Anhedonia and effort mobilization in dysphoria: Reduced cardiovascular response to reward and punishment☆

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A B S T R A C T

Instigated by evidence for reduced responsiveness to reward in depression, the present two studies addressed the question if such anhedonic behavior would also become evident in reduced mobilization of mental effort in terms of cardiovascular reactivity. Undergraduates completed the Center for Epidemiologic Studies-Depression Scale (CES-D) and worked on mental tasks, expecting either no consequence, a performance-contingent reward, or a performance-contingent punishment. Study 1 revealed that participants with low CES-D scores showed high systolic blood pressure reactivity in the punishment condition, whereas participants with high CES-D scores showed low systolic reactivity. Study 2 corroborated this finding for reward: Nondysphoric participants expecting a reward showed higher reactivity of systolic blood pressure and pre-ejection period than participants in the neutral condition or than dysphoric participants. Together, the studies demonstrate that reward insensitivity in (subclinical) depression is also found in cardiovascular reactivity. Furthermore, dysphoric individuals do not respond to punishment either, suggesting a general insensitivity to hedonic consequences.

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1. Introduction

Depression has commonly been associated with motivational deficits and anhedonia, which is the inability to experience pleasure. One of the core symptoms of a major depressive episode is the loss of interest and pleasure in almost all activities enjoyed before (Diagnostic and Statistical Manual [DSM-IV]; American Psychiatric Association, 1994). This also relates to depressed individuals' lack of responsiveness to rewards. A loss of reinforcing effectiveness in depression has already been described by Costello (1972), and Meehl (1975) states that “some persons [are] born with more cerebral ‘joy-juice’ than others” (p. 299). Strauman (2002) describes depression as a loss of the motivation to respond to rewarding stimuli, which manifests itself on the neural, cognitive, and behavioral level. Thus, depressed individuals' cognition and behavior seem to be guided by the core conviction that striving for reward and avoiding punishment are futile (Fowles, 1994). This phenomenon of insensitivity to rewards in depression has inspired intense research, from self-report and behavioral to neurophysiological and neurobiological studies.

1.2. Reward and punishment responsiveness in depression

With respect to self-report studies, early research on the basis of “expectancy × value” theories of motivation came to the conclusion that depressed individuals have reduced reward motivation and in part lower punishment motivation (Layne et al., 1982, 1983). The authors suggest that depressed individuals do not care about any outcome, either positive or negative. Similarly, previous research showed that clinical depression but also negative mood are associated with less anticipated and obtained pleasure concerning a variety of activities (Carson and Adams, 1980; MacPhail and Lewinsohn, 1974) and less engagement in pleasant, rewarding activities (Lewinsohn and Graf, 1973). More recent studies based on Gray's (e.g., 1982, 1990) theory of a behavioral approach system (BAS) and a behavioral inhibition system (BIS) converge on the fact that depressed individuals report reduced BAS activation and increased BIS activation (e.g., Kasch et al., 2002; but see also Johnson et al., 2003).

On the neurophysiological level, activation differences in prefrontal cortical areas have received particular attention. Those areas are associated with the representation and maintenance of goals as well as with approach and withdrawal behaviors. A substantial number of studies confirm that depression is related to a relative hypoactivation in left frontal regions, compared to the activation pattern found under normal conditions (e.g., Davidson and Henriques, 2000; Davidson et al., 2002; see also Harmon-Jones et al., 2002; Tomarken and Keener, 1998). This
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sensitive to signs of punishment and showed a more liberal response
participants and depressed patients with concomitant anxiety were
ambiguous across the two studies, but suggest that purely depressed
failed to adopt a more liberal response bias—which would maximize
their earnings. Results under monetary punishment conditions were
ambiguous across the two studies, but suggest that purely depressed
individuals are not motivated by punishment. In contrast, subclinical
participants and depressed patients with concomitant anxiety were
sensitive to signs of punishment and showed a more liberal response
bias, maximizing their earnings. Reduced reward responsiveness even
proved to be predictive of melancholic symptoms one month later in a
nonclinical sample (Pizzagalli et al., 2005).

Taken together, the findings from self-report, behavioral, neuro-
physiological, and neurobiological studies–investigating clinical as well
as subclinical samples–strongly suggest that depressed individuals
underestimate rewarding outcomes, do not behaviorally respond to
rewards, and have altered cortical and subcortical brain activation and
neurotransmission in the respective areas. However, it remains open if
this motivational deficit causes depressed individuals to mobilize less
effort when they are confronted with challenges that promise
rewarding or punishing consequences. Given the reduced responsive-
ness to reward and punishment reported above, it seems very probable
that such anhedonic behavior is also evident in measures of effort
mobilization. We therefore hypothesized that clinically depressed but
also subclinical (i.e., dysphoric) individuals would be reluctant to
mobilize effort in order to obtain a performance-contingent reward or to
avoid a performance-contingent punishment.

1.3. Effort mobilization and cardiovascular reactivity

To test our hypotheses about effort mobilization, we revert to the
concept of effort intensity, which can be defined as the mobilization of
resources at a certain point in time in order to carry out a behavior
(Brehm and Self, 1989). According to the work of Obrist (1981) and
Wright (1996), effort intensity or task engagement can reliably be
quantified as the reactivity of the cardiovascular system in the context
of task performance. This corresponds in particular to the reactivity of
parameters that are systematically influenced by the activation of the
sympathetic nervous system (see Brownley et al., 2000; Levick, 2003;
Papillo and Shapiro, 1990). The operationalization of effort intensity
by a person’s cardiovascular response—and especially by systolic blood
pressure (SBP) reactivity—has been corroborated by a body of research
involving different kinds of mental tasks and different task contexts
(for reviews see Gendolla and Brinkmann, 2005; Gendolla et al., 2007;
Wright and Kirby, 2001).

The theoretical framework of motivational intensity theory (Brehm
and Self, 1989) offers predictions for the influence of a performance-
contingent incentive. According to this approach, rewards can have either
an indirect impact or a direct impact on effort intensity. For tasks with
fixed difficulty, that is, when people have clear information about an
upcoming challenge, rewards are supposed to have an indirect impact on
effort intensity: Effort intensity is expected to directly vary with task
difficulty as long as effort investment seems possible and is justified by
success importance. This means that rewards do not influence actual
effort intensity but the maximum people are willing to invest (see Brehm
and Self, 1989; Wright, 1996, for details). However, rewards are supposed
to have a direct impact on effort intensity for tasks with unfixed difficulty
(i.e., tasks without performance standard but the instruction to do one’s
best) and for tasks with unclear difficulty (i.e., when people are ignorant of
the existing fixed performance standard). Under these two conditions
people are expected to mobilize the maximum effort that seems justified,
either because there is no standard or because they lack information
about task difficulty that could be used in order to adjust effort
mobilization. Therefore, motivational intensity theory predicts that task
engagement or effort intensity varies with success importance (e.g., with
an incentive value in form of a reward) for tasks with unfixed or unclear
difficulty (see Brehm and Self, 1989; Wright, 1996, for details).

Using tasks with unclear difficulty, recent work of Richter and
Gendolla (2006, 2007, 2009) has shown that people indeed mobilize
more effort in terms of cardiovascular reactivity during task
performance when they are offered a reward for successful perform-
ance. In their experiments, the authors ensured that participants
were not aware of the underlying predefined performance standard of
the mental task in order to keep task difficulty unclear. Specifically,
participants were instructed to memorize a list of senseless letter
strings. However, these letter strings appeared only successively on
the computer screen, leaving it open until the end as to how many
letter strings were to be memorized and what standard was to be
attained. These experiments showed that participants in the mone-
tary and nonmonetary reward conditions had higher reactivity of SBP
and in part also of diastolic blood pressure (DBP) and heart rate (HR)
(Richter and Gendolla, 2006). Moreover, the authors could show a
linear increase in the reactivity of SBP, HR, and cardiac pre-ejection
period (PEP) over several reward conditions with increasing mone-

1.4. The present studies

Given the longstanding notion of and the empirical evidence for
depressives’ insensitivity to reward and in part also to punishment, our
studies aimed at testing whether this anhedonic behavior is also evident
in reduced effort mobilization. As in prior research, we assessed
participants’ cardiovascular response to mental tasks with unclear task
difficulty (see Richter and Gendolla, 2006, 2007). We chose to test our
hypotheses in subclinical samples of university students with varying
levels of self-reported depression on the Center for Epidemiologic
Studies-Depression Scale (CES-D; Radloff, 1977).

We hypothesized that participants with low CES-D scores would
show the “normal” increase in cardiovascular reactivity if they were
promised a performance-contingent reward or if they could avoid a
performance-contingent loss. We expected furthermore that partici-
pants with high CES-D scores would show no increase in cardiovascular
reactivity in the reward and punishment conditions and rather have a
cardiovascular response similar to a neutral condition without explicit
ehedonic consequences. Given the body of previous evidence for SBP
reactivity as a reliable indicator for effort intensity, our primary variable
of interest was participants’ SBP response. Recently, also PEP reactivity
has been shown to correspond to the predictions of motivational
intensity theory (Annis et al., 2001; Richter et al., 2008; Richter
and Gendolla, 2009). Therefore, we also assessed PEP as well as DBP and HR,
which have been found to correspond to the SBP pattern in several
studies (for reviews see Gendolla et al., 2007; Wright and Kirby, 2001).

2. Study 1

The first study was a quasi-experiment with the CES-D score as
continuous predictor variable and three between-person conditions
(hedonic consequences: neutral vs. reward vs. punishment). We
predicted an interaction between depression score and condition.
Specifically, we expected no association between the depression score
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