective by demonstrating reduced effort-related cardiovascular reactivity to social rewards.

Keywords Depression · Effort mobilization · Cardiovascular reactivity · Social reward · Reward responsiveness

K. Brinkmann (✉) · J. Franzen · C. Rossier · G. H. E. Gendolla
Geneva Motivation Lab, FPSE, Department of Psychology, University of Geneva, 40, Bd. du Pont d'Arve, 1211 Geneva 4, Switzerland
e-mail: kerstin.brinkmann@unige.ch

Introduction

Reduced reward responsiveness in depression and dysphoria

For a long time, reduced reward responsiveness has been considered as one of the fundamental deficits in major depression (Costello 1972; Meehl 1975). To date, evidence for this deficit has accumulated across various measures, for clinical depression as well as for subclinical states of depression (i.e., dysphoria). Studies based on self-report measures show less anticipated and experienced pleasure concerning a variety of activities and hedonic consequences in depression and dysphoria (Chentsova-Dutton and Hanley 2010; MacPhillamy and Lewinsohn 1974). Moreover, depression is associated with weaker approach motivation and fewer approach goals (Bijttebier et al. 2009; Dickson and MacLeod 2006). A number of behavioral studies demonstrate depressed and dysphoric individuals' deficits in reward learning (e.g., Henriques and Davidson 2000; Kunisato et al. 2012; Liu et al. 2011; Pizzagalli et al. 2009b; Vrieze et al. 2013).

Evidence for reduced reward responsiveness also comes from a variety of brain imaging measures. For instance, depression and dysphoria have been linked to a reduced frontal electroencephalogram asymmetry during reward anticipation (Shankman et al. 2013). These findings are complemented by evidence for depressed individuals' blunted feedback-related negativity—a frontally maximal event-related potential associated with reward processing—to monetary gains and losses (e.g., Bress et al. 2012). Finally, numerous studies using functional magnetic resonance imagining point to altered activity in cortical and subcortical components of the neural reward circuit of depressed and dysphoric individuals (e.g., Knutson et al.

2008; Smoski et al. 2009; Steele et al. 2007; see also Zhang et al. 2013).

Taken together, findings from the studies discussed above indicate that reduced reward responsiveness in clinical and subclinical depression is a well-established phenomenon (see Eshel and Roiser 2010, for a review). It concerns not only current states of depression but also recovered patients (McCabe et al. 2009) and populations at risk (Gotlib et al. 2010; Nelson et al. 2013) and has predictive value for the development of depression (Bress et al. 2013). Moreover, reduced reward responsiveness in depression and dysphoria has been observed during both phases of reward processing: the motivational "anticipatory" phase (i.e., "reward wanting") as well as the "consummatory" outcome phase (i.e., "reward liking") (e.g., Forbes et al. 2009; Pizzagalli et al. 2009a). However, some authors argue that reduced reward responsiveness is primarily driven by deficits in anticipatory pleasure (Sherdell et al. 2012, see also Dichter 2010). This raises the important question of whether depressed individuals mobilize the same effort as healthy controls in situations where they must invest effort in order to obtain a desired consequence.

Effort-related cardiovascular reactivity

In the psychological literature, there is no consistent use of the term "effort". It usually refers to the investment of resources for carrying out actions. In our research, we refer to the definition by Gendolla and Wright (2009; see also Gendolla et al. 2012b), which describes effort intensity as the momentary mobilization of resources at a point in time in the process of goal pursuit. According to this definition, effort is mobilized to overcome obstacles that hamper goal attainment. We thus refer to the intensity aspect of motivated behavior, that is, the question how vigorously people pursue an action. An influential elaboration of the process that determines effort mobilization is Brehm's motivational intensity theory (Brehm and Self 1989; Brehm et al. 1983). Even though the main focus of the original formulation was on the prediction of motivational arousal and goal attractiveness, respectively, in dependence on task difficulty, the theory's underlying concept of energy mobilization has subsequently been interpreted in terms of effort intensity and task engagement (see Wright 1996, 2008), enabling the assumption of a direct link between energy investment and effort mobilization (see also Richter 2013).

Motivational intensity theory draws on a resource conservation principle, that is, an organism's propensity to avoid wasting resources. It follows that people adjust their effort to the perceived difficulty of an action or task: the higher the subjective task difficulty, the more effort is invested. This proportional relationship holds as long as success is possible (i.e., the task is feasible for the individual) and justified by the importance of success (i.e., the necessary effort is not higher than the maximally justified effort) and applies to tasks with *fixed* and clear difficulty. In case that task difficulty is fixed but *unclear* (i.e., the individual has no information about the performance standard to attain) or *unfixed* (i.e., there is no performance standard and individuals are asked to do their best), effort mobilization is a direct function of the importance of success: the higher the positive consequences to be obtained or the negative consequences to be avoided, the more effort is invested. In the present study, we refer to a task with *unclear* difficulty, which allows directly testing the impact of a reward on effort mobilization during the motivational anticipatory phase of reward processing.

In his integrative model, Wright (1996) draws on the active coping approach by Obrist (1976, 1981) to propose that effort mobilization can be operationalized by beta-adrenergic sympathetic nervous system impact on the heart. It follows that in active coping (i.e., when the individual can actively influence the outcome of a situation or task) effort mobilization can be operationalized by assessing cardiovascular parameters that are influenced by beta-adrenergic sympathetic activation. The most sensitive noninvasive parameter is pre-ejection period (PEP; in milliseconds), a measure of myocardial contractility. PEP is the time interval from the onset of left ventricular excitation until the opening of the aortic valve. Numerous studies have supported the idea that PEP is a sensitive and reliable measure of effort (see Gendolla 2012; Kelsey 2012). Besides PEP, also systolic blood pressure (SBP; in millimeter mercury)—the maximum arterial pressure following a heartbeat—has been frequently used as a physiological measure of effort (see Gendolla et al. 2012b; Wright and Kirby 2001). This is reasonable because SBP is systematically influenced by myocardial contractility via its impact on cardiac output. Given this systematic link, performance-related SBP responses can be used as indicators of effort mobilization. Diastolic blood pressure (DBP; in millimeter mercury) is the minimum arterial pressure between two heartbeats. It is less influenced by myocardial contractility and thus not considered as a reliable indicator of effort mobilization. Finally, heart rate (HR; in beats per minute) is jointly determined by the sympathetic and parasympathetic nervous systems and may under some circumstances reflect sympathetic activation (see Berntson et al. 1993; Brownley et al. 2000; Levick 2003; Papillo and Shapiro 1990).

Over two decades of research on Wright's integrative model have corroborated that cardiovascular reactivity follows the predictions of motivational intensity theory as described above (see Gendolla et al. 2012a, b; Wright and Kirby 2001). Importantly, several studies have demonstrated that monetary rewards raise the level of success importance and directly lead to increased SBP and PEP reactivity in tasks with unclear difficulty (Richter and Gendolla 2006, 2007, 2009). Moreover, studies on social evaluation have shown that manipulations such as the presence of an observer raise the level of success importance as well, leading to increased SBP reactivity for unfixed difficulty tasks (Wright et al. 1995, 2002) and for fixed and difficult tasks because high success importance justifies the high effort required for difficult tasks (Gendolla and Richter 2006; Wright et al. 1998). However, until now the impact of social evaluation has not been investigated in tasks with unclear difficulty, where success importance should directly determine effort mobilization.

Effort mobilization in depression and dysphoria

Based on these previous studies in the framework of motivational intensity theory (Brehm and Self 1989; Brehm et al. 1983) and on evidence for reduced reward responsiveness in depression described above, several recent studies have tested the central prediction of reduced effort mobilization for obtaining rewards in subclinical individuals with high depression scores (i.e., dysphoric). In these studies, we used tasks with unclear task difficulty that allow to directly manipulate the impact of success importance. We hypothesized that dysphoric individuals would perceive the proposed monetary rewards as less attractive, resulting in a lower subjective success importance and lower cardiovascular reactivity during task performance (Brinkmann et al. 2009, Study 2). Results indeed revealed that nondysphoric participants had higher PEP and SBP reactivity when they could earn 10 Swiss Francs (about 10 USD) for successful task performance compared to a neutral condition without hedonic consequence. In contrast, dysphoric participants showed no increase in cardiovascular reactivity in the reward condition. In a subsequent study, we tested the question of dysphoric individuals' reduced sensitivity to differences in reward value (Brinkmann and Franzen 2013). In support of our predictions, we found attenuated PEP reactivity in dysphoric participants across three levels of reward (0 vs. 5 vs. 15 Swiss Francs for successful task performance). In accord with prior studies (Richter and Gendolla 2009), nondysphoric participants showed increasing PEP reactivity with increasing reward value.

These studies lend support to the hypothesis of dysphorics' reduced effort mobilization for obtaining a reward for successful performance of a cognitive task with unclear task difficulty. Like most of the research on reduced reward responsiveness in depression, those previous studies relied on monetary rewards (for exceptions see McCabe et al. 2009; Pechtel et al. 2013; Sherdell et al. 2012). However, a complete picture of reward responsiveness in depression needs the consideration of other, potentially more meaningful, positive consequences (Forbes 2009; Forbes and Dahl 2012). A domain that is potentially impaired in depression is the social domain. Moreover, previous studies on social evaluation with nondysphoric individuals have tested predictions derived from motivational intensity theory (Brehm and Self 1989; Brehm et al. 1983) for tasks with unfixed or fixed difficulty but evidence for nondysphoric individuals' responsiveness to social rewards in unclear difficulty tasks is lacking. In the present study, we aimed at addressing these claims by testing dysphoric and nondysphoric individuals' effort mobilization during a task with unclear difficulty that is instrumental for obtaining a social reward.

The present study

Based on theory and evidence for reduced reward anticipation responsiveness in clinical and subclinical depression as well as the claim for more relevant types of reward, we aimed at testing the effort mobilized by dysphoric and nondysphoric individuals for obtaining a social reward, that is, social approval for good performance. Effort mobilization was operationalized by participants' cardiovascular reactivity during the memorization period of a recognition memory task. Our central hypothesis states that nondysphoric individuals would have higher cardiovascular reactivity when expecting the opportunity to obtain social approval for good performance. In contrast, we expected dysphoric individuals' cardiovascular reactivity to be less affected by the presence of this social reward but equal the neutral conditions without reward. Moreover, we hypothesized that self-reported success importance would mirror this cardiovascular 3:1 pattern. We also assessed participants' momentary mood at the beginning of the experiment and expected the preselected dysphoric participants to report less positive mood compared to the nondysphoric participants.

In addition to effort mobilization during the central memorization period of the experimental task, we assessed participants' subjective evaluation of the type of recognition during the word recognition period. In brief, depression and dysphoria have been reported to be associated with reduced self-reported *recollection* of episodic details during encoding but not with recognition based on feelings of *familiarity* (Ramponi et al. 2010). To test for group differences in the subjective evaluation of the type of word recognition we chose the "I remember—I know—I guess" procedure (Gardiner 1988, for details see the description of the experimental task below). Consistent with previous studies (Drakeford et al. 2010; Ramponi et al. 2004), we expected that among the correct responses, dysphoric participants would report less recollection (i.e., "I remember" responses) but more feelings of familiarity (i.e., "I know" responses).

Method

Participants and design

This study was run in a 2 (dysphoric vs. nondysphoric) × 2 (no reward vs. social approval) between-persons design. After having obtained approval of the protocol by the appropriate local ethics committee, we recruited participants from an introductory psychology class of 206 university students who had participated in questionnaire sessions. Out of this sample, we randomly selected participants according to their score on the Center for Epidemiologic Studies—Depression Scale (CES-D; Radloff 1977) from the lower quartile (<10; i.e., nondysphoric) or the upper quartile (>18; above the recommended cut-off score of 16; i.e., dysphoric) of the distribution. Two months later, we invited these students via an anonymous code to participate in the present experiment in exchange for course credit. Dysphoric and nondysphoric participants were randomly assigned to one of the two reward conditions. From the 62 participants, data of three participants had to be excluded because they took part in the experimental session without having been selected before. Moreover, data of two participants could not be used for analyses because of missing blood pressure and heart rate data.

The final sample consisted of 57 students (48 women and 9 men with a mean age of 20.81 years, $SD = 3.54$). Twenty-six participants were located in the upper quartile of the CES-D score distribution ($M = 31.38$, $SD = 8.19$) and were referred to as dysphoric. Thirty-one participants were situated in the lower quartile of the CES-D ($M = 6.26$, $SD = 2.35$) and were referred to as nondysphoric. The cell distributions were as follows: Nondysphoric-no reward: 12 women, 3 men; nondysphoric-social approval: 13 women, 3 men; dysphoric-no reward: 12 women, 2 men; dysphoric-social approval: 11 women, 1 man.

Cardiovascular measures

Cardiovascular measures were assessed during habituation and task performance and directly transferred to and stored on a computer drive so that both experimenter and participants were ignorant of these values. SBP and DBP [in millimeters of mercury (mmHg)] and HR [in beats per minute (bpm) were measured noninvasively with a Vasotrac® APM205A monitor (MEDWAVE®, St. Paul, MN] that uses applanation tonometry (for a validation study see Belani et al. 1999). A pressure sensor was placed on the wrist on top of the radial artery of the participant's nondominant arm. The device yields one measure every 12–15 heart beats (i.e., 4–6 measures per minute).[1]

Self-report measures

We used the CES-D, a self-report depression scale for community samples, to measure dysphoria. The French version by Fuhrer and Rouillon (1989) consists of 20 items. Participants had to indicate the frequency of depressive symptom occurrence during the past week on 4-point scales from 0 (*never, very seldom*) to 3 (*frequently, always*). The total score corresponds to the sum of all negative and reverse-scored positive items and varies from 0 to 60. CES-D scores at both measurement points (i.e., at the questionnaire session and after participation in the experiment) were significantly correlated, $r(57) = .73$, $p < .001$, and showed high internal consistency (Cronbach's αs $> .93$).

Participant's momentary mood was assessed with a French version of the positive and negative hedonic tone scales of the UWIST mood adjective checklist (Matthews et al. 1990). Participants had to indicate their momentary feeling state by scoring four positive and four negative adjectives on 7-point scales ranging from 1 (*not at all*) to 7 (*very much*). A mood index was calculated by summing all positive and reverse-scored negative items, so that higher scores indicate a more positive mood (Cronbach's $\alpha = .94$).

In order to assess the impact of our reward manipulation and to ensure that success importance was salient (see Richter 2010), we asked participants to rate five questions about the importance of succeeding in the upcoming task on 7-point scales ranging from 1 (*not at all*) to 7 (*very much*): "How attractive is it for you to show a good performance?"; "How important is it for you to succeed in the task?"; "How valuable is it for you to show a good performance?"; "How satisfied will you be after a successful performance?"; "How interesting is it for you to show a good performance?". The five questions showed good

[1] We also assessed PEP continuously and noninvasively with electrocardiogram and impedance cardiogram signals using a Cardioscreen® 1000 (medis, Ilmenau, Germany) hemodynamic monitoring-system (for a validation study see Scherhag et al. 2005). Four dual gel-pad sensors (medis-ZTECT™) were placed on each side of the base of the participant's neck and on each side of the thorax along the middle axillary line at the level of the xiphoid. Data were sampled at 1,000 Hz. Unfortunately, due to a deficient transmission cable, the signal quality of 33 participants' impedance data was so bad that the data could not be analyzed or were completely missing. We therefore refrained from analyzing and reporting the PEP data of the remaining 24 participants.

internal consistency (Cronbach's $\alpha = .91$) and were summed up to a success importance index.

Experimental task

We chose a recognition memory task consisting of a memorization and a recognition period. The function of the memorization period was to present a cognitive task with unclear task difficulty: During 5 min participants had to memorize all 25 neutral nouns (e.g., toe, flag) that were presented successively in the middle of the screen for a random presentation time of 8–12 s. The nouns had been selected from a database by Bonin et al. (2003) according to the criteria of neutral valence, an average length, and an average subjective frequency in the French language. To keep task difficulty unclear, participants had no information about the duration of the memorization period, the total number of words to be memorized, and the presentation time of each word. During the recognition period participants saw 50 words in random order, the 25 target words and 25 matched distractor words (e.g., cap, bean). For each word, participants had to indicate whether this was a new word ("New word"), whether they remembered contextual details of the previous presentation of the word ("I remember"), whether they knew that the word had been presented before but without remembering specific details ("I know"), or whether they guessed that it had been shown before ("I guess") (see Bruno and Rutherford 2010). The memorization and recognition periods were separated by a 6-min distractor task during which participants had to count the number of blue and red squares, respectively, among a number of squares of different colors appearing on the screen.

Procedure

The study was run in individual sessions, which took about 40 min and were computerized using a personal computer and experimental software (Inquisit 3.0, Millisecond Software, Seattle, WA) for all instructions and stimuli presentation. The experimenter first welcomed the participant, asked her or him to take a seat in front of the computer monitor, to answer some demographic questions, and to sign an informed consent form. Then, the experimenter applied the blood pressure sensor and the gel-pad sensors for electrocardiogram and impedance cardiogram recordings. After that, she left the room and monitored the experiment from an outside control room. Participants read introductory information and answered questions about their momentary mood. Then, participants watched a 8.5-min excerpt of a hedonically neutral documentary film, which served as a habituation period to determine cardiovascular baseline measures.

After the habituation period, participants received instructions for the recognition memory task. All participants learned that at the end of the recognition period, they would get to know their success rate. Participants in the social approval-condition received the supplemental information that there was a public "best list" with the names of previous participants who "had shown a good performance in the task". They were told that "if they showed a good performance", they would have the possibility to enter their name or pseudonym in the list. Importantly, task difficulty was kept unclear as there was no hint what score was required for a "good performance". These reward instructions were followed by a preview of the alleged best list that contained 16 fictitious names as well as the date of the day before.

Following these instructions, all participants answered the five questions evaluating success importance. Then the 5-min memorization period started during which cardiovascular activity was assessed. This was followed by the 6-min distractor task and the recognition period. At the end, the individual performance score appeared on the screen ("You have correctly answered to 46 out of 50 words."). In case the score was 45 or higher (i.e., $\geq$90 % correct responses), participants in both conditions had the opportunity to enter their name or pseudonym in the best list so that independent of whether they expected it or not, 43 participants (75 %) with $\geq$90 % correct responses had this opportunity. Then, the experimenter re-entered the room, removed the blood pressure sensor and the electrodes, and asked the participant to complete the CES-D in an adjacent room, ostensibly for an unrelated questionnaire validation study. Finally, participants were fully debriefed, thanked, and given their course credit.

Data scoring and analysis

Cardiovascular baseline scores were determined by averaging the values obtained during the last 5 min of the habituation period for each measure (Cronbach's αs > .98). Task scores were determined by averaging the values obtained during the 5 min of the memorization period for each measure (Cronbach's αs > .97). We then calculated cardiovascular reactivity scores by subtracting baseline scores from task scores (Cronbach's αs > .86) (Llabre et al. 1991).

For evaluating overall task performance, we calculated the number of hits and false alarms as well as the discrimination and response bias indices on the basis of signal detection theory. Following the recommendations of Snodgrass and Corwin (1988), discrimination was calculated as the difference of corrected hit rate minus corrected false alarm rate. Response bias was calculated as corrected false alarm rate divided by 1 minus discrimination. For

Table 1 Means and standard errors of cardiovascular baseline activity

	M			*SE*		
	SBP	DBP	HR	SBP	DBP	HR
Nondysphoric						
No reward	118.28	66.27	77.27	3.78	2.58	2.63
Social approval	115.03	65.16	71.55	3.77	2.55	2.61
Dysphoric						
No reward	111.55	63.16	79.88	4.85	2.83	2.43
Social approval	110.72	62.60	83.89	3.54	2.45	3.02

SBP and DBP are indicated in millimeters of mercury and HR is indicated in beats per minute

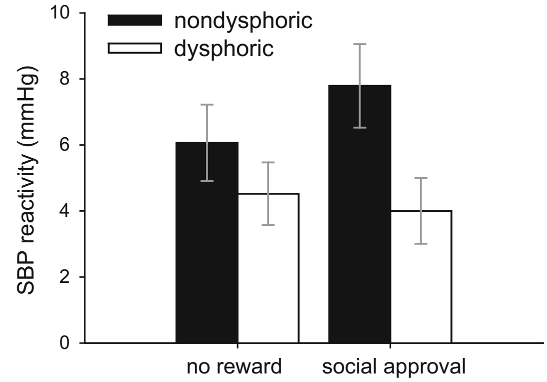

Fig. 1 Means and standard errors of systolic blood pressure reactivity in millimeters of mercury

Table 2 Means and standard errors of cardiovascular reactivity

	M			*SE*		
	SBP	DBP	HR	SBP	DBP	HR
Nondysphoric						
No reward	6.06	3.53	4.00	1.16	0.75	1.41
Social approval	7.79	5.14	6.49	1.27	0.93	0.65
Dysphoric						
No reward	4.52	3.12	2.69	0.95	0.85	1.02
Social approval	4.00	2.85	4.95	1.00	0.66	1.18

SBP and DBP are indicated in millimeters of mercury and HR is indicated in beats per minute

evaluating the type of word recognition, we calculated the proportions of "I remember", "I know", and "I guess" responses by subtracting the false alarm rates from the respective hit rates (e.g., % $\text{hits}_{\text{remember}}$ − % false $\text{alarms}_{\text{remember}}$) (see Jermann et al. 2008; Ramponi et al. 2004).

For all specific hypotheses, we calculated a priori contrasts, modeling the contrast weights according to our predictions (see Rosenthal and Rosnow 1985). Accordingly, contrast weights for cardiovascular reactivity and for self-reported success importance were +3 for nondysphorics in the social approval-cell and −1 for the remaining three cells. These contrast weights allowed us to simultaneously test the expected increase in cardiovascular reactivity and success importance in the nondysphoric-social approval-cell as well as the hypothesized attenuated response across both conditions in the dysphoric group. For the hypothesized dysphoria main effects regarding self-reported momentary mood and type of word recognition, contrast weights were −1 for dysphoric participants in both conditions and +1 for nondysphoric participants in both conditions. We did not have specific hypotheses for cardiovascular baseline and task performance measures and thus conducted 2 (dysphoric vs. nondysphoric) × 2 (no reward vs. social approval) omnibus ANOVAs.

Results

Cardiovascular baseline

Means and standard errors of cardiovascular baseline values appear in Table 1. Results of 2 (dysphoria) × 2 (reward) ANOVAs revealed no significant main or interaction effects on SBP and DBP baseline measures, $Fs < 1.85$, $ps > .18$. For HR there was a significant dysphoria main effect, $F(1, 53) = 7.76$, $p = .01$, $\eta_p^2 = .13$, indicating that dysphoric participants ($M = 81.73$, $SE = 1.92$) had higher HR baseline values than nondysphoric participants ($M = 74.32$, $SE = 1.90$). No other main or interaction effects were significant, $Fs < 3.29$, $ps > .07$.[2]

Cardiovascular reactivity

Systolic blood pressure

The a priori contrast specified above proved to be reliable for SBP reactivity, $F(1, 53) = 5.43$, $p = .02$, $\eta_p^2 = .09$. The residual was not significant ($F < 1$), indicating that no significant variance remained that was not captured by the contrast. As can be seen in Fig. 1, SBP reactivity of nondysphoric participants was higher in the social approval-condition than in the no reward-condition. In contrast, dysphoric participants' SBP reactivity was rather low regardless of condition (see also Table 2). This

[2] Given the quasi-experimental design of this study with the non-randomized group factor, we analyzed HR reactivity without controlling for these HR baseline differences (Jamieson 2004).

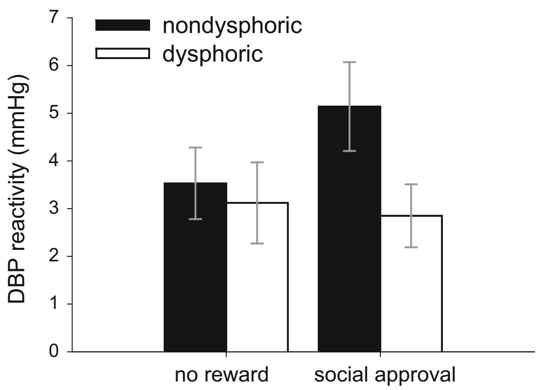

Fig. 2 Means and standard errors of diastolic blood pressure reactivity in millimeters of mercury

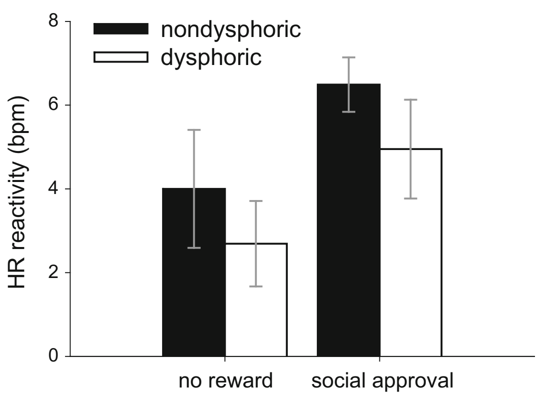

Fig. 3 Means and standard errors of heart rate reactivity in beats per minute

corroborates our main hypothesis that nondysphoric participants would show increasing SBP reactivity when given the opportunity to obtain social approval, whereas dysphoric participants' reactivity would be low independent of the absence or presence of a social reward.

Diastolic blood pressure

The pattern of DBP reactivity mirrored that of SBP reactivity. The a priori contrast was significant, $F(1, 53) = 4.59$, $p = .04$, $\eta_p^2 = .08$, and captured all significant variance (residual $F < 1$). As depicted in Fig. 2, nondysphoric participants in the social approval-condition had higher DBP reactivity than participants in the other three cells (see also Table 2). This result further strengthens our main hypothesis about reduced cardiovascular reactivity to social rewards in dysphoria.

Heart rate

Finally, results revealed a significant a priori contrast for HR as well, $F(1, 53) = 4.68$, $p = .04$, $\eta_p^2 = .08$, that captured all significant variance (residual $F = 1.10$, $p = .34$). As shown in Fig. 3, HR reactivity was highest in the nondysphoric-social approval-cell, whereas it was less pronounced for dysphoric participants, lending further support to our main hypothesis (see also Table 2).

Self-report measures

Success importance

Results of the a priori contrast on the success importance ratings did not reveal the expected 3:1 pattern, $F(1, 53) < 1$, $p = .96$ (residual $F = 3.99$, $p = .02$). When inspecting the descriptive values, it was rather dysphoric participants in the no reward-condition ($M = 25.79$, $SE = 1.20$) who indicated high success importance compared to the other three cells (dysphoric-social approval $M = 19.50$, $SE = 1.83$; nondysphoric-no reward $M = 22.07$, $SE = 1.63$; and nondysphoric-social approval $M = 22.37$, $SE = 1.41$). Our hypothesis of higher success importance ratings in the nondysphoric-social approval-cell was thus not corroborated.

UWIST mood adjective check list

The a priori contrast for self-reported momentary mood state proved to be reliable, $F(1, 53) = 16.58$, $p < .001$, $\eta_p^2 = .24$. As expected, nondysphoric participants ($M = 44.10$, $SE = 1.62$) were in a more positive mood than dysphoric participants ($M = 33.96$, $SE = 1.82$) at the beginning of the experiment.

Task performance measures

Overall performance

The results of 2 (dysphoria) × 2 (reward) ANOVAs on the number of hits and false alarms as well as on the discrimination and response bias indices revealed no significant main or interaction effects, Fs < 1.04, ps $> .31$. Overall means and standard errors were as follows: Hits $M = 23.60$, $SE = 0.21$; false alarms $M = 2.32$, $SE = 0.39$; discrimination $M = 0.82$, $SE = 0.02$; and response bias $M = 0.53$, $SE = 0.03$. In order to test for the associations between cardiovascular reactivity and performance outcome, we calculated the correlations between SBP, DBP, and HR reactivity with the four task performance measures, using a Bonferroni-corrected significance level of $p < .01$ to account for multiple correlations. Results revealed that SBP and DBP reactivity significantly correlated with number of hits, $r(57) = .40$, $p < .01$ and $r(57) = .37$, $p < .01$, respectively, showing higher cardiovascular reactivity to be accompanied by better task performance outcomes.

Type of word recognition

Results revealed the expected differences in the subjective evaluation of the type of word recognition. Nondysphoric participants ($M = 0.77$, $SE = 0.03$) reported higher rates of “I remember” responses than dysphoric participants ($M = 0.60$, $SE = 0.04$), $F(1, 53) = 8.76$, $p < .01$, $\eta_p^2 = .14$. In contrast, dysphoric participants ($M = 0.26$, $SE = 0.04$) reported higher rates of “I know” responses compared to nondysphoric participants ($M = 0.10$, $SE = 0.03$), $F(1, 53) = 12.72$, $p < .001$, $\eta_p^2 = .19$. There were no significant differences in “I guess” responses (dysphoric $M = -0.01$, $SE = 0.01$; nondysphoric $M = -0.02$, $SE = 0.02$), $F(1, 53) < 1$, $p = .85$.

Discussion

The present study aimed at testing nondysphoric individuals’ effort mobilization for social rewards during a task with unclear difficulty and at expanding previous evidence for dysphoric individuals’ reduced effort mobilization during the motivational anticipatory phase of reward processing. In contrast to prior studies that relied on monetary rewards (Brinkmann and Franzen 2013; Brinkmann et al. 2009), participants in the present study were promised a social reward, that is, social approval for good performance (see also Forbes 2009; Forbes and Dahl 2012). We expected that dysphoric individuals’ reduced reward responsiveness would generalize to social rewards. The results of cardiovascular reactivity during the memorization period confirmed the predictions: nondysphoric participants had higher reactivity of SBP, DBP, and HR when expecting to enter their name in the best list. In contrast, dysphoric participants’ cardiovascular reactivity was less affected by the presence or absence of this social reward and resembled the reactivity of nondysphoric participants in the no reward-condition.

Based on motivational intensity theory (Brehm and Self 1989; Brehm et al. 1983) and the integrative model by Wright (1996), the pattern of SBP reactivity leads us to conclude that nondysphoric individuals mobilized more effort when anticipating to obtain social approval, whereas dysphoric individuals did not adjust effort mobilization according to the hedonic consequences. As stated in the beginning, DBP and HR are less systematically influenced by beta-adrenergic sympathetic activation of the heart. Past research in the framework of Wright’s model has revealed mixed evidence, with some studies showing DBP or HR effects (e.g., Brinkmann and Franzen 2013; Brinkmann et al. 2009; Gendolla and Richter 2006; Wright et al. 2002) and others not (see Gendolla et al. 2012b; Wright and Kirby 2001, for reviews). The present study thus adds to the former cases, where DBP and HR reactivity mirror the pattern of SBP or PEP reactivity.

We expected the reward manipulation to increase nondysphoric individuals’ success importance, whereas it should have less effect on dysphoric individuals. Assessing success importance by means of five self-report questions, results did not corroborate the hypothesized 3:1 pattern. In a study with healthy participants, Richter and Gendolla (2009) demonstrated that self-reported success importance increased with monetary reward and mediated the relationship between reward value and cardiovascular reactivity. In contrast, previous studies with dysphoric individuals (e.g., Brinkmann and Franzen 2013) did not show that pattern. There are several possible reasons for the absence of effects on self-reported success importance: First, self-reports are generally problematic as they are susceptible to self-presentation biases (Pyszczynski and Greenberg 1983; Rhodewalt and Fairfield 1991). It is thus conceivable that participants were reluctant to reveal their success importance. This might be particularly pronounced in dysphoric individuals. Second, the five questions did not stem from an established questionnaire but were self-generated. It is possible that our formulations did not accurately capture participants’ perceived success importance. Finally, it might be more difficult to evaluate success importance on the basis of a social reward manipulation compared to a monetary reward manipulation. However, the absence of a significant verbal manipulation check does not challenge the validity of our clear cardiovascular findings (see Sigall and Mills 1998).

As the relationship between effort mobilization and performance outcome is complex (see Locke and Latham 1990), we did not have specific hypotheses concerning overall task performance. Indeed, results did not reveal any significant differences between the four cells. Concerning the type of word recognition, results confirmed that dysphoric individuals reported lower percentages of “I remember” correct responses but higher percentages of “I know” correct responses. These findings add to the literature (e.g., Drakeford et al. 2010; Ramponi et al. 2010) by demonstrating that dysphoria is not related to a general word recognition deficit but rather to reduced recollection based on episodic details during encoding as compared to recognition based on feelings of familiarity. Taken together, the overall performance results and the specific evaluation of type of recognition memory suggest that our recognition memory task did not evoke general memorization impairments in depression that could have called for compensatory effort mobilization during the memorization period (Hockey 1997, see also Eysenck et al. 2007).

Instead, differences emerged only during the following subjective recognition period. The moderate positive correlations between cardiovascular reactivity and overall performance outcomes are comparable with previous studies (e.g., Gendolla and Krüsken 2002) and indicate that higher effort mobilization is accompanied by better performance, even though other variables like ability or strategy presumably play a role in determining performance outcomes as well (see Locke and Latham 1990).

Reduced reward responsiveness is one of the central problems in depression and dysphoria and has been confirmed using a variety of measures (see Eshel and Roiser 2010). Recent studies from our laboratory have expanded the extant evidence by documenting reduced effort mobilization during the anticipatory motivational phase of reward processing (Brinkmann and Franzen 2013; Brinkmann et al. 2009). The present study shows that this holds not only for monetary rewards but also for nonmonetary ones. It is important to note that reduced reward responsiveness in depression and dysphoria does not necessarily imply complete insensitivity to all types and levels of positive consequences. Rather, an underestimation of rewards or an overestimation of the associated costs might lead to this attenuated response or to a higher response threshold (see also Treadway and Zald 2011). Future research should systematically test this possibility by comparing varying levels of incentives, including extremely high ones.

Another important avenue for future research remains the further disentangling of anhedonia into the anticipatory and consummatory phases of reward processing (see Treadway and Zald 2011) and their mutual influences on each other. For instance, Sherdell et al. (2012) suggest that reduced reward responsiveness in depression is primarily driven by impaired anticipatory pleasure and that reward wanting and reward liking are dissociated in depression. However, the authors could not corroborate depressed individuals' reduced effort expenditure to see humorous compared to nonhumorous cartoons. Operationalizing effort mobilization not as an explicit choice of how much effort to mobilize but as the rather difficult-to-perceive cardiovascular reactivity during task performance, we could demonstrate dysphoric individuals' reduced effort mobilization to obtain social approval. Similar to functional neuroimaging studies (e.g., Forbes et al. 2009; Knutson et al. 2008), future research should thus measure not only anticipatory effort mobilization but also reward liking before the task and consummatory pleasure when the reward is delivered.

From a clinical perspective, it is important to disentangle anticipatory pleasure from experienced pleasure, to determine potential individual thresholds of reward responsiveness, and to individually tailor therapeutic interventions to the specific impairments. For instance, promising treatments for the motivational symptoms of anticipatory anhedonia are behavioral activation psychotherapy and dopamine-active pharmacotherapies (Treadway and Zald 2011). Specifically, behavioral activation techniques encourage depressed individuals to reengage in pleasant activities, which will increase reinforcement obtained from the environment and elicit the experience of pleasure. In this way, behavioral activation is a promising approach to increase reward sensitivity (Dimidjian et al. 2008).

To conclude, the present study confirms the direct impact of a social reward on nondysphoric individuals' effort mobilization during a task with unclear difficulty. Moreover, our findings expand previous evidence for reduced reward responsiveness in clinical and subclinical depression that primarily relied on self-report, behavioral, and neurobiological data. From a motivational perspective of effort mobilization, we could show that dysphoric individuals have reduced reactivity of SBP, DBP, and HR when working on a cognitive task and anticipating social approval for good performance. Attenuated effort-related cardiovascular reactivity in dysphoria thus holds not only for monetary but also for nonmonetary rewards during the anticipatory motivational phase of reward processing. Even though the present sample was an analogue subclinical sample, the high retest correlations of the depression scale as well as the pronounced differences in momentary mood strengthen the view of our dysphoric participants as an analogue sample with vulnerability for depression and suggest that our findings hold for clinical samples as well.

Acknowledgments Kerstin Brinkmann, Jessica Franzen, Cyrielle Rossier, Guido H. E. Gendolla, Geneva Motivation Lab, University of Geneva, Switzerland. This research was supported by a research grant from the Swiss National Science Foundation (SNF 100014-134557) awarded to the first author. Parts of the present research were presented at the 52nd Annual Meeting of the Society for Psychophysiological Research, New Orleans, LA, September 19–23, 2012, at the 25th Annual Convention of the Association for Psychological Science, Washington, DC, May 23–26, 2013, and at the 6th Annual Meeting of the Society for the Study of Motivation, Washington, DC, May 23, 2013.

References

Belani, K., Ozaki, M., Hynson, J., Hartmann, T., Reyford, H., Martino, J.-M., et al. (1999). A new noninvasive method to measure blood pressure. *Anesthesiology, 91*, 686–692. doi:10.1097/00000542-199909000-00021.

Berntson, G. G., Cacioppo, J. T., & Quigley, K. S. (1993). Cardiac psychophysiology and autonomic space in humans: Empirical perspectives and conceptual implications. *Psychological Bulletin, 114*, 296–322. doi:10.1037/0033-2909.114.2.296.

Bijttebier, P., Beck, I., Claes, L., & Vandereycken, W. (2009). Gray's reinforcement sensitivity theory as a framework for research on

personality–psychopathology associations. *Clinical Psychology Review, 29*, 421–430. doi:10.1016/j.cpr.2009.04.002.
Bonin, P., Méot, A., Aubert, L., Malardier, N., Niedenthal, P. M., & Capelle-Toczek, M.-C. (2003). Normes de concrétude, de valeur d'imagerie, de fréquence subjective et de valence émotionnelle pour 866 mots. *L'Année Psychologique, 103*, 655–694. doi:10.3406/psy.2003.29658.
Brehm, J. W., & Self, E. A. (1989). The intensity of motivation. *Annual Review of Psychology, 40*, 109–131. doi:10.1146/annurev.ps.40.020189.000545.
Brehm, J. W., Wright, R. A., Solomon, S., Silka, L., & Greenberg, J. (1983). Perceived difficulty, energization, and the magnitude of goal valence. *Journal of Experimental Social Psychology, 19*, 21–48. doi:10.1016/0022-1031(83)90003-3.
Bress, J. N., Foti, D., Kotov, R., Klein, D. N., & Hajcak, G. (2013). Blunted neural response to rewards prospectively predicts depression in adolescent girls. *Psychophysiology, 50*, 74–81. doi:10.1111/j.1469-8986.2012.01485.x.
Bress, J. N., Smith, E., Foti, D., Klein, D. N., & Hajcak, G. (2012). Neural response to reward and depressive symptoms in late childhood to early adolescence. *Biological Psychology, 89*, 156–162. doi:10.1016/j.biopsycho.2011.10.004.
Brinkmann, K., & Franzen, J. (2013). Not everyone's heart contracts to reward: Insensitivity to varying levels of reward in dysphoria. *Biological Psychology, 94*, 263–271. doi:10.1016/j.biopsycho.2013.07.003.
Brinkmann, K., Schüpbach, L., Ancel Joye, I., & 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. doi:10.1016/j.ijpsycho.2009.09.009.
Brownley, K. A., Hurwitz, B. E., & Schneiderman, N. (2000). Cardiovascular psychophysiology. In J. T. Cacioppo, L. G. Tassinary, & G. G. Berntson (Eds.), *Handbook of psychophysiology* (pp. 224–264). New York, NY: Cambridge University Press.
Bruno, D., & Rutherford, A. (2010). How many response options? A study of remember–know testing procedures. *Acta Psychologica, 134*, 125–129. doi:10.1016/j.actpsy.2010.01.002.
Chentsova-Dutton, Y., & Hanley, K. (2010). The effects of anhedonia and depression on hedonic responses. *Psychiatry Research, 179*, 176–180. doi:10.1016/j.psychres.2009.06.013.
Costello, C. G. (1972). Depression: Loss of reinforcers or loss of reinforcer effectiveness? *Behavior Therapy, 3*, 240–247. doi:10.1016/S0005-7894(72)80084-4.
Dichter, G. S. (2010). Anhedonia in unipolar major depressive disorder: A review. *The Open Psychiatry Journal, 4*, 1–9. doi:10.2174/1874354401004010001.
Dickson, J. M., & MacLeod, A. K. (2006). Dysphoric adolescents' causal explanations and expectancies for approach and avoidance goals. *Journal of Adolescence, 29*, 177–191. doi:10.1016/j.adolescence.2005.03.007.
Dimidjian, S., Martell, C. R., Addis, M. E., & Herman-Dunn, R. (2008). Behavioral activation for depression. In D. H. Barlow (Ed.), *Clinical handbook of psychological disorders: A step-by-step treatment manual* (4th ed., pp. 328–364). New York, NY: Guilford Press.
Drakeford, J. L., Edelstyn, N. M. J., Oyebode, F., Srivastava, S., Calthorpe, W. R., & Mukherjee, T. (2010). Recollection deficiencies in patients with major depressive disorder. *Psychiatry Research, 175*, 205–210. doi:10.1016/j.psychres.2008.08.010.
Eshel, N., & Roiser, J. P. (2010). Reward and punishment processing in depression. *Biological Psychiatry, 68*, 118–124. doi:10.1016/j.biopsych.2010.01.027.
Eysenck, M. W., Derakshan, N., Santos, R., & Calvo, M. G. (2007). Anxiety and cognitive performance: Attentional control theory. *Emotion, 7*, 336–353. doi:10.1037/1528-3542.7.2.336.
Forbes, E. E. (2009). Where's the fun in that? Broadening the focus on reward function in depression. *Biological Psychiatry, 66*, 199–200. doi:10.1016/j.biopsych.2009.05.001.
Forbes, E. E., & Dahl, R. E. (2012). Research review: Altered reward function in adolescent depression: What, when and how? *Journal of Child Psychology and Psychiatry, 53*, 3–15. doi:10.1111/j.1469-7610.2011.02477.x.
Forbes, E. E., Hariri, A. R., Martin, S. L., Silk, J. S., Moyles, D. L., Fisher, P. M., et al. (2009). Altered striatal activation predicting real-world positive affect in adolescent major depressive disorder. *American Journal of Psychiatry, 166*, 64–73. doi:10.1176/appi.ajp.2008.07081336.
Fuhrer, R., & Rouillon, F. (1989). La version française de l'échelle CES-D (Center for epidemiologic studies—depression scale): Description et traduction de l'échelle d'autoévaluation. *European Psychiatry, 4*(3), 163–166.
Gardiner, J. M. (1988). Functional aspects of recollective experience. *Memory & Cognition, 16*, 309–313. doi:10.3758/bf03197041.
Gendolla, G. H. E. (2012). Implicit affect primes effort: Theory and research on cardiovascular response. *International Journal of Psychophysiology, 86*, 123–135. doi:10.1016/j.ijpsycho.2012.05.003.
Gendolla, G. H. E., Brinkmann, K., & Silvestrini, N. (2012a). Gloomy and lazy? On the impact of mood and depressive symptoms on effort-related cardiovascular response. In R. A. Wright & G. H. E. Gendolla (Eds.), *How motivation affects cardiovascular response: Mechanisms and applications* (pp. 139–155). Washington, DC: American Psychological Association.
Gendolla, G. H. E., & Krüsken, J. (2002). The joint effect of informational mood impact and performance-contingent consequences on effort-related cardiovascular response. *Journal of Personality and Social Psychology, 83*, 271–283. doi:10.1037/0022-3514.83.2.271.
Gendolla, G. H. E., & Richter, M. (2006). Cardiovascular reactivity during performance under social observation: The moderating role of task difficulty. *International Journal of Psychophysiology, 62*, 185–192. doi:10.1016/j.ijpsycho.2006.04.002.
Gendolla, G. H. E., & Wright, R. A. (2009). Effort. In D. Sander & K. R. Scherer (Eds.), *Oxford companion to the affective sciences* (pp. 134–135). New York, NY: Oxford University Press.
Gendolla, G. H. E., Wright, R. A., & Richter, M. (2012b). Effort intensity: Some insights from the cardiovascular system. In R. M. Ryan (Ed.), *The Oxford handbook of human motivation* (pp. 420–438). New York, NY: Oxford University Press.
Gotlib, I. H., Hamilton, J. P., Cooney, R. E., Singh, M. K., Henry, M. L., & Joormann, J. (2010). Neural processing of reward and loss in girls at risk for major depression. *Archives of General Psychiatry, 67*, 380–387. doi:10.1001/archgenpsychiatry.2010.13.
Henriques, J. B., & Davidson, R. J. (2000). Decreased responsiveness to reward in depression. *Cognition and Emotion, 14*, 711–724. doi:10.1080/02699930050117684.
Hockey, G. R. (1997). Compensatory control in the regulation of human performance under stress and high workload: A cognitive-energetical framework. *Biological Psychology, 45*, 73–93. doi:10.1016/S0301-0511(96)05223-4.
Jamieson, J. (2004). Analysis of covariance (ANCOVA) with difference scores. *International Journal of Psychophysiology, 52*, 277–283. doi:10.1016/j.ijpsycho.2003.12.009.
Jermann, F., Van der Linden, M., & D'Argembeau, A. (2008). Identity recognition and happy and sad facial expression recall: Influence of depressive symptoms. *Memory, 16*, 364–373. doi:10.1080/09658210801935413.
Kelsey, R. M. (2012). Beta-adrenergic cardiovascular reactivity and adaptation to stress: The cardiac pre-ejection period as an index of effort. In R. A. Wright & G. H. E. Gendolla (Eds.), *How motivation affects cardiovascular response: Mechanisms and applications* (pp. 43–60). Washington, DC: APA.

Knutson, B., Bhanji, J. P., Cooney, R. E., Atlas, L. Y., & Gotlib, I. H. (2008). Neural responses to monetary incentives in major depression. *Biological Psychiatry, 63*, 686–692. doi:10.1016/j.biopsych.2007.07.023.

Kunisato, Y., Okamoto, Y., Ueda, K., Onoda, K., Okada, G., Yoshimura, S., et al. (2012). Effects of depression on reward-based decision making and variability of action in probabilistic learning. *Journal of Behavior Therapy and Experimental Psychiatry, 43*, 1088–1094. doi:10.1016/j.jbtep.2012.05.007.

Levick, J. R. (2003). *An introduction to cardiovascular physiology* (4th ed.). London, UK: Arnold.

Liu, W.-H., Chan, R. C. K., Wang, L.-Z., Huang, J., Cheung, E. F. C., Gong, Q.-Y., et al. (2011). Deficits in sustaining reward responses in subsyndromal and syndromal major depression. *Progress in Neuro-Psychopharmacology and Biological Psychiatry, 35*, 1045–1052. doi:10.1016/j.pnpbp.2011.02.018.

Llabre, M. M., Spitzer, S. B., Saab, P. G., Ironson, G. H., & Schneiderman, N. (1991). The reliability and specificity of delta versus residualized change as measure of cardiovascular reactivity to behavioral challenges. *Psychophysiology, 28*, 701–711. doi:10.1111/j.1469-8986.1991.tb01017.x.

Locke, E. A., & Latham, G. P. (1990). *A theory of goal setting & task performance*. Upper Saddle River, NJ: Prentice Hall.

MacPhillamy, D. J., & Lewinsohn, P. M. (1974). Depression as a function of levels of desired and obtained pleasure. *Journal of Abnormal Psychology, 83*, 651–657. doi:10.1037/h0037467.

Matthews, G., Jones, D. M., & Chamberlain, A. G. (1990). Refining the measurement of mood: The UWIST mood adjective checklist. *British Journal of Psychology, 81*, 17–42. doi:10.1111/j.2044-8295.1990.tb02343.x.

McCabe, C., Cowen, P. J., & Harmer, C. J. (2009). Neural representation of reward in recovered depressed patients. *Psychopharmacology (Berl), 205*, 667–677. doi:10.1007/s00213-009-1573-9.

Meehl, P. E. (1975). Hedonic capacity: Some conjectures. *Bulletin of the Menninger Clinic, 39*, 295–307.

Nelson, B. D., McGowan, S. K., Sarapas, C., Robison-Andrew, E. J., Altman, S. E., Campbell, M. L., et al. (2013). Biomarkers of threat and reward sensitivity demonstrate unique associations with risk for psychopathology. *Journal of Abnormal Psychology, 122*, 662–671. doi:10.1037/a0033982.

Obrist, P. A. (1976). The cardiovascular-behavioral interaction as it appears today. *Psychophysiology, 13*, 95–107. doi:10.1111/j.1469-8986.1976.tb00081.x.

Obrist, P. A. (1981). *Cardiovascular psychophysiology: A perspective*. New York, NY: Plenum Press.

Papillo, J. F., & Shapiro, D. (1990). The cardiovascular system. In L. G. Tassinary & J. T. Cacioppo (Eds.), *Principles of psychophysiology: Physical, social, and inferential elements* (pp. 456–512). New York, NY: Cambridge University Press.

Pechtel, P., Dutra, S. J., Goetz, E. L., & Pizzagalli, D. A. (2013). Blunted reward responsiveness in remitted depression. *Journal of Psychiatric Research, 47*, 1864–1869. doi:10.1016/j.jpsychires.2013.08.011.

Pizzagalli, D. A., Holmes, A. J., Dillon, D. G., Goetz, E. L., Birk, J. L., Bogdan, R., et al. (2009a). Reduced caudate and nucleus accumbens response to rewards in unmedicated individuals with major depressive disorder. *The American Journal of Psychiatry, 166*, 702–710. doi:10.1176/appi.ajp.2008.08081201.

Pizzagalli, D. A., Iosifescu, D., Hallett, L. A., Ratner, K. G., & Fava, M. (2009b). Reduced hedonic capacity in major depressive disorder: Evidence from a probabilistic reward task. *Journal of Psychiatric Research, 43*, 76–87. doi:10.1016/j.jpsychires.2008.03.001.

Pyszczynski, T., & Greenberg, J. (1983). Determinants of reduction in intended effort as a strategy for coping with anticipated failure. *Journal of Research in Personality, 17*, 412–422. doi:10.1016/0092-6566(83)90069-7.

Radloff, L. S. (1977). The CES-D scale: A self report depression scale for research in the general population. *Applied Psychological Measurement, 1*, 385–401. doi:10.1177/014662167700100306.

Ramponi, C., Barnard, P. J., & Nimmo-Smith, I. (2004). Recollection deficits in dysphoric mood: An effect of schematic models and executive mode? *Memory, 12*, 655–670. doi:10.1080/09658210344000189.

Ramponi, C., Murphy, F. C., Calder, A. J., & Barnard, P. J. (2010). Recognition memory for pictorial material in subclinical depression. *Acta Psychologica, 135*, 293–301. doi:10.1016/j.actpsy.2010.07.015.

Rhodewalt, F., & Fairfield, M. (1991). Claimed self-handicaps and the self-handicapper: The relation of reduction in intended effort to performance. *Journal of Research in Personality, 25*, 402–417. doi:10.1016/0092-6566(91)90030-T.

Richter, M. (2010). Pay attention to your manipulation checks! Reward impact on cardiac reactivity is moderated by task context. *Biological Psychology, 84*, 279–289. doi:10.1016/j.biopsycho.2010.02.014.

Richter, M. (2013). A closer look into the multi-layer structure of motivational intensity theory. *Social and Personality Psychology Compass, 7*, 1–12. doi:10.1111/spc3.12007.

Richter, M., & Gendolla, G. H. E. (2006). Incentive effects on cardiovascular reactivity in active coping with unclear task difficulty. *International Journal of Psychophysiology, 61*, 216–225. doi:10.1016/j.ijpsycho.2005.10.003.

Richter, M., & Gendolla, G. H. E. (2007). Incentive value, unclear task difficulty, and cardiovascular reactivity in active coping. *International Journal of Psychophysiology, 63*, 294–301. doi:10.1016/j.ijpsycho.2006.12.002.

Richter, M., & Gendolla, G. H. E. (2009). The heart contracts to reward: Monetary incentives and pre-ejection period. *Psychophysiology, 46*, 451–457. doi:10.1111/j.1469-8986.2009.00795.x.

Rosenthal, R., & Rosnow, R. L. (1985). *Contrast analysis: Focused comparisons in the analysis of variance*. Cambridge: Cambridge University Press.

Scherhag, A., Kaden, J. J., Kentschke, E., Sueselbeck, T., & Borggrefe, M. (2005). Comparison of impedance cardiography and thermodilution-derived measurements of stroke volume and cardiac output at rest and during exercise testing. *Cardiovascular Drugs and Therapy, 19*, 141–147.

Shankman, S. A., Nelson, B. D., Sarapas, C., Robison-Andrew, E. J., Campbell, M. L., Altman, S. E., et al. (2013). A psychophysiological investigation of threat and reward sensitivity in individuals with panic disorder and/or major depressive disorder. *Journal of Abnormal Psychology, 122*, 322–338. doi:10.1037/a0030747.

Sherdell, L., Waugh, C. E., & Gotlib, I. H. (2012). Anticipatory pleasure predicts motivation for reward in major depression. *Journal of Abnormal Psychology, 121*, 51–60. doi:10.1037/a0024945.

Sigall, H., & Mills, J. (1998). Measures of independent variables and mediators are useful in social psychology experiments: But are they necessary? *Personality and Social Psychology Review, 2*, 218–226. doi:10.1207/s15327957pspr0203_5.

Smoski, M. J., Felder, J. N., Bizzell, J., Green, S. R., Ernst, M., Lynch, T. R., et al. (2009). fMRI of alterations in reward selection, anticipation, and feedback in major depressive disorder. *Journal of Affective Disorders, 118*, 69–78. doi:10.1016/j.jad.2009.01.034.

Snodgrass, J. G., & Corwin, J. (1988). Pragmatics of measuring recognition memory: Applications to dementia and amnesia. *Journal of Experimental Psychology: General, 117*, 34–50. doi:10.1037/0096-3445.117.1.34.

Steele, J. D., Kumar, P., & Ebmeier, K. P. (2007). Blunted response to feedback information in depressive illness. *Brain, 130*, 2367–2374. doi:10.1093/brain/awm150.

Treadway, M. T., & Zald, D. H. (2011). Reconsidering anhedonia in depression: Lessons from translational neuroscience. *Neuroscience and Biobehavioral Reviews, 35*, 537–555. doi:10.1016/j.neubiorev.2010.06.006.

Vrieze, E., Pizzagalli, D. A., Demyttenaere, K., Hompes, T., Sienaert, P., de Boer, P., et al. (2013). Reduced reward learning predicts outcome in major depressive disorder. *Biological Psychiatry, 73*, 639–645. doi:10.1016/j.biopsych.2012.10.014.

Wright, R. A. (1996). Brehm's theory of motivation as a model of effort and cardiovascular response. In P. M. Gollwitzer & J. A. Bargh (Eds.), *The psychology of action: Linking cognition and motivation to behavior* (pp. 424–453). New York, NY: Guilford Press.

Wright, R. A. (2008). Refining the prediction of effort: Brehm's distinction between potential motivation and motivational intensity. *Social and Personality Psychology Compass, 2*, 682–701. doi:10.1111/j.1751-9004.2008.00093.x.

Wright, R. A., Dill, J. C., Geen, R. G., & Anderson, C. A. (1998). Social evaluation influence on cardiovascular response to a fixed behavioral challenge: Effects across a range of difficulty levels. *Annals of Behavioral Medicine, 20*, 277–285. doi:10.1007/bf02886377.

Wright, R. A., Killebrew, K., & Pimpalapure, D. (2002). Cardiovascular incentive effects where a challenge is unfixed: Demonstrations involving social evaluation, evaluator status, and monetary reward. *Psychophysiology, 39*, 188–197. doi:10.1017/S0048577202011137.

Wright, R. A., & Kirby, L. D. (2001). Effort determination of cardiovascular response: An integrative analysis with applications in social psychology. In M. P. Zanna (Ed.), *Advances in experimental social psychology* (Vol. 33, pp. 255–307). New York, NY: Academic Press.

Wright, R. A., Tunstall, A. M., Williams, B. J., Goodwin, J. S., & Harmon-Jones, E. (1995). Social evaluation and cardiovascular response: An active coping approach. *Journal of Personality and Social Psychology, 69*, 530–543. doi:10.1037/0022-3514.69.3.530.

Zhang, W.-N., Chang, S.-H., Guo, L.-Y., Zhang, K.-L., & Wang, J. (2013). The neural correlates of reward-related processing in major depressive disorder: A meta-analysis of functional magnetic resonance imaging studies. *Journal of Affective Disorders*. doi:10.1016/j.jad.2013.06.039.