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Blunted cardiovascular reactivity in dysphoria during reward and punishment anticipation

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ABSTRACT

Hyposensitivity to reward in depression and dysphoria has been found in behavioral and neuroimaging studies. For punishment responsiveness, some studies showed hyposensitivity to punishment while other studies demonstrated hypersensitivity. Only few studies have addressed the motivational question as to whether depressed individuals mobilize less effort in anticipation of a positive or a negative consequence.

The present study aimed at investigating reward and punishment responsiveness in subclinical depression from an effort mobilization perspective. Working on a recognition memory task, one third of the participants could earn small amounts of money, one third could lose small amounts of money, and one third could neither earn nor lose money. Effort mobilization was operationalized as participants' cardiovascular reactivity during task performance. As expected, reactivity of cardiac pre-ejection period and heart rate was higher in both incentive conditions compared to the neutral condition for nondysphorics, while it was blunted across conditions for dysphorics. Moreover, the present study found that dysphorics show an altered behavioral response to punishment. These findings thus show that dysphorics present a reduced motivation to obtain a reward or to avoid a punishment in terms of reduced effort-related cardiac reactivity.

1. Introduction

Depression is one of the most frequent psychiatric disorders (Diagnostic and Statistical Manual of Mental Disorders [DSM-IV-TR], American Psychiatric Association, 2000). One of its core symptoms is anhedonia, defined as the loss of pleasure and interest (see Dichter, 2010, for a review) and related to insensitivity to hedonic consequences.

In the present study, we focus on one specific aspect of this anhedonic symptom, which is reward and punishment responsiveness. Using cardiovascular and behavioral measures, this study aims at investigating anticipatory motivation for obtaining a monetary reward and for avoiding a monetary punishment in dysphoria (i.e., subclinical depression). Our main hypothesis suggests that nondysphoric individuals would mobilize more effort in the incentive conditions than in the neutral condition, while effort mobilization would be blunted across all conditions for dysphoric individuals.

1.1. Reward and punishment anticipation in depression

Regarding reward responsiveness, depression has been associated with a deficit in the motivational approach system. Behavioral theories suggest that depressed individuals experience a lack of positive reinforcement. As a consequence, the behavior leading to positive consequences is given up (Beck, 1979; Jacobson, Martell, and Dimidjian, 2001). Depression is also characterized by a deficit in the behavioral facilitation system (Depue and Iacono, 1989) and in the behavioral activation system (Fowles, 1994). Finally, several authors affirm that depressed individuals do not experience rewards as reinforcing (Costello, 1972; Meehl, 1975; Strauman, 2002). Nowadays, reward is considered as a complex construct involving several psychological components, including reward learning, reward wanting, and reward liking (Berridge and Kringelbach, 2008). In the present study, we focus on reward wanting, which is defined as the anticipatory motivated behavior to obtain a reward (Berridge and Robinson, 2003). Most of the behavioral and neuroimaging studies revealed that depressed (Olino et al., 2011) and dysphoric individuals (Chentsova-Dutton and Hanley, 2010) showed a reduced motivation to obtain a reward.

Contrary to reward, punishment responsiveness has been less studied and the literature is less consistent (see Eshel and Roiser, 2010, for a review). However, the emotion context insensitivity hypothesis (Rottenberg, Gross, and Gotlib, 2005), considers depression as characterized by disengagement and suggests that depressed individuals show diminished emotional reactivity to both positive and negative stimuli. Moreover, following an error feedback, depressed persons are at an enhanced risk of making a subsequent error (e.g., Elliott et al., 1997). An interpretation of this phenomenon suggests a hyposensitivity to negative consequences, in the sense that depressed individuals have

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difficulties using negative feedback to improve future performance (Eshel and Roiser, 2010). There are a couple of studies that have investigated punishment anticipation with tasks involving monetary gains and losses. Some of them found that high risk girls (Gotlib et al., 2010) and remitted depressed (Schiller, Minkel, Smoski, and Dichter, 2013) showed a neural hyposensitivity during punishment anticipation. However, other studies (Knutson, Bhanji, Cooney, Atlas, and Gotlib, 2008; Olino et al., 2011) did not find these neural differences between depressed and nondepressed individuals during punishment anticipation.

In summary, the literature consistently shows reduced reward sensitivity in depression and dysphoria during reward anticipation (i.e., wanting). The literature also demonstrates hyposensitivity to punishment, even though this evidence is less consistent. From a motivational perspective the important question remains open as to whether clinically and subclinically depressed individuals indeed mobilize less effort in anticipation of a positive or a negative consequence.

1.2. Effort mobilization and cardiovascular reactivity

Effort mobilization is defined as the mobilization of resources for attaining goals (Gendolla and Wright, 2009) and represents the intensity of motivation. Brehm's motivational intensity theory (Brehm and Self, 1989) postulates that task difficulty and success importance determine effort mobilization in goal pursuit. Reward and punishment are variables that determine success importance: The higher the positive consequence to be obtained or the higher the negative consequence to be avoided, the higher is success importance. In motivational intensity theory, success importance is expected to have a direct impact on effort mobilization when task difficulty is unclear or unfixed (i.e., when the performance standard is unknown or when the performance standard can be chosen by the individual; Brehm and Self, 1989; Richter, 2012; Wright, 1996). Accordingly, unclear or unfixed task contexts allow testing the direct impact of reward and punishment on effort mobilization in goal pursuit.

As proposed by Wright's integration (Wright, 1996, 2008; Wright and Kirby, 2001) of motivational intensity theory (Brehm and Self, 1989) and Obrist's (1981) active coping approach, effort mobilization in active coping situations is proportional to the sympathetic activation of the heart. Pre-ejection period (PEP), the time interval between the onset of left ventricular excitation and the opening of the heart's left ventricular valve, is a direct measure of the sympathetically determined force of myocardial contraction. Systolic blood pressure (SBP) is also systematically influenced by myocardial contractility, while diastolic blood pressure (DBP) is mainly determined by total peripheral resistance and heart rate (HR) is determined by both sympathetic and parasympathetic activation (Papillo and Shapiro, 1990). A large number of studies have confirmed the predictions of motivational intensity theory by using cardiovascular reactivity (see Gendolla, Brinkmann, and Silvestrini, 2012 for a review). Importantly, findings from tasks with unclear difficulty have demonstrated increased cardiovascular reactivity during reward anticipation in comparison to a neutral condition (Richter and Gendolla, 2006, 2007, 2009). These studies showed that healthy participants mobilized more effort when a reward was at stake for successful performance.

2. The present study

As outlined above, the literature consistently demonstrates reduced sensitivity to reward—and in part also to punishment—in depression and dysphoria. However, only a few studies have addressed the question as to whether depressed or dysphoric individuals indeed mobilize less effort when incentives are anticipated (Brinkmann et al., 2009; Brinkmann and Franzen, 2013). Specifically, only one study has demonstrated reduced cardiovascular reactivity to a monetary punishment, which was delivered on an all-or-nothing basis. What is more, this study did not find results on the primary cardiovascular measure, which is PEP (Brinkmann et al., 2009, Study 1). Finally, all of these studies have focused only on physiological measures and did not simultaneously take behavioral measures into account.

The present study aims to close these gaps in the literature by investigating not only reward but also punishment responsiveness from a motivational point of view, using cardiovascular reactivity as an operationalization of effort mobilization during the anticipatory phase of reward and punishment processing (i.e., wanting). PEP reactivity, our primary measure of sympathetic impact on the myocardium (Kelsey, 2012), as well as SBP, DBP, and HR reactivity were assessed during performance of a cognitive task with unfixed difficulty, that is, a task where incentives directly determine effort mobilization (Brehm and Self, 1989; Wright and Kirby, 2001). Moreover, in order to link effort-related cardiovascular reactivity to previous research on reward and punishment insensitivity in depression and dysphoria (Henriques and Davidson, 2000), monetary rewards and punishments in the present study were delivered on a trial-by-trial basis. Finally, to take into account both physiological and behavioral levels, a recognition memory task similar to previous behavioral studies (Henriques and Davidson, 2000) was chosen for the present study.

Based on previous research with healthy participants (Richter and Gendolla, 2009), we hypothesized that nondysphoric participants would show an increase in cardiovascular reactivity if they can win a monetary reward or if they can avoid a monetary loss, compared to a neutral condition without hedonic consequence. In contrast, we expected a blunted cardiovascular response to both reward and punishment anticipation in dysphoria (e.g., Eshel and Roiser, 2010). Specifically, we hypothesized that dysphoric participants would show no increase in cardiovascular reactivity in the incentive conditions but have a cardiovascular response similar to the one in the neutral condition. Moreover, we hypothesized the same pattern for the behavioral measure, expecting that in the incentive conditions nondysphoric participants would show a stronger reward maximization behavior than dysphoric individuals, whereas behavioral responses of the two groups would be similar in the neutral condition (Henriques and Davidson, 2000). Furthermore, we hypothesized that nondysphoric inidividuals would use the negative feedback after an unsuccessful trial in the punishment condition to perform better in the subsequent trial, whereas dysphoric participants would not (Elliott et al., 1997; Eshel and Roiser, 2010). Finally, we expected that dysphoric individuals would report lower reward attractiveness, lower punishment aversion, and lower success importance than nondysphoric individuals.

3. Method

3.1. Participants and experimental design

The study was run in a 2 (dysphorics vs. nondysphorics) × 3 (neutral vs. reward vs. punishment) between-persons design and was approved by the appropriate local ethics committee. Participants were University students recruited from an introductory psychology course and by announcement at the University blackboards and received 15 Swiss Francs (about 15 USD) for participation. The final sample consisted of 107 students, composed of 87 women and 20 men aged from 19 to 35 years (see Table 1 for sample characteristics). Dysphoric and nondysphoric participants were randomly assigned to one of the three experimental conditions.

Preceding the experimental session, participants first answered the Center for Epidemiologic Studies-Depression Scale (CES-D; Radloff, 1977) as part of a questionnaire session. Participants scoring in the lower or in the upper quartiles of the CES-D score distribution were then invited via an anonymous code to participate in the experimental session. Of the 126 students who participated in the experimental session, only those participants whose CES-D scores at this second measurement time stayed within the lower (≤ 11) or upper (≥ 15) quartile of the CES-D were retained for analyses. Of the 116 remaining

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